Brazil:UK:Africa Partnership on Bioethanol
Scoping study

– Full report –

E4tech
July 2006

Brazil:UK:Africa Partnership on Bioethanol – scoping study

Full report

Study undertaken on behalf of the UK Office of Science and Innovation by E4tech (UK) Ltd.

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www.ost.gov.uk/ostinternational/world/2_2.htm

Foreword

When I visited Brazil as part of the preparations for the UK G8 Summit in Gleneagles in July 2005, I was impressed with Brazil's expertise in biofuel production – notably biodiesel using ethanol produced from sugar cane. There is worldwide interest in expanding the production of biofuels in order to reduce carbon emissions from transport. Bioethanol from sugar cane is an option already in widespread use, especially in Brazil; if produced with the appropriate technologies, it is a competitive and low-CO_2 transport fuel. I felt there was an opportunity for the UK to work with Brazil on a joint research project to evaluate worldwide potential capacity for ethanol production as a viable energy source. This report focused particularly on Southern Africa, identified as a potential area where conditions may be suitable and where expansion may contribute to other aspects of sustainable economic development.

A technical scoping study investigated the potential for a Brazil: UK: Africa partnership to stimulate the production of bioethanol. The findings contained herein indicate that there is potential for increasing bioethanol production from sugar cane in a number of Southern African countries. There are considerable potential markets for bioethanol in Africa and globally.

As well as reducing carbon emissions from road transport, this could contribute to African development and poverty reduction by aiding energy security, creating employment, adding value to agricultural production and developing agricultural and industrial infrastructures, and improving the national and regional balances of payment. The report also highlights areas, including effects on water supply and biodiversity, which need to be carefully managed in order to ensure that the overall effect of such development is beneficial.

The ultimate aim of the partnership will be to try and address two difficult global problems, climate change and African development, through a tri-partite partnership through development of bioethanol production capacity from sugar cane.

SIR DAVID KING, FRS
Chief Scientific Adviser to HM Government

Executive Summary

Climate change and African development are two global problems that G8 countries committed themselves to tackle in the 2005 Gleneagles communiqué.

There is worldwide interest in expanding production of biofuels in order to reduce carbon emissions from transport, and several studies indicate that biomass could make a material contribution to world primary energy, including for transport. Bioethanol from sugar cane is an existing technology already in widespread use, especially in Brazil; if produced with the appropriate technologies, it is a competitive and low-CO_2 transport fuel.

There is significant commercial and Governmental interest in expanding bioethanol production in other countries. Africa has been identified as a potential area where conditions may be suitable, and where this expansion may contribute to other aspects of sustainable development provided that environmental and social issues are fully addressed

A study commissioned by the UK Government's Office of Science and Innovation is investigating what scope there is for a Brazil:UK:Africa partnership to stimulate the production of bioethanol in Africa.

The study showed that there is potential for increasing bioethanol production from sugar cane in this region. As well as reducing carbon emissions from road transport, this could contribute to African development and poverty reduction, by creating employment, developing agricultural and industrial infrastructures and by improving the national and regional balances of payment. The study also highlights areas, including effects on water supply and biodiversity, which need to be addressed in order to ensure that the overall effect of such development is beneficial.

The study also addressed the possible aim and role of a partnership, in order to lay the ground for the creation of a partnership. The proposed high-level aim of the partnership is to facilitate the development of competitive and sustainable bioethanol production in Africa for local and potentially export markets.

Potential for bioethanol production in Africa

Bioethanol production in Africa can be increased through three complementary strategies: diversion of sugar cane resources from sugar production to bioethanol production, increase in sugar cane yields and expansion of sugar cane cultivation.

The adoption of flexible processing technologies allows the production balance between ethanol and sugar to be adjusted to respond to market conditions; in the short term this could allow diversion of sugar cane resources to ethanol production.

Sugar cane agricultural yields in the leading sugarcane producing countries have increased steadily in the last three decades as a result of improvements in variety selection and agronomic practices, and prospects appear to exist for further improvements. Furthermore, the varieties most suited to ethanol production have generally higher yields than the current ones which have been optimised for crystalline sugar production.

The current level of sugar cane cultivated area and the potential for increasing sugar cane growing area is of a similar magnitude in SADC and non-SADC Africa. However, the average yield is significantly lower in non SADC countries.

The study concludes that the African region has significant land areas suitable for expansion of sugar cane agriculture. The potential for sugarcane production was assessed first in southern Africa (the South African Development Community, SADC) and then in the rest of Africa. Both regions had similar potential for sugar cane agriculture.

The study makes an assumption, validated by local experts from industry, academia and NGOs, that it could be feasible to expand southern African sugar cane agriculture from the current 0.7 million hectares to an area of around 1.5 million hectares in the next 10 to 15 years. The additional area being relatively small, the study suggests that the expansion could be achieved with minimal impacts on protected areas and natural ecosystems or

conflicts with crops for food production. However, the implications of land use change will need to be addressed depending on the individual circumstances of the specific areas concerned. Based on the additional analysis on the technical potential for sugar cane production in non SADC countries, it may be possible to make a similar assumption for those countries.

If sugar cane cultivation in southern Africa were to be expanded to 1.5 million hectares, the production would be enough to satisfy twice as much the current regional consumption of sugar and in addition produce up to 7.3 billion litres of bioethanol each year.

This volume of bioethanol could replace around 30% of the gasoline required by the projected southern African gasoline vehicle fleet of 17 million cars by 2020. Alternatively, if blended into gasoline at a 10% rate, it could fuel between 50 and 60 million gasoline cars.

Climate change and sustainable economic development

Bioethanol production in Africa can bring material contributions to sustainable economic development and greenhouse gas reduction.

If sugar cane agriculture were to be expanded to 1.5 million hectares in southern Africa, the resulting volumes of bioethanol could reduce annual CO_2 emissions by up to 11 million tons, which is roughly equivalent to the annual emissions of three coal power stations.

Levels of employment in the sugar industry depend substantially on many local and regional factors, such as technology adopted and labour cost. However, preliminary estimates suggest that the benefits could be in the order of a few hundred thousand extra jobs in the region.

Were this volume of bioethanol to be used in the region, it could also make an important contribution to the regional balance of payments, by avoiding the import of gasoline worth around 1.6 billion US dollars at current prices. If exported, at current ethanol market prices it could provide 2.9 billion US dollars of extra revenues to the region.

The local communities could also benefit from other related effects, such as improvement or creation of road and rail infrastructures, development of related service sectors, skills and capabilities, and electrification of the rural areas surrounding the processing plants.

Environmental and social sustainability and barriers

A fundamental prerequisite for expansion of sugar cane agriculture in Africa is that it happens sustainably. There are many sensitive issues surrounding agricultural expansion which need to be addressed, in particular issues relating to water use, sensitive ecosystems and the agricultural model used. The study's conclusions are that, if the expansion is properly planned and managed, any negative impact can be minimised. An essential prerequisite is that environmental and social regulations at local and national levels are in place and properly enforced, to ensure that negative impacts are avoided or minimised. Global assurance schemes will play a key role in guaranteeing the short and long term environmental sustainability.

However, the further development of the African bioethanol industry will require a range of favourable conditions, some of which are not yet in place:

- availability of suitable skills, which will be affected by the diffusion of the HIV/AIDS epidemic;
- favourable policy context, including commitment to address environmental impacts;
- adequate infrastructures;
- political stability to attract investments.

Rationale for a partnership

The study has identified a range of barriers and gaps that affect the development of a competitive and sustainable bioethanol sector in Africa. They relate to aspects such as:

availability of finance; development of appropriate policy and regulation; availability of suitable infrastructure; regional planning; adoption of appropriate environmental and social standards; need for continued R&D; and development of knowledge, skills and capacity in industry and government. The partnership will therefore need to cover a range of aspects along the bioethanol supply chain. However, it should engage differently depending on its potential influence and the potential impact of its contribution. The partnership should:

- give high priority to and lead activities in relation to barriers and gaps on which it can have the greatest influence and which have the greatest impact on the development of a competitive and sustainable bioethanol sector;
- where it is not well placed to exert a strong direct influence, raise awareness of barriers and gaps that have a high impact on the development of bioethanol with those organisations that could have the greatest influence on them, and provide support where appropriate;
- give lower priority to leading activities in relation to barriers and gaps on which it can have a strong influence, but which have a lower impact on bioethanol development;
- have minimal engagement, as appropriate, in activities in relation to barriers and gaps which have a low impact on the development of bioethanol and on which the partnership cannot exert strong influence.

Potential partnership roles

The following table describes the potential partnership roles and their priority level.

Potential partnership role	**Issue addressed**
High priority – lead activities	
Raise high-level awareness in Africa about issues affecting the competitiveness and sustainability of bioethanol production	Benefits and requirements of sustainable bioethanol production not widely known or understood
Play active role in the development of environmental and social assurance schemes for the international bioethanol industry	Risk of unsustainably produced ethanol entering the market
Promote adoption of sustainability best practice	Risk of unsustainable practices
Support the development of policy making capacity	Insufficient policy making capacity
Support the development of enforcement capacity	Insufficient enforcement capacity
Promote exchange of policy options and implementation mechanisms	Need for long-term policies to enable (and stimulate) the uptake of bioethanol
Support mechanisms to embed environmental and social value of bioethanol	Need for mechanisms that recognise the value of environmental and social assurance
Share the Brazilian experience of integrating ethanol and oil infrastructures	Participation of incumbent industries in setting up and running ethanol-compatible infrastructures and equipment
Support development of skills	Availability of necessary skills along the chain, including RD&D skills in plant science.
High priority – raise awareness and provide support	
Promote long-term demand continuity	Long-term international market uncertainty
Promote integration of planning with resource assessment	Lack of integration between "sub-national" regional planning and resource assessment
Promote integration of bioethanol into infrastructure planning	Lack of adequate infrastructure for ethanol transport (including towards export markets). May also apply to feedstock.
Raise awareness and promote development of	Barriers to cogeneration and rural

cogeneration and rural electrification from ethanol facilities	electrification
Promote harmonisation of environmental and social regulations	Uneven levels of environmental and social regulations and enforcement, potentially leading to distortions
Promote best practices in HIV/AIDS prevention and management	Possible loss of workforce due to the effects of the HIV/AIDS epidemic
Work towards trade barrier removal	International trade barriers
Promote awareness of bioethanol benefits to funding agencies	Availability of capital, including to small-scale farmers
Low priority – lead activities	
Work to manage expectations on demand and supply-side issues	Potential worldwide imbalance between demand and supply, resulting in market instability and loss of credibility
Minimal engagement as appropriate	
Improve harmonisation of legal framework	Uneven legal framework e.g. fuel standards

It would be logical for the high priority areas identified above to be implemented in a sequence going from activities such as awareness raising in the policy and industrial communities, to capacity, knowledge and skills development, through to support in the development and implementation of policies, regulations, assurance schemes and best practice.

The creation of a partnership now requires engagement of relevant partners, agreement on its scope, and definition of its structure and operational aspects. Also, there are several current regional and global initiatives that the partnership should recognise and collaborate with. These include initiatives such as the recently launched Global Bioenergy Partnership. The partnership will need to recognise internal risks, associated with its organisation and activities, and external risks, outside the possible influence of the partnership, that may affect its chances of success. It will need to assess these risks and consider ways to mitigate them where possible.

Outline of report

This document contains four sections.

- The potential for sugar cane and ethanol production in the Southern African Development Community (SADC)
- Options for a Brazil:UK:Africa bioethanol partnership
- The potential for sugar cane production in African countries outside SADC
- The global potential for biofuels

Section 1: The potential for sugar cane and ethanol production in SADC

Brazil:UK:Africa bioethanol partnership

Phase 1 : technical analysis

London

March 2006

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The overall challenge

Climate change and African development have been key G8 agenda goals under the UK Presidency

Brazil has world-leading experience and technology in relation to bioethanol production from sugar cane and its use

Africa may be able to benefit from expansion of sugar cane and bioethanol production

Sir David King identified the potential for the UK to act to enable technology and skills transfer in support of G8 agenda goals

How could stimulating the production of bioethanol under a Brazil:UK:Africa partnership successfully contribute to G8 agenda goals?

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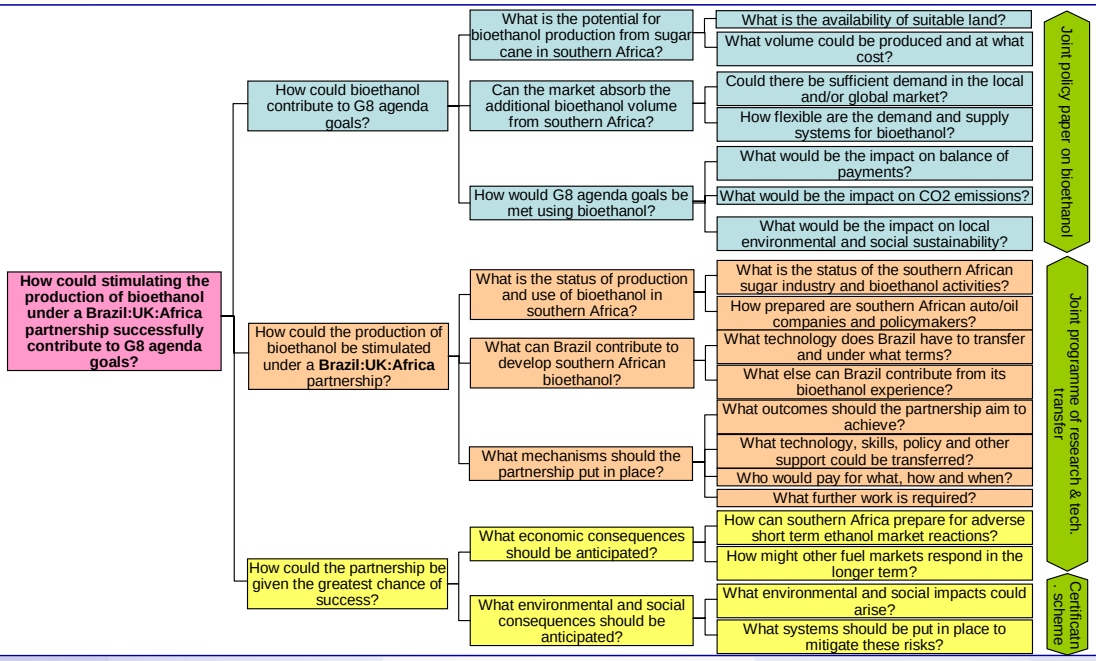
Our breakdown of the challenge



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Why sugar cane and bioethanol?

The scope of the study is:

- the use of **bioethanol** as a transport fuel: biodiesel and other bioenergy products are not considered
- production of ethanol from **sugar cane**: other routes to ethanol such as from corn, wheat or ligno-cellulosic routes are not considered

The rationale is:

- the sugar cane - bioethanol fuel chain has the potential to be among the lowest cost and lowest CO_2 fuel chains:
  - sugar cane is a tropical and equatorial crop with very high biomass yields
  - the technology to produce bioethanol from sugar cane is well developed
  - bioethanol from sugar cane is the main biofuel used today, Brazil being the leading country in both production of ethanol from sugar cane and its use as a transport fuel

However, there may also be opportunities related to other bioethanol and bioenergy routes.

South Africa or southern Africa?

The initial scope of the study was **South Africa** alone, as:

- it has the most developed economy in the region
- it is the regional centre of excellence for sugar and ethanol, as the main companies are based there
- its gasoline market represents around 80% of the whole southern Africa market

However, our analysis and the discussions with the local experts showed that the potential for expanding sugar cane in South Africa is rather limited. The main potential for sugar cane expansion is instead located in other countries of the **Southern African Development Community** (**SADC**).

Therefore, the scope of the study has been enlarged to include the whole of SADC.

It is also likely that there is potential for expansion in both production and use of bioethanol in Africa as a whole. This has not been addressed as it was felt to be too far removed from a South African 'entry point' at this stage

Policy priorities in Brazil and South Africa are different but can be met by the development of African bioethanol production

South Africa

- The most important policy priorities in South Africa are **economic and social development**, including job creation, income generation for the poor, and black empowerment
- South Africa benefits from a well developed national synthetic fuel sector: this makes **energy security** a less critical issue, although diversification and reduction of the imports of petroleum products remain important
- South Africa is not part of Kyoto "Annex I" country group, and is not therefore bound by direct commitments or obligations to reduce its **GHG emissions**. However, it views positively a possible role as a regional champion against climate change

Brazil

- Brazil is interested in establishing a **global market for bioethanol** as a traded commodity. This would help improve market stability and build confidence in the international financial community around investments in the sector
- Brazil also sees potential benefit in having other producing countries join or increase their contribution to the bioethanol sector. Far from being perceived by Brazil as threats to its dominant position in the bioethanol market, **new producers could actually relieve pressure** on Brazilian supply and contribute to the security of worldwide ethanol supply
- Brazil is keen to exploit opportunities related to the **transfer of know-how and technologies** as a result of its leading position in the bioethanol from sugar cane sector

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What's in it for the UK?

The are several aspects of a Brazil:UK:Africa partnership that could interest the UK:

- lead action contributing to the two main UK G8 agenda goals of climate change and African development
- assist the development of environmentally and socially sustainable bioethanol supply
- improve the security of bioethanol supply to the UK biofuel market, through:
  - helping develop a global market for bioethanol - this would improve the perception of bioethanol as a commercially established and reliable transport fuel
  - diversifying the sources of bioethanol - this would help increase the security of bioethanol supply at the time when demand for it is projected to grow

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Project status and objectives of this document

Status of the work

- On 23rd January the outputs of a desk study on bioethanol potential were discussed with the UK Steering Group.
- Since then, the team have met with:
  - Sir David King, DEFRA;
  - 20+ representatives of farming, sugar, energy, auto industries, government, academia and NGOs in South Africa;
  - 20+ representatives of farming, sugar, energy, auto industries, government, academia and NGOs in Brazil;
  - International Sugar Organisation

  to validate and discuss the analysis.
- The findings were summarised and presented to the UK Steering Group on 27th February.

Objectives of this document

- Present the results of our analysis and the discussions with South African and Brazilian stakeholders
- Receive further comments on these findings
- Obtain views about the way ahead

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UK Steering Group and consultees

UK Steering Group:
- Office for Science and Technology - OST
- Department for the Environment, Food and Rural Affairs - DEFRA
- Department for Transport - DfT
- Department for International Development - DFID
- Department for Trade and Industry - DTI
- Foreign and Commonwealth Office - FCO
- Brazilian Embassy in London

Other UK consultees:
- International Sugar Organisation - ISO
- Imperial College

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Organisations interviewed in South Africa and Brazil

South Africa

- Government
  - Departments of Science and Technology
  - Departments of Minerals and Energy
- Sugar cane and sugar industry
  - Canegrowers SA
  - Noodsberg Canegrowers
  - South African Sugar Association – SASA
  - Illovo Sugar
  - Tongaat-Hulett
  - UCL Sugar
  - AGAMA Energy
- Academia and research organisations
  - South African Sugarcane Research Institute – SASRI
  - Sugar Millers' Research Institute – SMRI
  - University of KwaZulu Natal - Durban
  - Energy Research Centre, University of Cape Town
- NGO
  - WWF + Wildlife & Environment Society of South Africa – WESSA

Brazil

- Government
  - Ministry of Agriculture
  - Ministry of the Environment
  - Ministry of Industry
  - Ministry of Foreign Affairs
  - São Paulo Secretary of State for Environment
  - São Paulo State Agency for Agribusiness – APTA
- Industry
  - Copersucar
  - National Association of Automotive Vehicle Manufacturers – ANFAVEA
  - São Paulo Sugar Cane Agroindustry Union – UNICA
- Academia and research organisations
  - Agronomic Institute of Campinas
  - National Biofuels Programme, University of São Paulo
  - Sugarcane Technology Centre – CTC
  - University of São Paulo

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Summary of findings to date

High level conclusions can be drawn from the analysis carried out and the input from South African and Brazilian stakeholders

It is possible to increase ethanol production in some areas of southern Africa

- such an increase could be planned and managed in a sustainable way that minimises negative environmental and social impacts
- the additional volumes of bioethanol could deliver significant benefits in terms of UK G8 agenda goals

The team also formed preliminary views on a possible international partnership on bioethanol:

- both Brazilian and South African stakeholders are interested in the further development of the African ethanol sector, as it could contribute to meeting the respective national policy priorities
- there is scope for and interest in a Brazil:UK:Africa partnership to stimulate the further development of the African bioethanol industry

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Sugar cane cultivation in South Africa, SADC and Brazil

Sugar cane production in South Africa and SADC is not yet as developed as it is in Brazil, both in absolute terms (area and production) and in relative ones (share of arable land)

		South Africa	SADC	Brazil	Global
Total land area	*M ha*	121.4	964.1	851.5	13,432.4
Arable land	*M ha*	14.8	48.3	59.0	1,403.4
Sugar cane growing area	*M ha*	0.325	0.684	5.10	20.4
as % of global sugar cane growing area	*%*	*1.6%*	*3.35%*	*25.0%*	-
Sugar cane growing area / arable land	*%*	2.20 %	1.42%	8.65 %	1.4%
Production	*M tonnes*	23.0	46.9	364.4	1,330.4
as % of global sugar cane production	*%*	*1.74%*	*3.53%*	*27.4%*	-
Average yield	*tonne / ha*	62.6	68.6	71.4	65.2

Source: FAO statistics, 2005. Data for 2002

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Agriculture and sugar cane in South Africa

Maize is the dominant crop in South Africa, being grown on a surface ten times larger than that of sugar cane.

	Harvested area [ha 2004]	**Production [tonnes 2004]**
Land classified as *arable land and permanent crops*	15,712,000	-
Maize	3,204,110	9,737,000
Mixed grasses & legumes	1,300,000	16,600,000
Primary oil crops	890,500	368,699
Wheat	851,200	1,761,000
Sugar Cane	***325,000****	***19,094,760***

Source: FAO statistics 2005, data for 2003 (land classification) and 2004 (crop data)

(*) During discussions with the South African sugar industry, a value of 420,000 ha was referred to as the provisional value for sugar cane area for 2005. However, updated 2005 values for the other variables were not available: therefore so in order to ensure comparability of statistics, this and the previous tables show 2003 and 2004 FAO data

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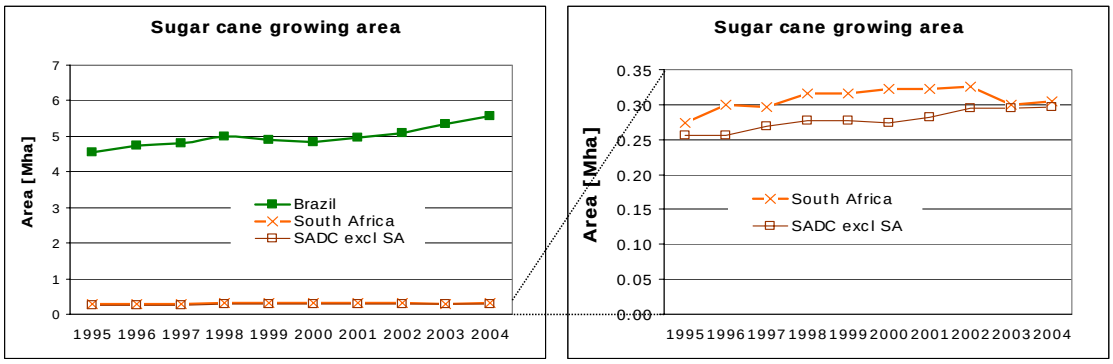
Sugar cane area: trends in Southern Africa and Brazil

Over the period 2000 – 2004, South Africa sugar cane area shrank by 5%, getting back to 1996 values, while in the remaining SADC countries the area rose by 8%

For comparison, Brazilian cultivated area rose by 15% over the same period.

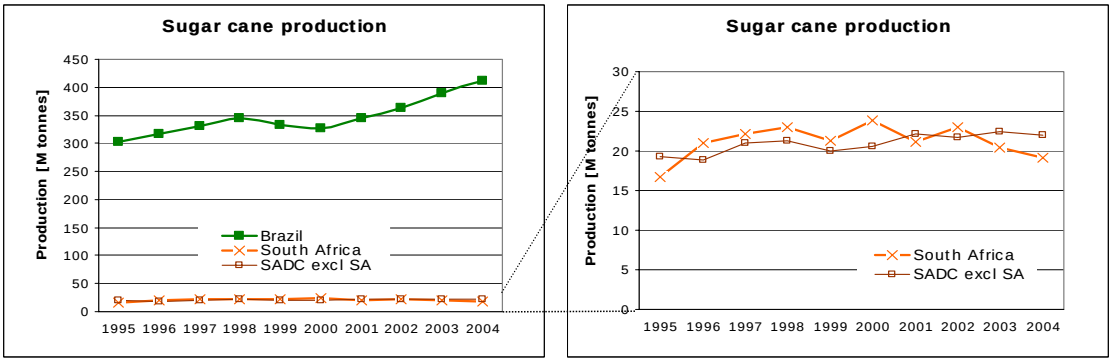


Source: FAO statistics, 2005. Data for 2004

Sugar cane production: trends in Southern Africa

Over the period 2000 – 2004, South Africa production shrank by 20% due to lower cultivated area and unfavourable weather conditions in the last years. In the rest of SADC countries production appeared to be more stable.

For comparison, Brazil showed a 25% increase in sugar cane production over the same period.



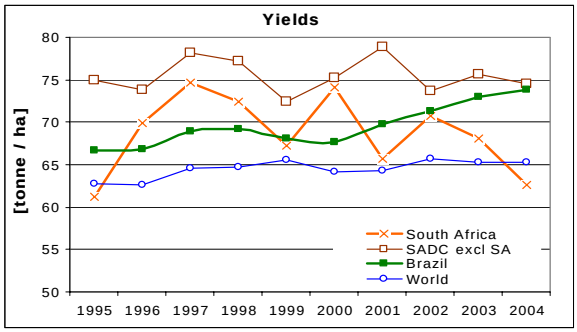
Source: FAO statistics, 2005. Data for 2004

Sugar cane agricultural yields in Southern Africa are comparable and in some cases higher than in Brazil

Sugar cane agricultural yields are similar in the geographies considered, and in most cases above the world average.

No prominent trends appear in South Africa and SADC yields over the last decade, which contrasts with the steady increase in Brazilian yields; the particularly low results of the 2004 harvest are attributed to an unusually dry season.

It should be noted that average yields in SADC countries outside South Africa were greater than in Brazil in each year between 1995 and 2004



Source: FAO statistics, 2005. Data for 2004

Yield variability is linked to agricultural practices and use of irrigation

Use of irrigation can bring yields close to and above 100 t/ha. Also, yields tend to be higher in large estates than in small farms.

Sugar Cane – Yield (t /ha)	Minimum	Average	Maximum	Max / Min variation
Angola	36.3	37.4	37.9	5%
Congo, Dem Republic of	41.5	45.9	49.3	19%
Madagascar	32	33.2	35.8	12%
Malawi	**100**	**104.3**	**105.6**	**6%**
Mauritius	**53.6**	**71.7**	**79.5**	**48%**
Mozambique *	11.6	13.8	17.1	47%
South Africa	**61.2**	**68.7**	**74.7**	**22%**
Swaziland	**90.8**	**97.7**	**108.1**	**19%**
Tanzania	**86.5**	**106.1**	**95.7**	**23%**
Zambia	**103.1**	**109.2**	**106.5**	**6%**
Zimbabwe	**90.5**	**113.3**	**104.8**	**25%**
SADC average	*63.9*	*67.9*	*71.8*	*12%*

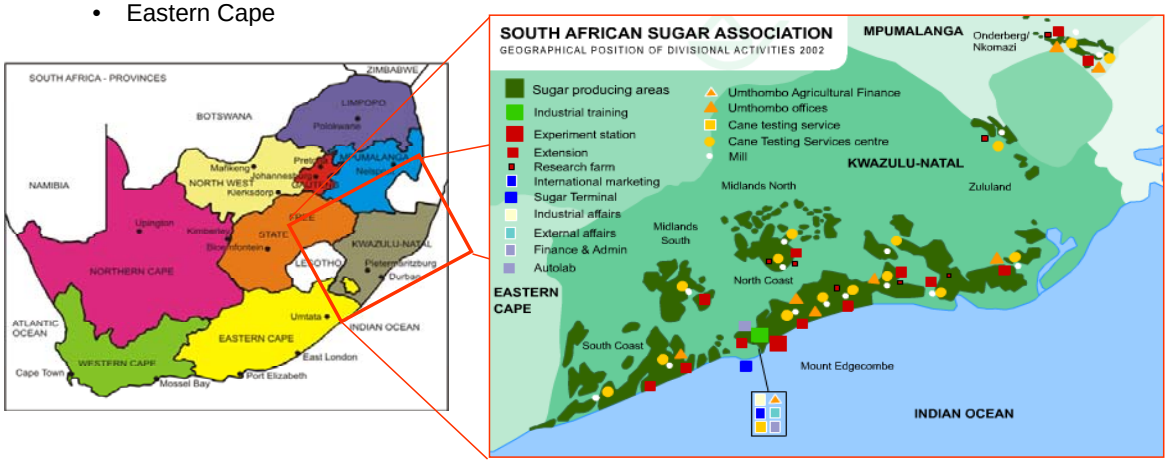
(*) In Mozambique sugar cane production was negatively affected by recent war events. Damaged or lost crops could explain the low yields recorded. Experts consider such low yields not representative of the high yield potential in Mozambique.

*Source: FAO statistics, 2005. data for 1995 – 2004. Botswana, Lesotho and Namibia do not have sugar cane agriculture and are not included. Countries with average yields above SADC average are in **bold***

Sugar cane and sugar industry in South Africa: geographical distribution…

Sugar cane production is concentrated in three provinces of eastern South Africa:

- KwaZulu-Natal, where the majority of sugar cane is grown
- Mpumalanga
- Eastern Cape



Source: South African Sugar Association www.sasa.org.za

… and structure

The sugar cane production sector in South Africa is composed of around 50,000 growers, of which:

- around 47,000 are small scale, accounting for around 25% of production
- around 3,000 are medium and large scale:
  - as a whole, they account for around 75% of production
  - they include integrated milling companies with own crop production, for around 11% of total production

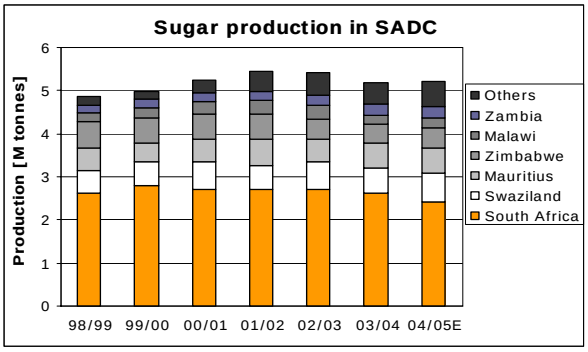
The sugar industry employs almost 85,000 people. The milling activities are carried out in 14 mills by almost 13,000 people. It is structured around 6 main companies, of which ILLOVO is the largest

Company	Growing estates	Mills	Refineries
Illovo Sugar	4	5	2
Tongaat-Hulett Sugar	Several	4	1
Transvaal Sugar	Several	2	1
UCL Company	Not known	1	-
Umvoti Transport	Not known	1	-
Ushukela Milling	Not known	1	-

Source: South African Sugar Association www.sasa.org.za

Around half of SADC sugar is produced in South Africa

		South Africa	SADC incl SA	Brazil	Global
Sugar production	*M tonnes*	2.4	5.2	29.2	144
of which, exported	*M tonnes*	1.3	2.2	17.8	-
% exported	%	53%	42%	61%	-
Total prod. as % of global prod.	%	1.7%	3.6%	20.2%	-

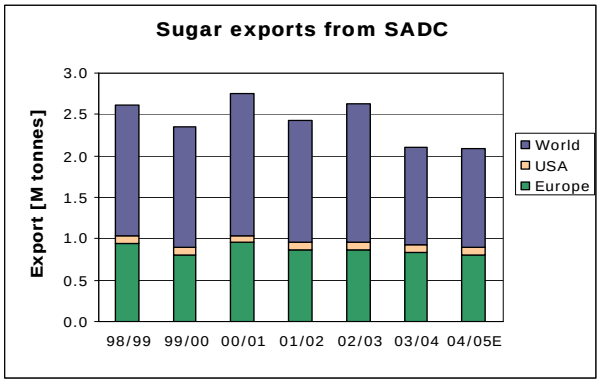


Source: E4tech analysis on ILLOVO data [values for the 2004/2005 season are estimates]

Sugar production and exports in Southern Africa

Until the recent reform of EU sugar regime, sugar exports from SADC to preferential markets tended to remain stable over time, due to lock-in in long term contracts. Swings in production were then absorbed by the world commodity market.

The phase-out of the preferential regime towards the EU may results in diversion of sugar cane resources from sugar to ethanol production, which may be sold on the international markets.



Source: E4tech analysis on ILLOVO data [values for the 2004/2005 season are estimates]

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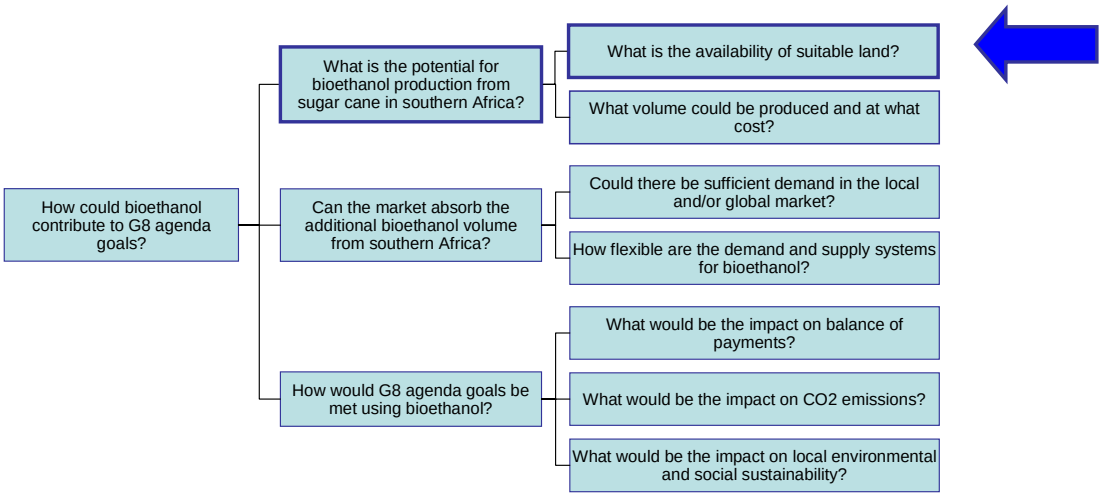
How could bioethanol contribute to G8 agenda goals?
What is the potential for bioethanol production from sugar cane in southern Africa?
What is the availability of suitable land?
What volume could be produced and at what cost?
Can the market absorb the additional bioethanol volume from southern Africa?
Could there be sufficient demand in the local and/or global market?
How flexible are the demand and supply systems for bioethanol?
How would G8 agenda goals be met using bioethanol?
What would be the impact on balance of payments?
What would be the impact on CO2 emissions?
What would be the impact on local environmental and social sustainability?
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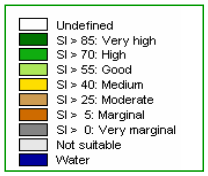
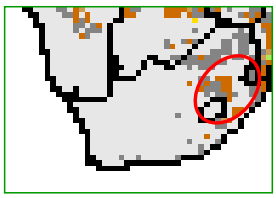
The initial focus of the sugar cane potential assessment was on South Africa…

The Global Agro-ecological Assessment carried out in 2002 for the UN-FAO shows that in South Africa sugar cane is already grown on the most suitable areas

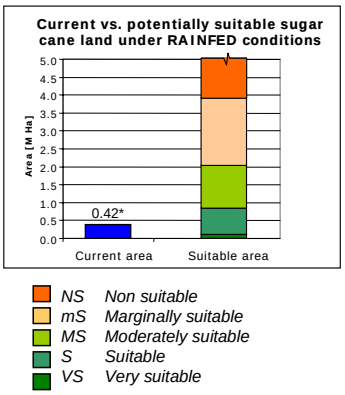
Suitability for rainfed sugar crops





Suitability for rainfed + irrigated sugar crops

Distribution of current sugar cane area and suitable land
Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002); SASA



Extent of current and suitable land, under **rainfed** conditions
(*) 0.42 Mha is the provisional value for sugar cane area for 2005 as discussed with SASA
Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002); SASA

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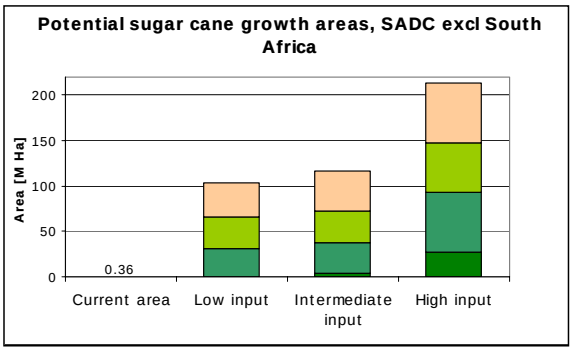
… but was broadened to the Southern African Development Community (SADC), where greater potential lies

The Global Agro-ecological Assessment carried out in 2002 for the UN-FAO shows that in the rest of SADC sugar cane is grown on only a tiny fraction of the most suitable areas. This was confirmed by both academia and industry in South Africa.

SADC countries



Current and potentially suitable land, under **rainfed** conditions
Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002)

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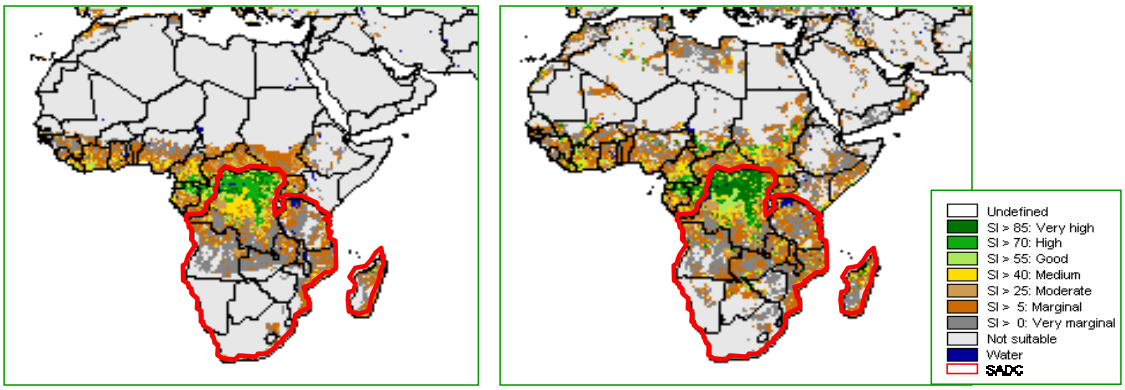
The most suitable areas for sugar cane agriculture are located in the northern and eastern parts of SADC

It is important to highlight that the IIASA-FAO assessment only considers the suitability of land depending on soil characteristics, slope and climatic conditions; current use of land (i.e. natural vegetation, pasture, crops, forestry, infrastructures, etc.) is not considered.

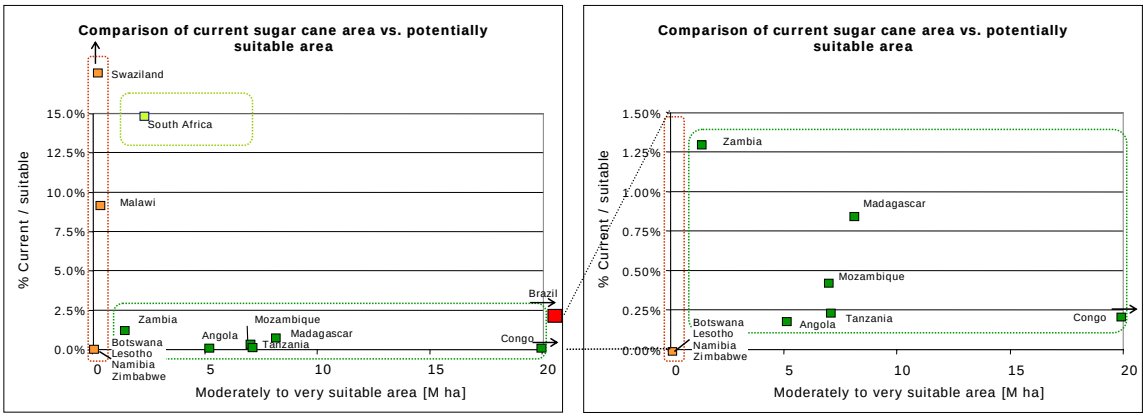


Suitability for rainfed sugar crops, high input

Suitability for rainfed + irrigated sugar crops, high input

Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002)

It is possible to identify three groups of countries according to the level of sugar cane expansion potential



- Limited potential: *Moderately* to *Very Suitable* rainfed land area < 1 M ha
- Medium potential: *Moderately* to *Very Suitable* rainfed land area > 1 M ha, already partially developed (more than Brazil)
- Large potential: *Moderately* to *Very Suitable* rainfed land area > 1 M ha, currently underdeveloped (less than Brazil)

Possible targets for sugar cane growing areas can be set

In order to understand the potential, requirements and implications of bioethanol production from extending sugarcane production, we have set a hypothetical target area for expansion in the period to 2020

Sugar cane growing area [ha]	Current	Possible target	Rationale
Countries with:			
large potential	186,000	**1,000,000**	Attainable target based on the Brazilian experience; discussed in more detail in following sections
medium potential	325,000*	**325,000**	Previous studies highlight a limited potential for expansion of sugar cane agriculture. **No further expansion is investigated** in this study
limited potential	177,000	**177,000**	**No further expansion is investigated** in this study
Total SADC	688,000	**1,500,000**	

(*) The estimated value for sugar cane area for 2005 is between 400,000 and 420,000 ha, as discussed with SASA. However, as comparable 2005 data were not available for the rest of SADC, this table presents homogeneous 2004 data as from FAO

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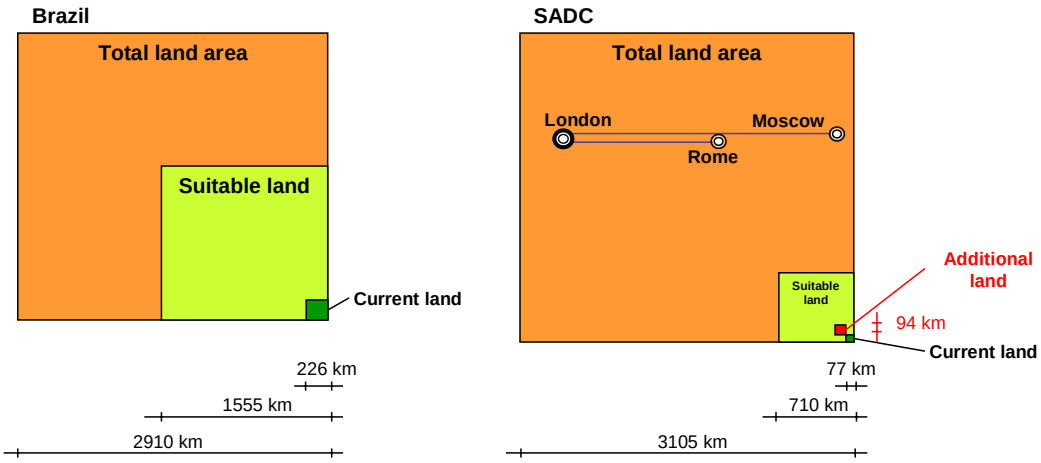
Expanding the production area to 1.5 Million ha would not be trivial but is nevertheless achievable



- Such expansion would mean adding 60,000 hectares each year, which is half the growth Brazil has had over the last 6 years
- To process the expanding volumes of sugar cane, 2 to 3 new sugar mills should be built each year to a total of 40 to 60 mills; about 300 mills are currently in operation in Brazil and 40 under construction

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Some aspects are not considered in detail in our top-down analysis…

Competition with other cultivated areas: the information available does not allow the overlay between sugar cane suitability and current land use, preventing a detailed assessment of possible conflicts between alternative land uses. However, the target area represents a small fraction (less than 3%) of the land classified as *Arable land and permanent crops* by FAO: therefore, we considered reasonable to assume that sugar cane will be expanded first where it does not compete with existing crops

Accessibility and infrastructures: the level of infrastructure development across SADC varies significantly. It is reasonable to assume that, within the very large extents of suitable areas, market forces will naturally lead expansion towards the areas with better infrastructures

Agricultural systems: the expansion of agricultural systems, including sugar cane agriculture, and their organisation (e.g. small holders vs large estates) will depend on several factors, such as: suitability of land and environmental conditions to low-medium-high input agriculture, current land tenure regimes, labour cost, market conditions and national policies. A detailed analysis of these factors, being very much dependent on local and national conditions, is beyond the scope of this study.

Arable land *is defined as "land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable"*

The classification ***Permanent crops*** *is defined as "land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee and rubber; this category includes land under flowering shrubs, fruit trees, nut trees and vines, but excludes land under trees grown for wood or timber."*

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… but different studies show that the 1.5 Mha target area is very conservative

	This scoping study	**Analysis carried out at the University of KwaZulu-Natal** [1]
Methodology	Top-down: a **target area** is estimated as an overall share of the total suitable land	Bottom-up: the **potential land area** is calculated by subtracting from the maps of suitable land: - protected areas [2] - steep areas with slope >16% [3] - land currently under food crops incl. sugarcane[4] - patches of land smaller than 500 ha [5]
Spatial granularity of underlying data	5 km	1 km
SADC countries investigated	All (14)	Malawi, Mozambique, Tanzania, Zambia
Outcome	**1.5 Mha**	**5.4 Mha**

Notes:
(1) courtesy of Dr. Helen Watson, University of KwaZulu-Natal, Durban – South Africa
(2) as identified by the World Database on Protected Areas (WDPA, 2005)
(3) as identified by the Africa Digital Elevation Model (EROS, 1996)
(4) as identified by the Global Land Cover database, 2000
(5) according to Makhanya (1997), the smallest plot area able to guarantee subsistence agriculture was, in South Africa, 500ha

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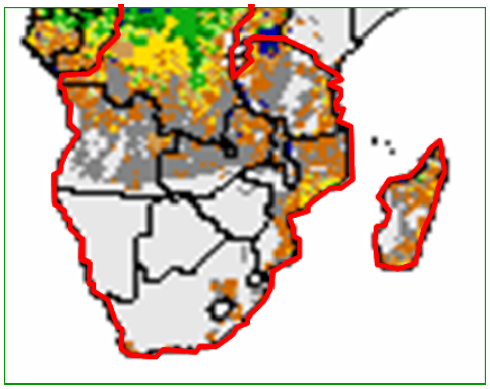
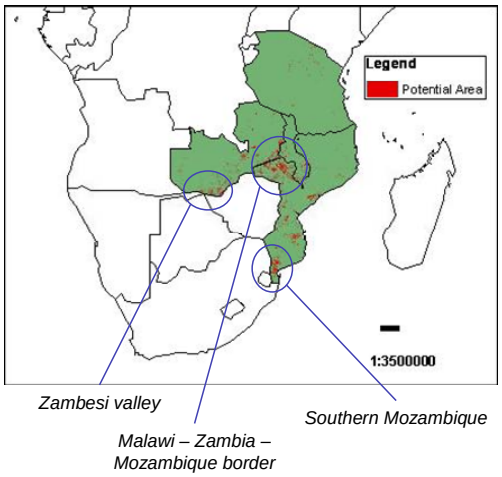
The 5.4 Mha identified in the bottom-up study cluster around distinct areas

– Suitable areas before deductions –



– Potential areas after deductions –



Source: courtesy Dr. Helen Watson, University of KwaZulu-Natal, Durban, South Africa

The extent of the target area is such that sugar cane agriculture, if carefully managed, could be expanded sustainably / 1

Issue	Remarks
Water use	• According to the agronomists consulted in South Africa and Brazil, the suitability for rainfed sugar cane is based on **current sugar cane varieties**, which are selected to maximise sucrose content for sugar production. Varieties with lower sucrose content and higher yield in biomass and fermentable material, more suitable for ethanol production, are likely to require less water and be more resistant to drought. • In some lowland areas, temperatures can be so high as to cause the plants to die, even during short dry periods. In these case, **irrigation is only required for short periods** to guarantee the survival of the plant. Plantations at higher altitude, such as in Tanzania, are not affected by this problem. • Some of the most suitable areas, such as along the Zambesi valley, are close to large rivers which can provide irrigation. In other areas, the total annual rainfall is sufficient and only small scale reservoir schemes would be required to compensate for short dry periods; **use of large water transfer schemes was considered unlikely** by the local experts consulted. • South Africa has very stringent water **regulations,** the status and enforcement of regulations in other SADC countries would need to be considered.

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The extent of the target area is such that sugar cane agriculture, if carefully managed, could be expanded sustainably / 2

Issue	Remarks
Conservation (habitat and biodiversity preservation, protected areas, etc.)	• Other studies suggest that larger areas of land than the target area discussed in this project could be dedicated to sugar cane after exclusion of protected areas and other land uses.This indicates that expanding sugar cane to around 1.5 Mha can be done **without overlap or interference with existing protected land**, if the protection regime is properly designed and enforced • At a smaller scale, pioneering work carried out by WWF/WESSA and a farmers' association in KZN developed **best practice guidelines** which include measures to protect waterways, wetlands and other sensitive habitats. Farmers involved in the scheme confirmed that such measures had also positive effects on profitability (lower water and chemical input coupled with higher yields)

Discussing the "*Environmental management guidelines for sugarcane*" with WWF/WESSA representatives, South Africa

Proper regulation and its enforcement can minimise environmental impacts, and the stakeholders interviewed indicated that South Africa and Brazil have stringent environmental regulations in place. The development of environmental assurance schemes would provide additional assurance that best practice is followed in the interest of the short and long-term sustainability of the industry.

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The extent of the target area is such that sugar cane agriculture, if carefully managed, could be expanded sustainably / 3

Issue	Remarks
Rural development	• The **economics** of sugar cane production are better for large agro-industrial estates than for small owners, for reasons of economies of scale and more advanced practices. However, both the government and the industry recognise that a mixed model is the most beneficial to guarantee a socially sustainable agriculture sector, and measure can be put in place for an efficient integration of small-holders. • Where agronomic conditions allow, farmers may prefer to have **different cultures** (e.g. sugar cane + forestry) coexist on the same estate: this helps diversify and overcome the seasonality typical of the sugarcane employment. • Manual **harvesting** of burnt cane and mechanical harvesting of green cane have different employment and environmental impacts. Mechanical harvesting may be the better option environmentally, but results in job losses. Where topography permits, there is a gradual move to mechanical harvesting. • In some cases, the establishment of new growing areas and plants could result in **creation or improvement of infrastructures** such as roads or railways. • Thanks to the availability of cane residues for cogeneration, plants can become hubs for **rural electrification** schemes.

Expansion will depend on a favourable context…

Issue	Remarks
Policy context	Industry would welcome a stable policy framework supporting ethanol, to generate demand, reduce business risk and thus promote investments. Historically, sugar prices could stay low for a very long time apart from short-term highs. According to the industry, it is difficult to justify 25 years investments in new plants on the basis of few months with sugar prices even as high as 18¢/pound.
Infrastructures	In most areas outside South Africa the presence of suitable infrastructures such as roads and railways is often mentioned as a major potential barrier: for instance, the road network in South Africa is good and dense, while northern countries have generally more dispersed road networks, and usually in worse conditions. Lack of easy access to suitably equipped ports could also be an issue. This could pose problems in transporting ethanol across SADC and potentially towards export markets.
Political stability	Industry remains sceptical about expanding its activities in countries with a troubled recent history, such a Mozambique, Zimbabwe or DRC.

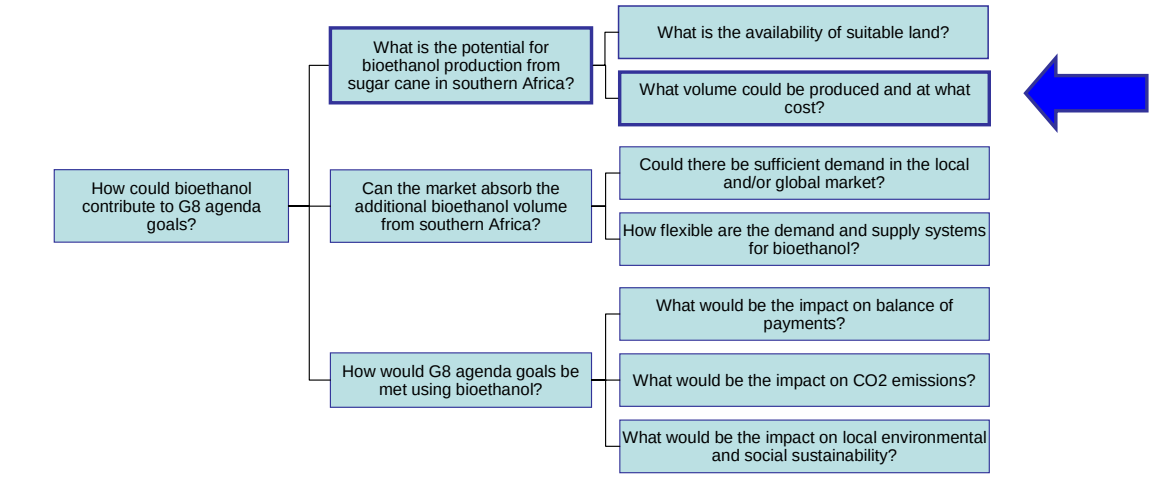
… and may be affected by several socio-economic constraints

Issue	Remarks
Skills	Availability of skilled workforce may be critical for a rapid expansion of the industry. The industry highlights that it could be difficult to find the right skills to build, run and maintain the plants, in particular for profiles such as technician, engineer or plant manager.
AIDS [1]	In all SADC countries excluding Angola, DRC and Madagascar, infection rates are above 10%; the average across SACD is 12.4% and in some countries rates exceed 30%. There is concern that the epidemic could deprive the society of a significant share of its workforce. In some cases, the industry mentioned the decision of doubling the number of apprentices to compensate for future losses.
Land tenure	Three main types of land tenure exist in southern Africa (freehold, leasehold and tribal ownership). In the past, it proved difficult or impossible to raise capital under a short-term lease or tribal regime.

(1) Statistics from UNAIDS, 2004

Brazil has plans to significantly expand its sugar cane agriculture

- Most sugar cane production in Brazil is in the State of Sao Paulo. Interviewees agreed that the industry is generally considered to be environmentally sustainable, with stringent environmental regulations being in place in the State of Sao Paulo. However, some interviewees said that there remains space for improvement, in particular in relation to erosion control, run-off and leaching.
- Interviewees from both the industry and government confirmed that the Brazilian sugar cane area could expand from the current 5.5 Mha to up to 8 to 9 Mha in the next 8 – 10 years.
- Such expansion will most likely take place on pasture land, much of which is considered to be degraded, and will in some cases replace the original *cerrado* ecosystem, whose biodiversity is particularly rich and whose transformation to agricultural land raises concerns.
- Also, even if most of the sugar cane expansion happens on abandoned pasture land, there is still the risk of “spillover” effects, i.e. indirect damage due to the displacement of pasture or other crops towards more sensitive areas such as the *cerrado.*
- Conservation laws are generally thought to be adequate by interviewees. However, the enforcement of environmental regulations remains an issue of concern in some States.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What would be the impact on CO2 emissions?
What would be the impact on local environmental and social sustainability?
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There are three ways in which bioethanol production could increase

- Using molasses and diverting part of the current sugar cane from sugar to ethanol production
- 'Vertical expansion': increasing sugar cane yields and process efficiency
- 'Horizontal expansion': growing sugar cane on more land – as discussed in previous section

More sugar cane resources could be used for ethanol production in different conversion plant configurations

In SADC the most common ethanol plant has so far been the "stand-alone" distillery. The Brazilian experience illustrates the benefits of the integrated sugar mill + distillery (also known as the "*Annex plant*")

Aspect	Advantages of the "Annex plant"
Sugar quality	The plant is not designed to extract the largest possible quantity of sucrose from the cane juice and the molasses to produce sugar. Instead, sugar is usually produced from the most easily recoverable sucrose, with benefits in terms of sugar cost and quality
Flexibility	It is possible to change the production mix from 40-60 (i.e. 40% sugar – 60% ethanol) to 60-40 without compromising the quality of the products; it is also possible to stretch the production mix up to 30-70 or 70-30, but cost and quality start to be affected. Such flexibility allows the company to adapt the production to changes in market conditions for the two products.
Use of co-products and co-generation	The bagasse from the mill can be efficiently used to supply the power required by the distillery. Depending on the configuration, surplus electricity can also be generated. The bagasse could also act as an additional source of ethanol.
Economics	Although the plant itself is larger and more expensive, use of co-products and production flexibility generally outweigh the greater capital investment

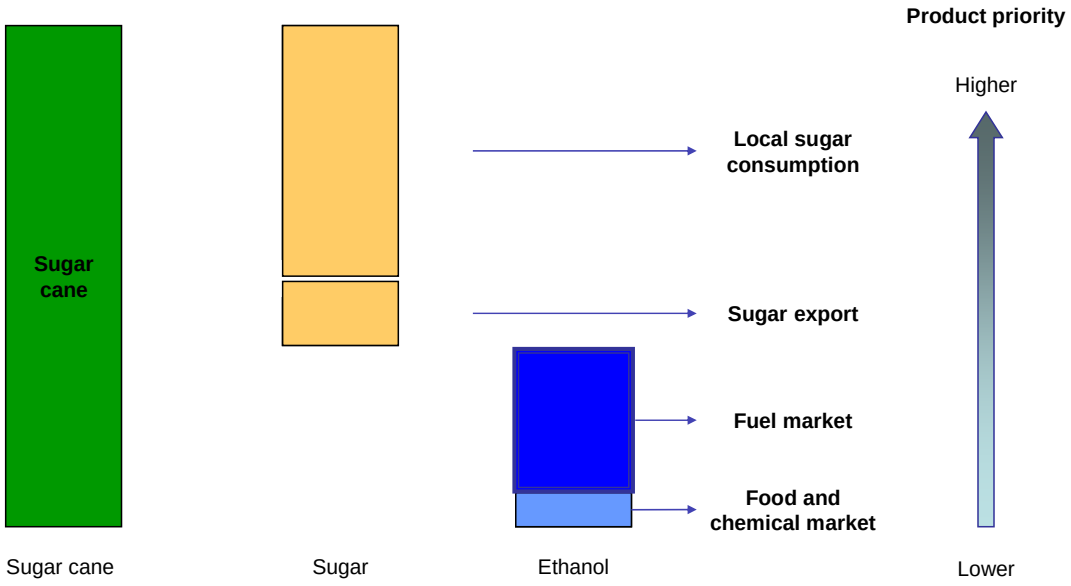
Improvement of yields can complement the expansion of cultivated areas to increase sugar cane and ethanol production / 1

Factor affecting yield	Notes
Selection of varieties	• Experts consider selection programmes as the most important factor able to improve yields. In Brazil, average yields rose from around 65 t/ha in the 1960s to almost 85 t/ha in 2001 (+30%); both industry and academic experts acknowledged the role of successful selection programmes in achieving such growth. • Expert consider that also in the future the most significant advances in yields will be obtained through variety selection.
Use of irrigation	• Without irrigation ("dryland" cultivation), yields between 60 and 80 tons of sugar cane per hectare are usually reported. • Use of irrigation can bring yields to 100 – 120 t / ha.

Improvement of yields can complement the expansion of cultivated areas to increase sugar cane and ethanol production / 2

Factor affecting yield	Notes
Sucrose vs. biomass objective	• The selection of current varieties had the objective of maximising the sucrose content, in order to improve the final sugar yield. Average sucrose content in Brazilian sugar cane rose from 14% in the 1980s to 14.3% in 2003. • Varieties selected for higher sucrose content tend to have lower total biomass yields. However, other existing varieties maximise the content of other non-sucrose sugars and of fermentable biomass in general, being more suitable to ethanol production. Also, these lower-sucrose / higher-biomass varieties benefit from better pest and drought resistance. • In some cases, switching from high-sucrose varieties to lower-sucrose was reported to reduce the time between two successive harvests from 16 to 12 months.
Agricultural practices	• Typically, smallholders tend to obtain lower yields than larger agro-industrial estates. • Such discrepancy is often attributed to less advanced practices (e.g. the use of vinasse on sugar cane fields is not common among Brazilian small holders), which may result from limited awareness, as well as availability of training or capital.

In considering bioethanol expansion, allocation of sugar cane to the different end products is expected to follow a set of priorities



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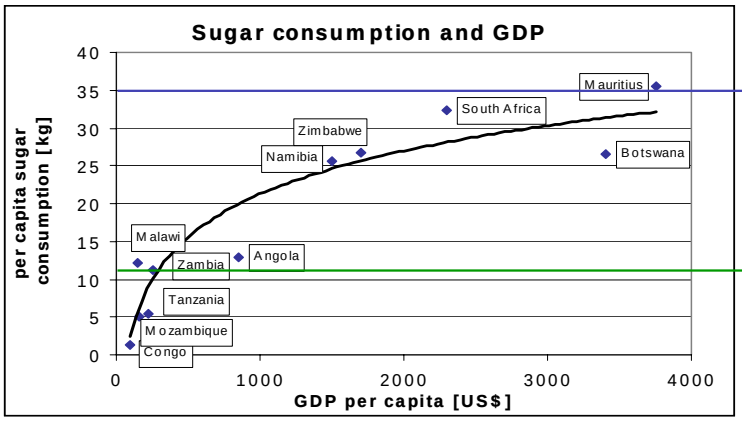
Demand for sugar is proportional to population and per-capita consumption

Per-capita consumption of sugar in SADC countries shows clear relation with per-capita GDP



Source: redrawn from ISO, 2005

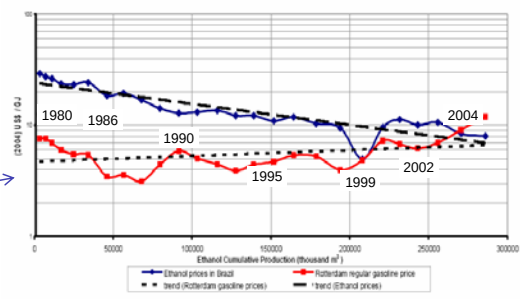
In a low sugar demand scenario, up to 7.3 billion litres of bioethanol could become available from the sugar cane grown on the target area

We have developed two scenarios to determine the potential for bioethanol production from 1.5 Mha of sugar cane after satisfying different levels of SADC sugar demand.

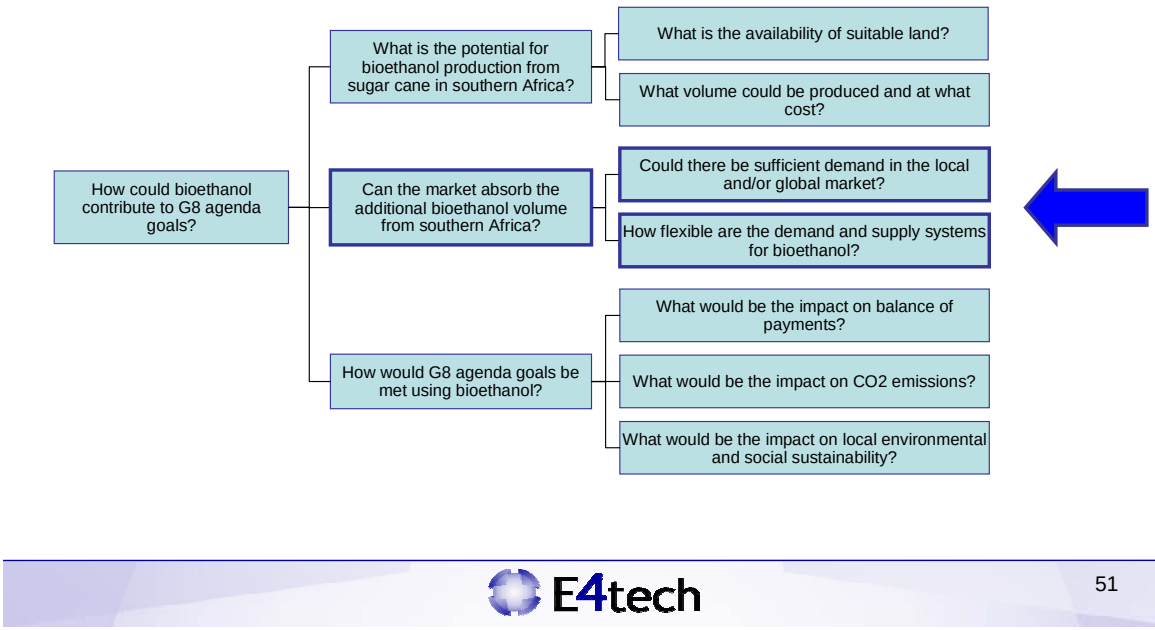
Scenario	"Low sugar" scenario	"High sugar" scenario
Scenario assumptions	24 kg per capita sugar consumption (double of current level) No sugar exports	35 kg per capita sugar consumption (current average of developed countries) Sugar exports constant at 2.5 Mt / yr
Sugar cane used for ethanol production [M t]	52.5 – 75.0	4.2 – 26.7
Ethanol production from cane juice	4.7 – 6.7	0.4 – 2.4
Ethanol production from molasses	0.6	1.1
Total ethanol production [B litres]	5.3 – **7.3**	1.5 – 3.5

Ethanol economics are opaque but southern African countries could be well positioned…

- Stakeholders underlined the difficulty in obtaining reliable estimates of production costs
  - sensitivity of production economics
  - volatility of exchange rates
- Brazil is widely believed to have the lowest production and export costs
  - 30 years of industrial development
  - Growing and production regions are conveniently located for export



- Southern Africa has the potential to produce ethanol at low cost, though export costs may be more variable
  - South Africa is already a 'top ten' sugar producer. The underlying production conditions are at least as favourable in other southern African countries
  - The export cost is likely to depend significantly on the location of production plants relative to export facilities. Landlocked countries appear to be worse positioned than coastal countries in this respect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The 7.3 billion litres could satisfy close to one third of projected SADC gasoline demand in 2020, so lower ethanol blends (5% to 10%) could be easily achieved.

	Current value (2000)	Estimates for 2020
SADC population	215,000,000	300,000,000
Number of gasoline light duty vehicles in SADC	6,700,000	17,500,000
Annual km driven per gasoline vehicles (km)	10,000	10,000
Average mileage in gasoline vehicles (km / l)	7.1	8.3
Annual gasoline consumption (billion litres)	**9.3**	**21.1**
Blend ratio required to absorb 7.3 Bl of ethanol	N/A	**29.5%**
Volumes at 5% blending (billion litres):		
Gasoline	9.1	20.6
Ethanol	**0.5**	**1.1**
Displaced gasoline	0.2	0.5
Volumes at 10% blending (billion litres):		
Gasoline	8.9	20.1
Ethanol	**1.0**	**2.2**
Displaced gasoline	0.4	1.0

Note: the ethanol volumes are calculated on an equivalent energy basis; the calorific value of ethanol is around 63% of that of gasoline
Source: E4tech analysis on IEA, WBCSD

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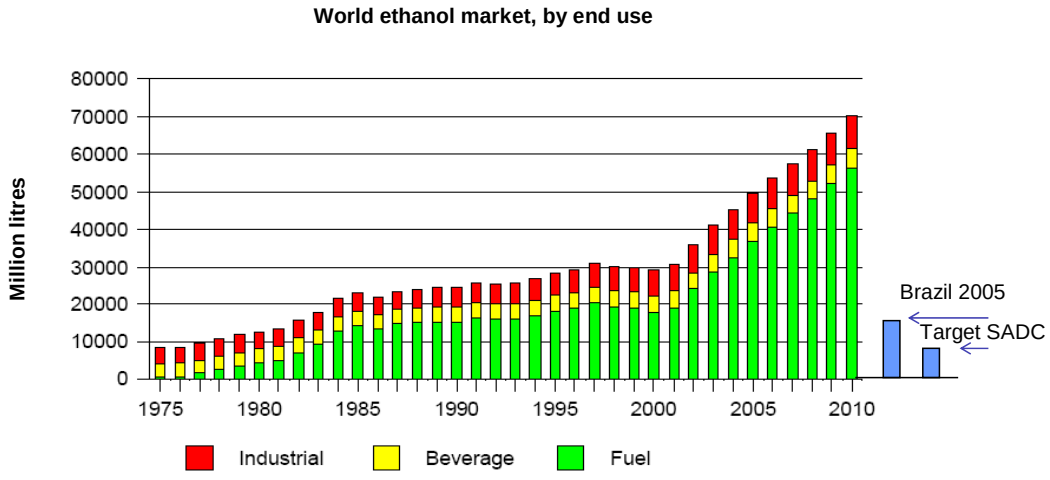
The contribution of the potential SADC output is small relative to the projected global bioethanol market



Source: FO Lichts

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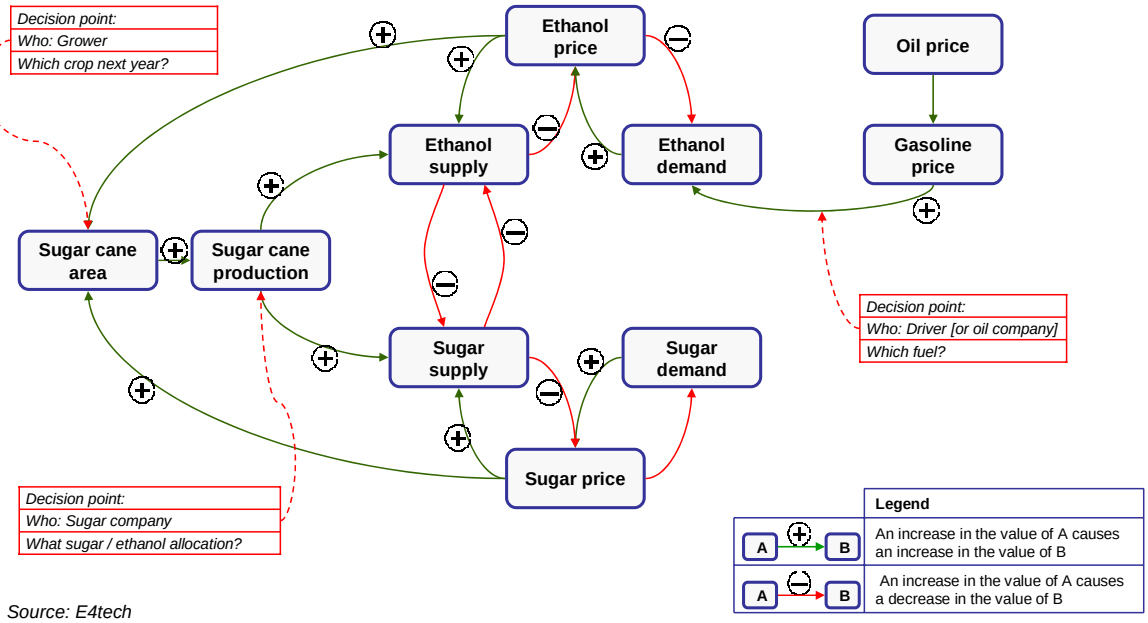
The prices of oil, ethanol and sugar are characterised by complex interactions…



Source: E4tech

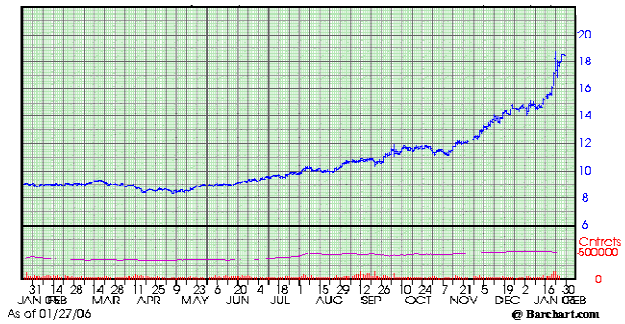
…which can result in significant sugar price volatility

Over the past year, sugar prices have doubled from around 8 – 9 US¢/lb to more than 18 US¢/lb.

From discussion with the sugar industry, this appears to have happened mainly due to:

- lower than anticipated volumes of Indian crop
- fast growth in Brazilian ethanol demand coupled with growing sugar demand from China
- high oil and gasoline price, which favour fuel switching to ethanol

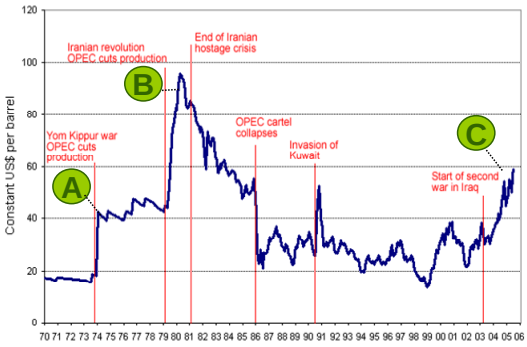
Expert consider that prices as high as 18-20¢ are a result of speculative activity on the market, but the economics would rather point to equilibrium prices between 10 and 14 ¢



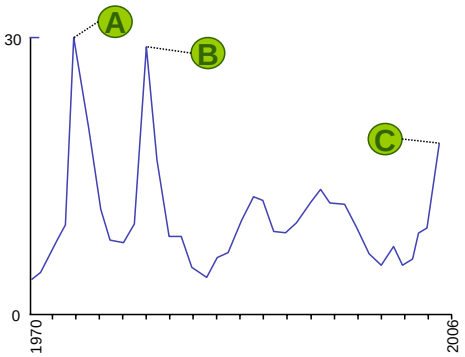
Sugar and oil prices are not directly correlated, but oil shocks have often lead to sharp increases in sugar prices, like in 1973, 1980 and 2005

- Rises in oil prices contribute to make ethanol more competitive against gasoline
- If this signal is strong enough to drive ethanol production up, then more sugarcane resources are shifted away from sugar production, which become scarcer and more valuable

Oil price – US$ / bbl



Sugar price – USc / lb



Source: sugar prices redrawn from Thomas and Kwong, 2002 and ISO

International **sugar** trade may face significant changes in the near future

Until very recently, the European Union had guaranteed subsidies to farmers growing sugar crops; in some cases, this led to the EU paying its farmers sugar prices three times higher than the world price.

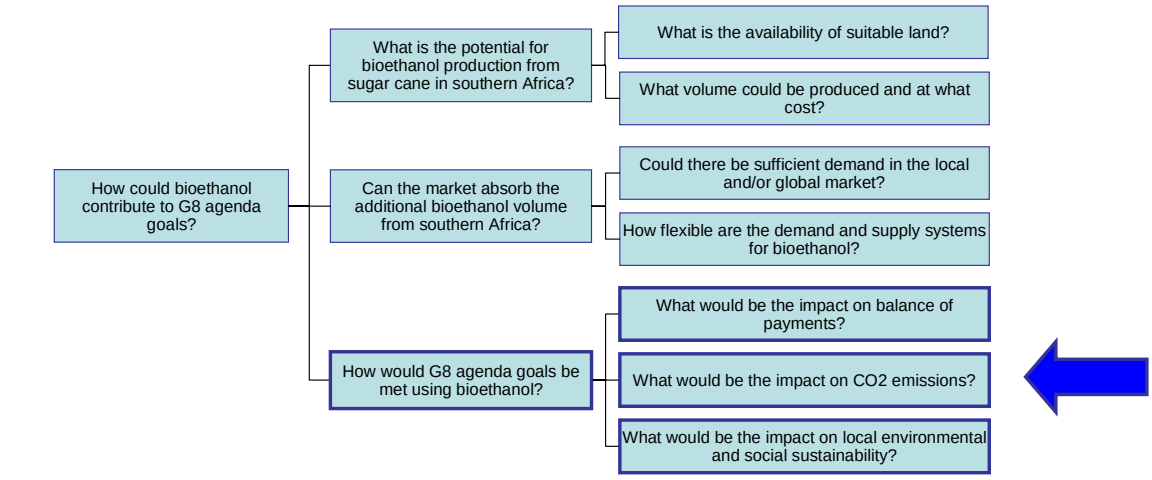
This preferential regime applied not only to EU countries, but also to former European colonies in Africa (e.g. Mauritius), the Pacific (e.g. Fiji) and the Caribbean (e.g. Barbados or Jamaica).

The WTO considered such subsidies a form of unfair trade; under pressure, in late 2005 the EU ministers agreed to phase them out.

The industry foresees that the most likely outcomes of such change will be:

- sugar prices paid to farmers in the EU, as well as to non-EU producing countries associated with the subsidy scheme, will drop and align to world prices
- developing countries previously outside the preferential market regime will generally benefit from subsidy withdrawal, as this could open them access to markets where they were previously outcompeted; however the exact impact on each country will depend significantly on the cost-competitiveness of its production
- producing countries within the preferential market regime are expected to suffer from losing the preferential access to the EU markets.

Source: European Commission, USDA


How could bioethanol contribute to G8 agenda goals?
What is the potential for bioethanol production from sugar cane in southern Africa?
What is the availability of suitable land?
What volume could be produced and at what cost?
Can the market absorb the additional bioethanol volume from southern Africa?
Could there be sufficient demand in the local and/or global market?
How flexible are the demand and supply systems for bioethanol?
How would G8 agenda goals be met using bioethanol?
What would be the impact on balance of payments?
What would be the impact on CO2 emissions?
What would be the impact on local environmental and social sustainability?
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The production of ethanol from the target land area has the potential to improve the balance of payment of SADC countries…

Volumes of ethanol and displaced gasoline (billion litres)	**Value**
Ethanol volume	7.3
Displaced gasoline volume (on energy basis)	4.6

Balance of payment (billion US$)	**Value**
Value as ethanol	2.9
Value as displaced gasoline	1.6
GDP of UK (2004)	*2,140.9*
GDP of South Africa (2004)	*212.8*
GDP of Malawi (2004)	*1.8*

Source: E4tech analysis; values calculated with oil price of 50$ / bbl

Note that for low ethanol blends (up to 10%) energy and volume may be treated on a par, because of higher efficiency obtained from the octane enhancement effect of ethanol.

… as well as to contribute to material reductions in CO2 emissions

Volumes of ethanol and displaced gasoline (billion litres)	**Value**
Ethanol volume	7.3
Displaced gasoline volume (on energy basis)	4.6

Reduction in CO2 emissions (million tonnes)	**Value**
CO2 savings through gasoline displacement	11.0
Total UK CO2 emissions from transport (1998)	*115.3*
Annual emissions from one 500MW coal power station	*3.5*

Source: E4tech analysis. Values calculated with 80% CO2 emission reductions, based on the average carbon intensity of Brazilian integrated mills, where bagasse is used to supply power to the process.

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Only a high level estimate can be provided of the number of jobs created from agricultural expansion of sugar cane

High level estimate of job creation	
Target area for SADC	1.5 Mha
Average labour intensity of Brazilian sugar cane agriculture	200,000 direct jobs /Mha 600,000 indirect jobs /Mha
Estimate of jobs from sugar cane agriculture on the target area in SADC	300,000 direct 900,000 indirect

Uncertainty	**Remarks**
Agricultural model	Labour intensity of sugar cane agriculture varies depending on the exact type of agriculture deployed (i.e. large estates vs. small holders).
Harvesting practices	Manual harvesting of burnt cane is more labour-intensive than mechanical harvesting of green cane. However, the type of harvesting is chosen depending on many factors including availability of capital, size of the land, topography, economics.
Economics	Employment level is likely to depend on cost of labour, which varies significantly among SADC.

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Local environment considerations are important and a number of lessons can be learned from existing African and Brazilian experience

- Impact on local environment depends on appropriateness of environmental regulations and on their enforcement – both Brazil and South Africa can provide examples of good practice.
- Best practice and environmental assurance schemes can help improve the sustainability of sugarcane production at the local level – examples being developed in South Africa and Brazil.
- In South Africa there are good examples of small holders participation in sugar cane production schemes; these are seen to be valuable for both the industry and the local communities.
- Development of infrastructures for sugar cane production and processing can have positive spillover effects on other economic activities.

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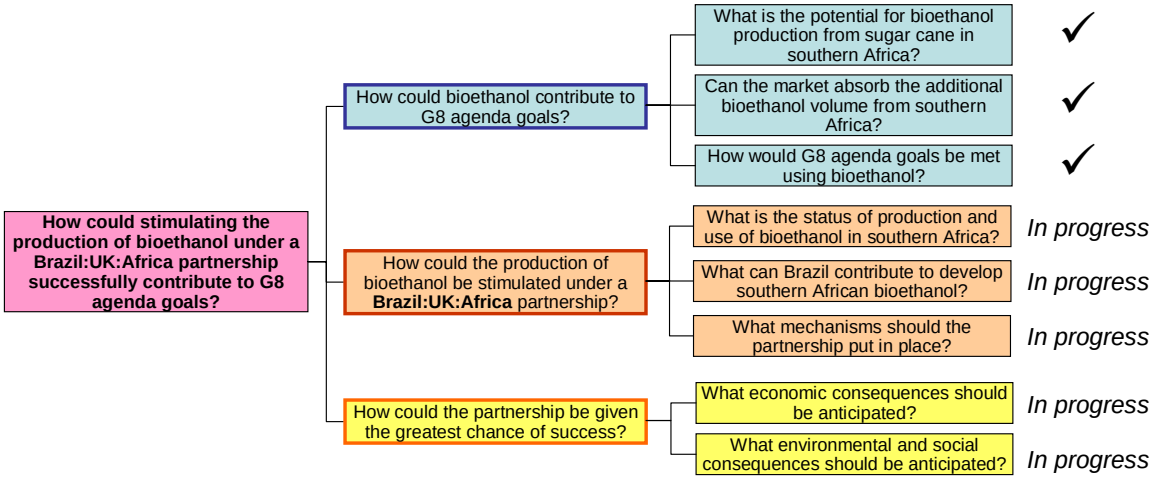
Next steps

The team is developing answers to the remaining questions:

- How could the production of bioethanol be stimulated under a UK:Brazil:Africa partnership?
- How could the partnership be given the greatest chance of success?



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Section 2: Options for a Brazil:UK:Africa bioethanol partnership

Brazil:UK:Africa bioethanol partnership

Phase 2 : Options for the partnership

15th May 2006

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Introduction

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The overall challenge

Climate change and African development have been key G8 agenda goals under the UK Presidency

Brazil has world-leading experience and technology in relation to bioethanol production from sugar cane and its use

Africa may be able to benefit from expansion of sugar cane and bioethanol production

Sir David King identified the potential for the UK to act to enable technology and skills transfer in support of G8 agenda goals

How could stimulating the production of bioethanol under a Brazil:UK:Africa partnership successfully contribute to G8 agenda goals?

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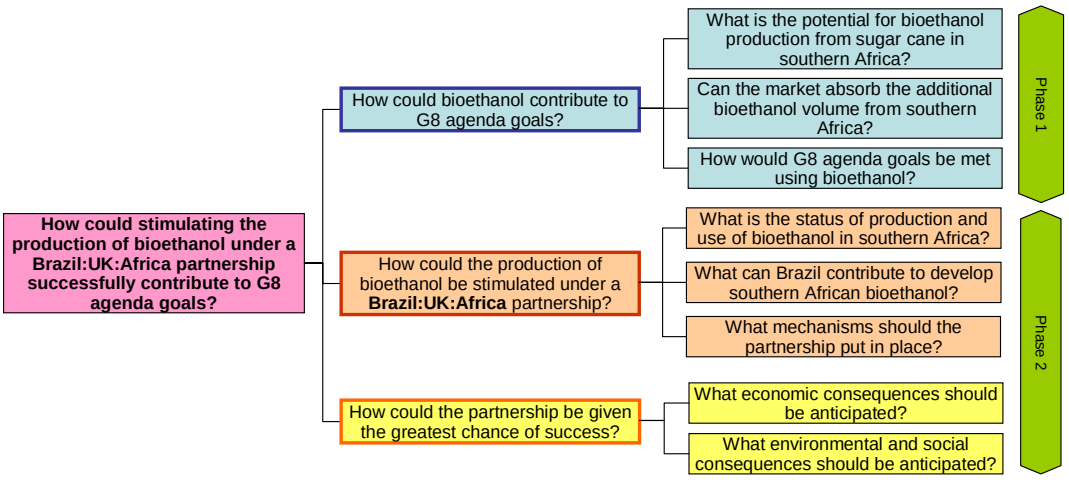
Our breakdown of the challenge



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Status of bioethanol in southern Africa and Brazil

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- Brazil

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The South African industry has focused so far on sugar production

The South African sugar and ethanol industry is considering a stronger engagement in ethanol production, but says it requires a more favourable context:

- **Policy context**: the industry would look favourably upon policy measures aimed at supporting the development of a national market for biofuels. A clear view about which policy instruments (e.g. subsidies, obligations, …) might best serve this goal has not emerged; however, most emphasis was put on stability, certainty and thrust of the policy context
- **Global bioethanol market**: international ethanol trade occurs via spot markets, futures, short and long term contracts. However, the lack of liquidity and the linkages with sugar and oil markets make prices fluctuate significantly. The industry would like greater liquidity and the development of more instruments such as long-term contracts and futures, as a way of reducing investment risk
- **Infrastructures**: the absence of modern and reliable infrastructures (mainly roads, but also railways and ports) outside South Africa raises concerns in the industry

Source: interviews with industry participants

Bioethanol and synthetic ethanol have been used in southern Africa for years

In southern Africa, blending ethanol into gasoline is not new:

- **Synthetic ethanol**: the South African oil company SASOL produces significant volumes of synthetic ethanol from its coal-based processes; blending of synthetic ethanol into gasoline has been a common practice in the last decades, also a way of utilizing surplus volumes of ethanol
- **Bioethanol**: different southern African countries have launched bioethanol programmes in the last decades; the most significant are:
    - Malawi: its national ethanol programme is probably one of the most successful outside Brazil; until recently, the government set a mandatory blending ratio of 25%. In 2005, supply problems led the government to reduce the blend to 10%
    - Kenya: in the 1980s the production from an ethanol plant (with average production of around 45,000 litres/ day) was blended into gasoline at about 10% volume ratio. One of the drivers for the use of ethanol was as a disposal route for surplus molasses that were an environmental hazard because of the past practice of dumping into rivers
    - Zimbabwe: in the 1990s the national alcohol programme was capable of producing about 40 million litres annually, 60% of which was used locally

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The extent of engine modifications is very limited for blending ratios up to 10%

Over 30 years, the Brazilian automotive industry has gained experience in building vehicles running on ethanol, and understood what are the key technical issues

Engine part / Blending ratio	Carburettor	Fuel Injection	Fuel Pump	Fuel Pressure Device	Fuel Filter	Ignition System	Evaporative System	Fuel Tank	Catalytic Converter	Basic engine	Motor oil	Intake Manifold	Exhaust System	Cold Start System
< 5%														
5% - 10%	■													
10% - 25%	■	■	■	■	■	■	■	■	■					
25% - 85%	■	■	■	■	■	■	■	■	■	■	■	■	■	

Legend
- No modification required
- Modification possibly required

Source: ANFAVEA 2005

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Any southern African bioethanol programme should start gradually and develop in phases

Market phase	Fuel(s) at the pump	Vehicle type(s)	Notes
A	Only E5 and later E10	Standard vehicles	Suggested starting point
B	• E10 • E100	• Normal vehicles • Pure ethanol vehicles	Old Brazilian approach; not currently considered due to fuel and vehicle fleet duplications
C	Gasoline with moderate blending ratio (E20 – E25)	Vehicles slightly modified to accept up to E25	Intermediate model, suggested as a later phase for southern Africa
D	• E25 • E100	Flex-fuel vehicles, which can run on any fuel, from pure gasoline to E100	Current Brazilian model and future possible model for southern Africa

Note: blends are usually referred to as EX, where X denotes the blending ratio. Therefore, E10 is gasoline with 10% ethanol, and E100 is pure ethanol

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Interest in bioethanol from South African policymakers is fairly recent

A South African policy context around biofuels is only just emerging:

- **National synthetic fuel industry**: SASOL has leading experience in producing synthetic fuels, and SASOL synthetic gasoline currently accounts for around 40% of home market. Therefore, South Africa has usually had a less stringent need for diversification of energy sources and reduction of fossil imports
- **Recent interest in biofuels**: since 2003, policymakers started considering biofuels as a possible way of meeting national policy goals. However, early focus was mainly on biodiesel, with little consideration for bioethanol as a transport fuel
- **Bioethanol as paraffin replacement**: there has been lots of interest (and controversy) in recent years in the use of ethanol to replace the (dangerous) paraffin used for heating and cooking in low-income dwellings. For such use, ethanol was produced in gel form, to prevent its use as an intoxicating beverage. The results of this programme are considered rather controversial in the country
- **Very recent interest in bioethanol as transport fuel**: around 2005, a stronger wave of consensus started forming across government departments around the benefits of a wider use of bioethanol as a transport fuel, in part driven by interest in producing ethanol from excess crops such as maize
- The South African government is now exploring the options for a more systematic stimulation of biofuels production and use

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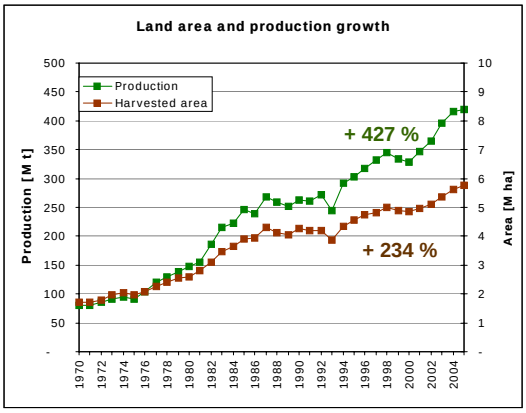
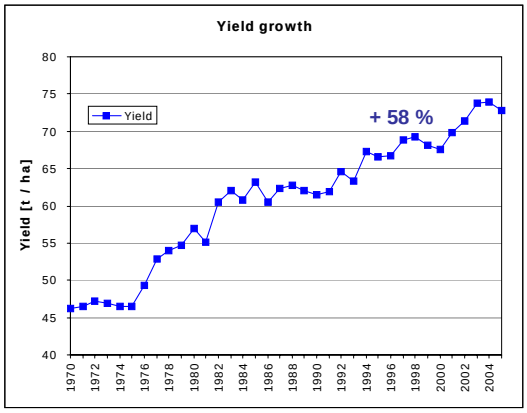
Over three decades, Brazil made significant progress in sugar cane agriculture…

– Sugar cane production and land area –



– Sugar cane yields –



Source: FAO 2005

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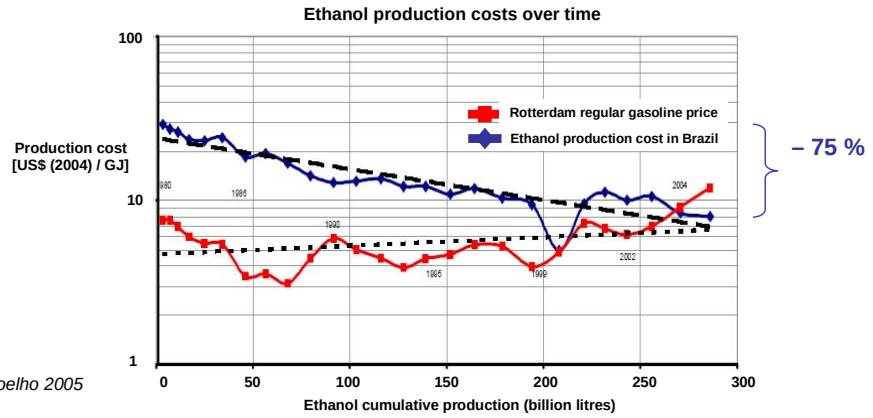
… industrial ethanol processing …

Production costs achieved in 2004 were one quarter of those 25 years earlier, thanks to:

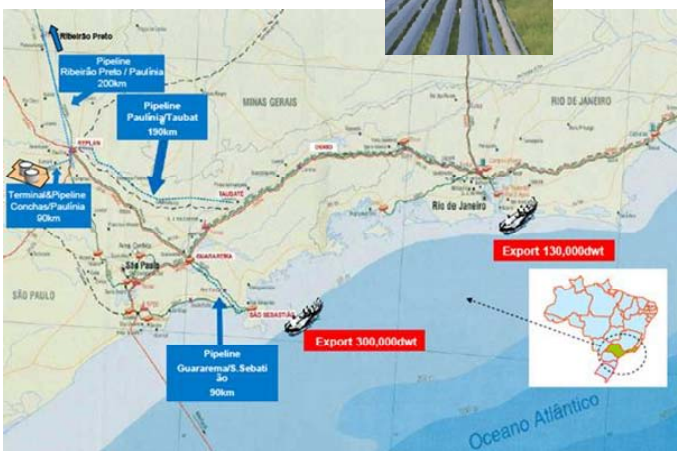
- improvements in processing technology
- economies of scale
- deployment of ethanol distilleries integrated with sugar mills, and of cogeneration



Source: Coelho 2005

… downstream operations …

- Integrated ethanol – gasoline infrastructures and equipment
- Storage
- Pipelines
- Blending
- Distribution and sales



Source: Petrobras 2005

… and market development

- PROALCOOL programme launched in 1975 to support the uptake of bioethanol from sugar cane as a transport fuel. For two decades the PROALCOOL programme supported bioethanol fuel, through:
  - guarantee of low ethanol fuel price at the pump (65% lower than gasoline price)
  - subsided loans for ethanol producers to improve production capacity
  - requirement for fuel stations (all over the country) to offer ethanol fuel
  - mandatory ethanol fuel reserves to guarantee supply and price
  - 5% tax reduction for alcohol-fuelled vehicles

  Also, the programme regulated technical aspects such as harvesting plans

- The programme was discontinued in 1997, and by 1999 the prices of sugar and ethanol were completely free from government regulations

- In 2003 Flex-Fuel Vehicles were introduced into the market. In 2005 they were available in 59 models from 7 makers, and accounted for 65% of new sales

Source: ANFAVEA 2005

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Environmental legislation has developed in parallel

- New legislation was introduced to manage the sustainable exploitation of land resources:
  - the Brazilian *Forestry Code* allows landowners to develop a maximum of 20% of pristine forest areas and prescribes the remaining 80% to remain untouched
  - The *Forestry Code* also mandates companies to maintain *Forestry Reserves* covering at least 20% of the land; where such forestry is not present, derogation is possible provided that reforestation plans are in place

- The practice of burning sugar cane before harvesting is going to be progressively phased out (*Law No. 11,241/02* of the State of São Paulo, effective since Sept. 2002):
  - in areas suitable for the replacement of manual harvest with mechanical harvest, the ban on sugar cane burning will extend from 20% of cultivated areas in 2002 to 100% in 2021
  - in areas non suitable for the replacement of manual harvest with mechanical harvest, the ban on sugar cane burning will extend from 10% of cultivated areas in 2011 to 100% in 2031

  The law was introduced on environmental grounds:
  - Reducing local air pollution
  - Increasing biomass available for cogeneration

- Any new plant in the São Paulo State must be licensed by the State agency for pollution control CETESB

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Brazil still faces challenges in bioethanol production and consumption

Sustainability challenges

- Long-term sustainability of sugar cane agriculture
  - More widespread use of best practices, including for control of soil erosion, run-off water quality, leaching
  - Labour conditions
- Meeting growing demand expectations:
  - Land expansion to new areas, including potentially onto the cerrado ecosystem
  - Phase-out of cane burning in areas not suitable to mechanisation

Market challenges

- Creation of a liquid ethanol market as a way of:
  - improving security of supply
  - increasing confidence in ethanol
- Creation of sustained demand internationally

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Our analysis and the discussions with South African and Brazilian stakeholders show that technology transfer should not be the main focus of a partnership…

- There is little scope for technology transfer in the areas of sugar and ethanol industrial processes:
  - the technology is owned by private companies and is available on the market
  - there is a history of continuous, albeit informal, contacts between South African and Brazilian players
- However, a number of technical areas were mentioned as possibly interesting for cooperation and knowledge transfer:
  - plant breeding and selection
  - agronomy and agronomic practices
  - cane response to production environment
  - productivity modelling
  - sustainability issues

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… while in other areas a partnership could be very effective

- **Policymaking**: the Brazilian experience in how a bioethanol market can be created and developed is considered extremely valuable; also, many South African stakeholders consider the lack of a similar context as a key barrier to widespread bioethanol deployment
- **'System thinking'**: a number of aspects of ethanol production are not directly related to processing technology but are nevertheless very important for the success of the whole chain: infrastructures, logistics, land use, plant configurations, use of co-products, and disposal of wastes
- **Downstream operations**: after ethanol has been produced, a number of downstream activities must be carried out properly to ensure the success of the whole chain: transport, storage, blending, distribution. In this area too Brazil can contribute with the lessons learned in more than three decades.
- **Skills and capabilities**: the South African sugar industry expressed a concern about the availability of a skilled workforce necessary to expand its activities. Similarly, there is a lack of capacity at policy-making level. There could be scope for transferring government and industry level knowledge from Brazil.

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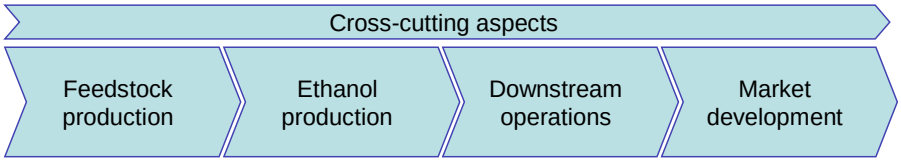
Proposed high-level aim for the partnership

*To facilitate the development of **competitive** and **sustainable** bioethanol production in southern Africa for **local** and potentially **export** markets*

This implies roles at different stages of the system:



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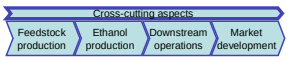
Options for potential partnership role – cross-cutting aspects / 1



Barrier or gap to be addressed	Potential partnership role	Goal
Benefits and requirements of sustainable bioethanol production not widely known or understood	Raise high-level awareness in SADC about issues affecting the competitiveness and sustainability of bioethanol production – this includes aspects that are preconditions for the development of the sector and can be showstoppers if not properly addressed	Competitiveness, sustainability
Availability of capital	Engage with multilateral organisations (WB, UN, ADB) and funding agencies, to increase the availability of funding opportunities, e.g. for industrial and infrastructure development	Competitiveness
Risk of unsustainably produced ethanol entering the market	Play active role in the development of environmental and social assurance schemes for the international bioethanol industry, covering both feedstock production and industrial operations. Link to international cooperation on the development of sustainability indicators	Sustainability
Possible loss of skilled workforce due to the effects of the HIV/AIDS epidemic	Assess, transfer and promote best practices in HIV/AIDS prevention and management, both from Brazil and elsewhere (e.g. extractive industries)	Sustainability, competitiveness

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Options for potential partnership role – cross-cutting aspects / 2

Cross-cutting aspects | Feedstock production | Ethanol production | Downstream operations | Market development

Barrier or gap to be addressed	Potential partnership role	Goal
Policymaking capacity	• Help identify areas with policymaking capacity constraints • Promote workshops, training and secondment schemes • Raise awareness about the importance of cooperation among the different departments within national governments	All
Enforcement capacity	• Raise awareness in the government about the critical role of proper enforcement in guaranteeing the effectiveness of regulation and the environmental and social sustainability of bioethanol production • Help identify areas with enforcement capacity constraints • Promote the establishment of schemes to share best practices, through knowledge and experience exchange, training and secondments	All
Lack of integration between "sub-national" regional planning and resource assessment	Promote the development and sharing of regional resource assessments and their integration with agriculture and bioenergy development plans	Sustainability

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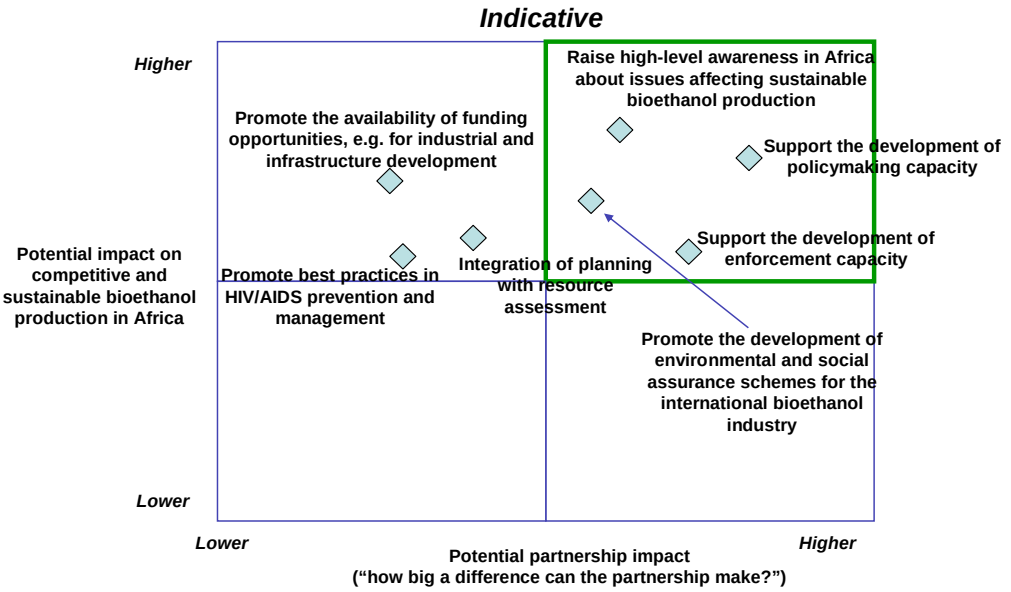
Options for partnership role – cross-cutting aspects

Cross-cutting aspects | Feedstock production | Ethanol production | Downstream operations | Market development



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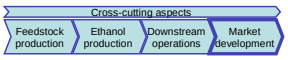
Options for partnership roles – market development



Barrier or gap to be addressed	Potential partnership role	Goal
Long-term policies to enable (and stimulate) the uptake of bioethanol	Facilitate high level exchange of policy options and implementation mechanisms (e.g. RTFO, mandate, ECA, fuel duties, …)	Local and export markets
Uneven legal framework	Work to improve harmonisation of legal framework, e.g. fuel standards	Competitiveness
Presence of (residual) trade barriers	Engage with governments and multilateral organisations (WTO, UNCTAD) to promote removal of trade barriers and harmonisation of trading regimes within the region and beyond	Competitiveness
Mechanisms to recognise the value of environmental and social assurance	Support the development and implementation of mechanisms at international level, e.g. carbon credits through CDM	Sustainability, competitiveness
Long-term international market uncertainty	Promote long-term policy commitment, in the UK and beyond, to support continuity of demand	Export markets
Potential worldwide imbalance between demand and supply, resulting in market instability and loss of credibility	Raise awareness in governments and industry about the risk of demand-supply unbalances, to: • reflect considerations on supply potential in planning demand-side measures • define and implement measures to minimise such risks (e.g. flexibility, reserves)	Economic sustainability

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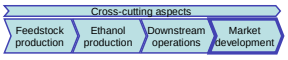
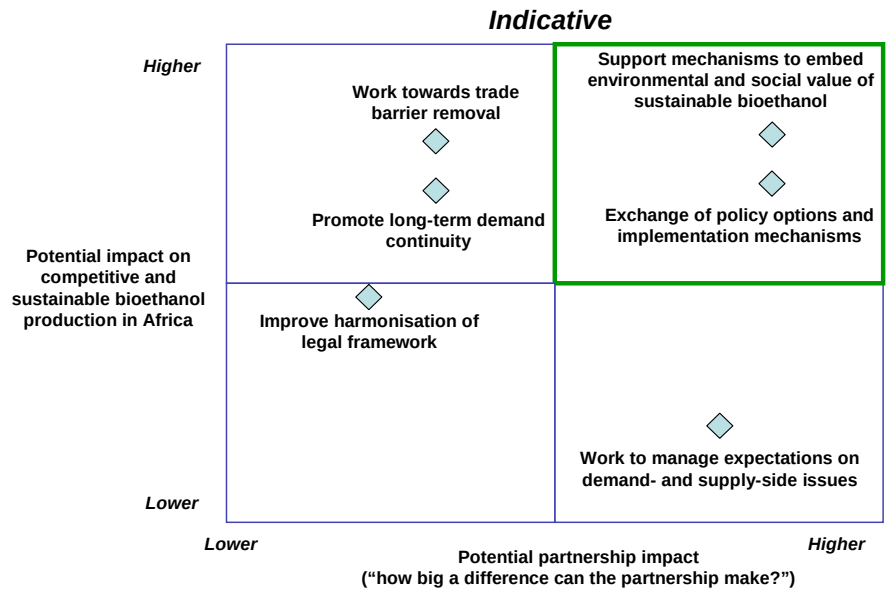
Options for partnership role – market development





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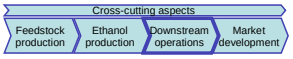
Options for partnership roles – downstream operations



Barrier or gap to be addressed	Potential partnership role	Goal
Lack of adequate infrastructures, for ethanol transport (including towards export markets). May also apply to feedstock.	Engage with governments, industry and international funding agencies to explain the importance of integrating bioethanol considerations into infrastructure planning decisions (road, railways, ports, pipelines).	Competitiveness
Some resistance from incumbent industries in setting up and running ethanol-compatible infrastructures and equipment	Identify, capture and transfer the Brazilian experience of integrating ethanol and oil infrastructures, including within multinational oil companies	Competitiveness

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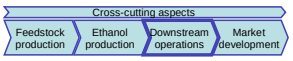
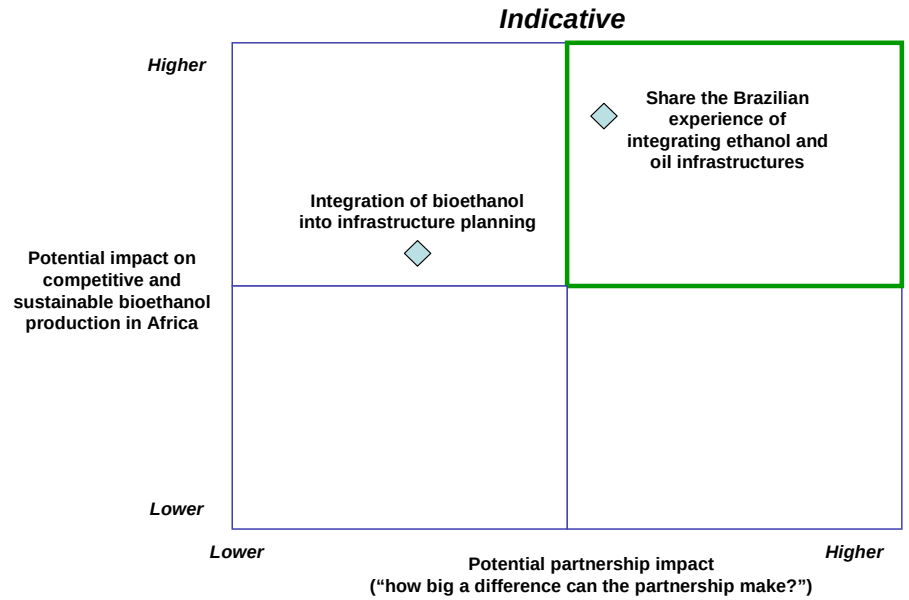
Options for partnership role – downstream operations





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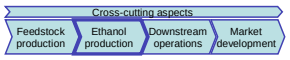
Options for partnership roles – ethanol production



Barrier or gap to be addressed	Potential partnership role	Goal
Availability of skills for plant construction, commissioning, operation and maintenance	Identify the skill gaps and begin to fill them, by facilitating the training of plant staff, also building on Brazilian experience	Competitiveness
Availability of capital at competitive conditions for plant	Showcase the benefits of bioethanol to multilateral organisations and other funding agencies, to improve availability and cost of capital. Raise awareness about risks involved ad how they can be minimised	Competitiveness
Cogeneration: in some countries there is limited access to grid and unfavourable arrangements to export surplus electricity to the grid	Promote awareness in governments of the benefits of cogeneration (also through case studies) Promote the development of rural electrification schemes from sugar mills	Competitiveness, sustainability
Uneven levels of environmental and social regulations and enforcement across the producing countries, potentially leading to distortions	Harmonisation of environmental regulations (on plant operations, e.g. emissions, water quality) and social regulations (e.g. labour conditions, health & safety), including level of enforcement	Sustainability

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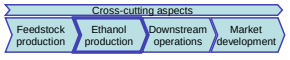
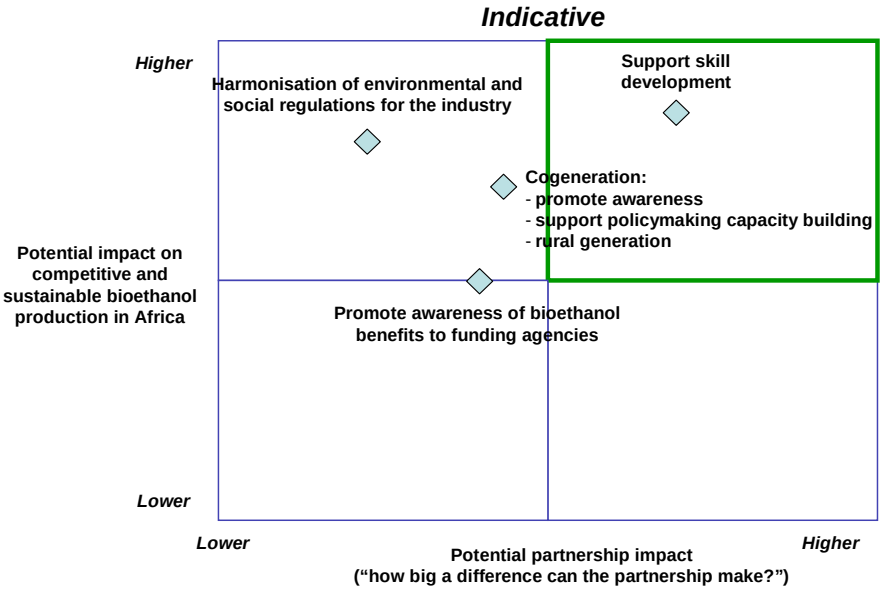
Options for partnership role – ethanol production





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Options for partnership roles – feedstock production

Cross-cutting aspects
Feedstock production | Ethanol production | Downstream operations | Market development

Barrier or gap to be addressed	Potential partnership role	Goal
Potential for yield improvement in some countries, especially for rainfed agriculture	Brazilian and UK expertise in plant sciences can be applied in southern Africa, with South Africa acting as a focal point for R&D initiatives, at least initially	Competitiveness, sustainability
Widespread adoption of sustainable practices	• Engage with industry, growers, NGOs to develop best practices locally – building on examples of best practices in Brazil and South Africa • Also work on disseminating them across industry, by showcasing the environmental and economic benefits	Competitiveness, sustainability
Brazil and South Africa have good environmental regulations. Potential issues about uneven regulation and varying level of enforcement in rest of Africa	Promote the adoption of environmental and social regulations across SADC, as well as their enforcement, in order to ensure level-playing field and to push the sector towards the widespread adoption of best practices	Sustainability
Availability of capital at competitive conditions, especially for small farmers	Engage with funding agencies to increase the availability of funding to small-scale farmers	Competitiveness

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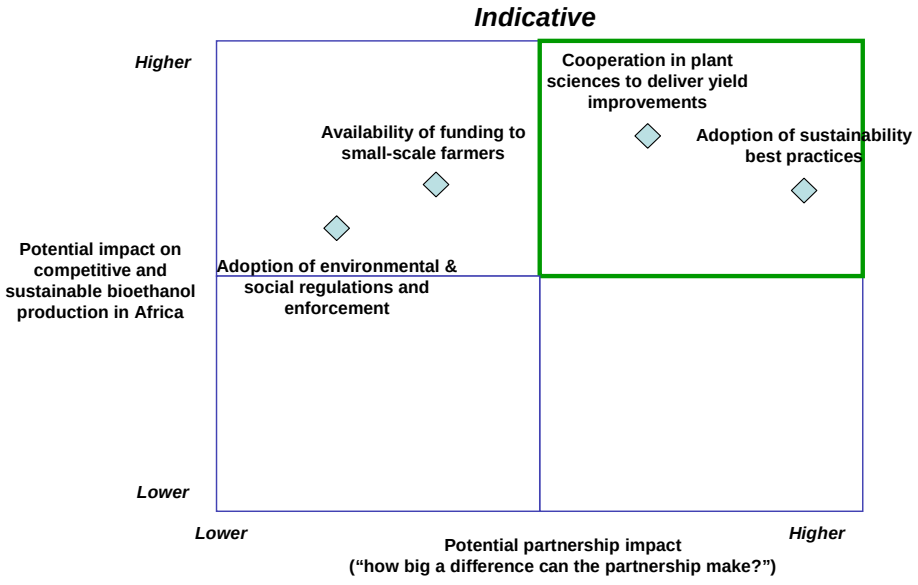
Options for partnership role – feedstock production

Cross-cutting aspects
Feedstock production | Ethanol production | Downstream operations | Market development



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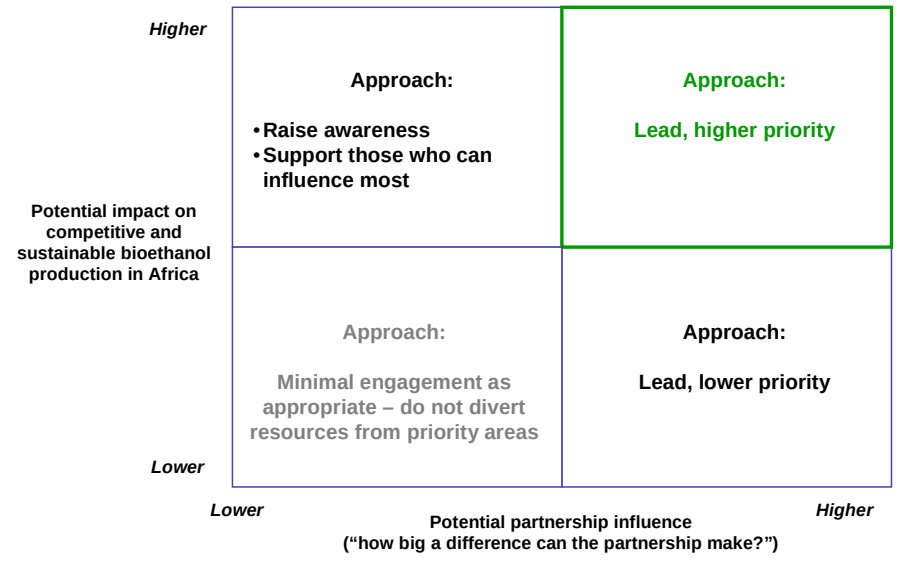
The partnership should engage differently depending on how large a contribution it can make to bioethanol development



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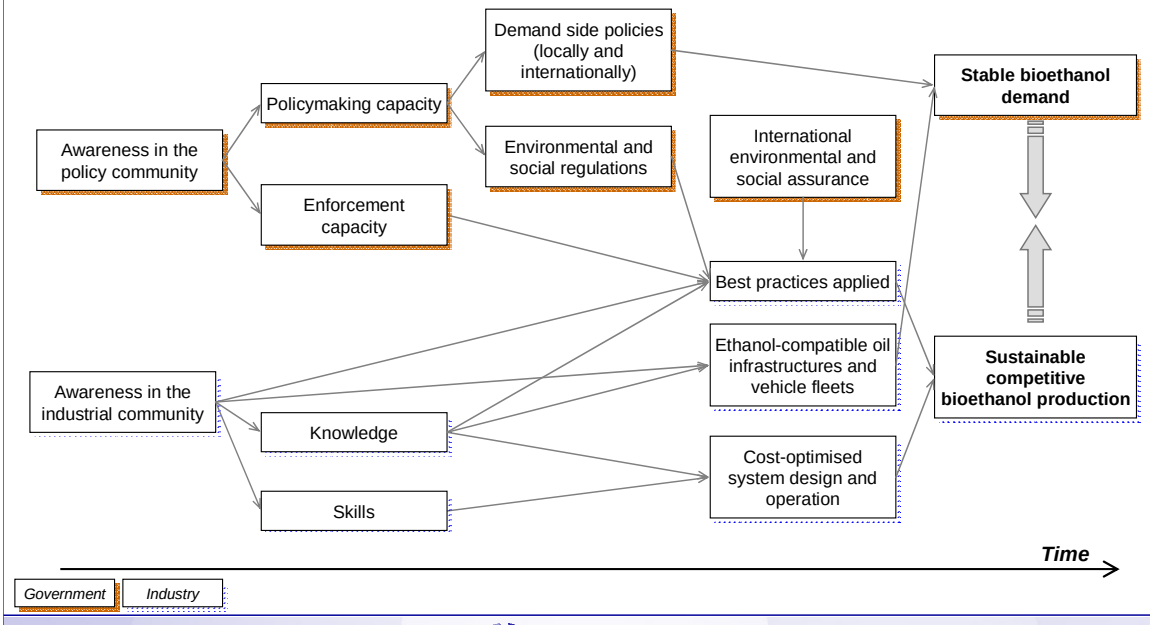
Amongst the priority areas identified for the partnership, there is a logical sequence to ensure the goals are achieved



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There are several current initiatives which the partnership should recognise and, potentially, build upon

Initiative	Focus region	Members	Goals / aims	Status
IBSA	India, Brazil, South Africa	India, Brazil, South Africa	Trilateral cooperation in a wide range of areas, including sustainable development	Active – early stages for energy
The New Partnership for Africa Development (NEPAD)	Africa	Members of the Organisation of African Unity (OAU)	Development	Active
Partners4Africa	Africa	Germany, Italy, UK, Sweden so far	Development	Early stages
Global Bioenergy Partnership	Global	Global	Promote and support the worldwide development of bioenergy	Being launched
CARENSA	SADC	13 research institutions	Explore the potential for sustainable bioethanol production in southern Africa	Concluded
SADC – "Farming for Energy"	Southern Africa	14 southern African countries	-Affordable energy sources -Rural employment	Inception
WWF Better Sugar Initiative	Global	Wide range of stakeholders in the sugar cane sector	Sustainable sugar cane production and processing	Inception
EU biofuels strategy	EU, global	EU	Accelerate the uptake of biofuels in the EU and elsewhere	Early stages
World Bank Clean Energy Investment Framework	Developing countries		Accelerate investment in clean energy	Early stages

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Agenda

Introduction

Status of bioethanol in southern Africa and Brazil

Aim of the partnership and its potential roles

Next steps

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What is required for the partnership to become operational and effective?

1. **Identify partners**
   - Governments
   - Non-government entities:
     - Industry ?
     - Multilateral organisations (e.g. WB, UN) ?
     - Regional organisations (e.g. SADC, African Development Bank) ?
   - Other existing initiatives
2. **Engage partners**
   - Secure high level commitment from partner governments
   - Agree priority areas with partners
   - Agree structure of the partnership and define the roles of individual partners
   - Define "interface" approaches with existing initiatives
3. **Define processes and operational aspects**
   - Set up a secretariat
   - Location? Budget? Periodicity?

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The success of the partnership requires a number of potential risks to considered

- **External risks**, i.e. changes in the broader context outside the possible influence of the partnership
  - Oil price shocks (NB: **low** oil price will be a shock for bioethanol)
  - Political instability
  - Major shifts in global energy policy agenda goals
- **Internal risks**, i.e. the partnership failing to deliver against its objectives
  - Lack of partners' commitment
  - Recommendations not being followed by governments
  - Failure to address and reconcile potentially conflicting goals (e.g. environmental aspects versus economic competitiveness)

The **risk-minimisation approaches** the partnership should adopt will depend critically on:

- the specific area of actions the partners will agree on
- the mechanisms put in place

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Section 3: The potential for sugar cane production in African countries outside SADC

Brazil:UK:Africa bioethanol partnership

Follow up work: The technical potential for sugar cane for bioethanol in Africa

London

June 2006

E4tech

Contents

Why sugar cane and bioethanol?

The scope of the study has been on:

- the use of **bioethanol** as a transport fuel: biodiesel and other bioenergy products are not considered
- production of ethanol from **sugar cane**: other routes to ethanol such as from corn, wheat or ligno-cellulosic routes are not considered

The rationale is:

- the sugar cane - bioethanol fuel chain has the potential to be among the lowest cost and lowest CO_2 fuel chains:
  - sugar cane is a tropical and equatorial crop with very high biomass yields
  - the technology to produce bioethanol from sugar cane is well developed
  - bioethanol from sugar cane is the main biofuel used today, Brazil being the leading country in both production of ethanol from sugar cane and its use as a transport fuel

However, there may also be opportunities related to other bioethanol and bioenergy routes.

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Potential for growing sugar cane in African countries outside SADC

The initial geographic scope of the study was **South Africa** alone, as:

- it has the most developed economy in the region
- it is the regional centre of excellence for sugar and ethanol, as the main companies are based there
- its gasoline market represents around 80% of the whole southern Africa market

After discovering that there was limited potential for expansion of sugar cane in South Africa, the scope of the study was extended to the rest of the **Southern African Development Community** (SADC). The technical analysis previously carried out therefore focused on the bioethanol from sugar cane potential in SADC countries.

However, potential may also exists for expansion in both production and use of bioethanol **beyond SADC countries**. In view of this, we have analysed the potential for expansion of sugar cane production in those African countries outside SADC, to provide a complete picture for **Africa as a whole**.

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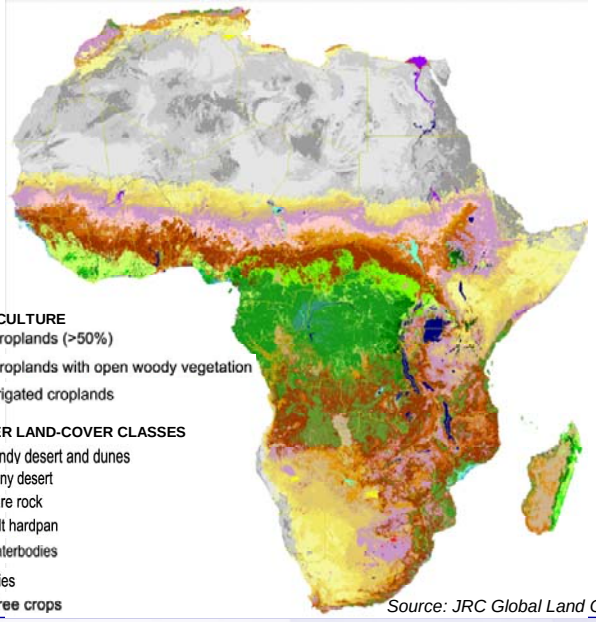
Land type and land use varies widely across Africa

Whilst the desert covers vast areas of Africa, there are large areas with potential for growing crops.



FORESTS
- Closed evergreen lowland forest (<900 m)
- Submontane forest (900 -1500 m)
- Montane forest (>1500 m)
- Swamp forest
- Mangrove
- Mosaic Forest / Croplands
- Mosaic Forest / Savanna
- Closed deciduous forest

WOOD, SHRUB & GRASS LANDS
- Deciduous woodland
- Deciduous shrubland with sparse trees
- Open deciduous shrubland
- Closed grassland
- Open grassland with sparse shrubs
- Open grassland
- Sparse grassland
- Swamp bushland and grassland

AGRICULTURE
- Croplands (>50%)
- Croplands with open woody vegetation
- Irrigated croplands

OTHER LAND-COVER CLASSES
- Sandy desert and dunes
- Stony desert
- Bare rock
- Salt hardpan
- Waterbodies
- Cities
- Tree crops

Source: JRC Global Land Cover 2000

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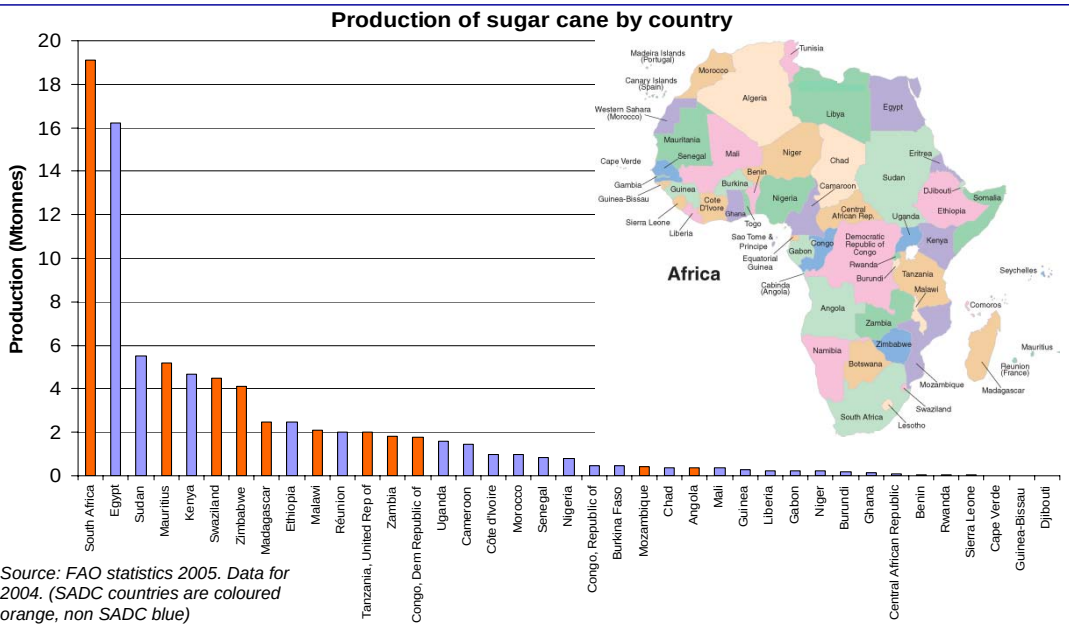
Sugar cane is an important crop, particularly in Central, Eastern and Southern parts of Africa



Source: FAO statistics 2005. Data for 2004. (SADC countries are coloured orange, non SADC blue)

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African sugar cane cultivation in a global context

The sugar cane planted area is similar for both the SADC and non SADC regions of Africa. However, the average yield for the SADC region is significantly higher than the non-SADC region.

The sugar cane industry throughout Africa is much less developed than in Brazil in terms of area and quantity produced, and the average yield in Africa is lower compared to Brazil.

		Africa	non-SADC	SADC	Brazil	Global
Total land area	*M ha*	2,936.0	1,971.9	964.1	851.5	13,432.4
Arable land	*M ha*	196.0	147.7	48.3	59.0	1,403.4
Sugar cane growing area	*M ha*	1.42	0.738	0.684	5.10	20.4
as % of global sugar cane growing area	*%*	6.97%	3.62%	3.35%	25.0%	-
Sugar cane growing area / arable land	*%*	0.73%	0.50%	1.42%	8.65%	1.45%
Production	*M tonnes*	87.0	40.0	46.9	364.4	1,330.4
as % of global sugar cane production	*%*	6.54%	3.01%	3.53%	27.39%	-
Average yield	*tonne / ha*	61.2	54.2	68.6	71.4	65.2

Source: FAO statistics, 2005. Data for 2002

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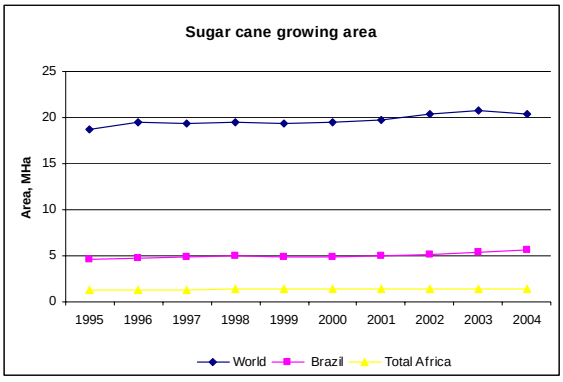
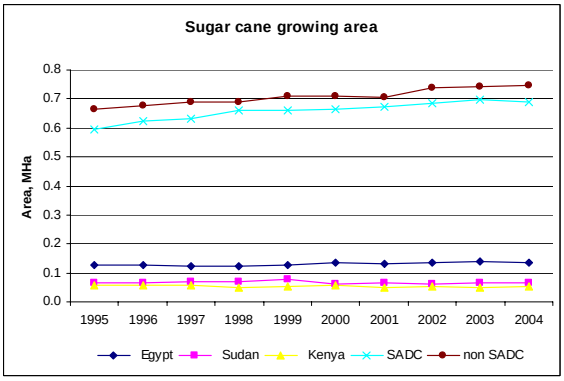
Sugar cane area: trends in Africa, Brazil and the World

There has been a steady but modest increase in the sugar cane growing areas in Africa over the last 10 years. The rate of increase has been similar in both the SADC and non-SADC regions.

However, the growth in planted area remains significantly lower than in Brazil in absolute and relative terms.





Source: FAO statistics, 2005. Data for 2004

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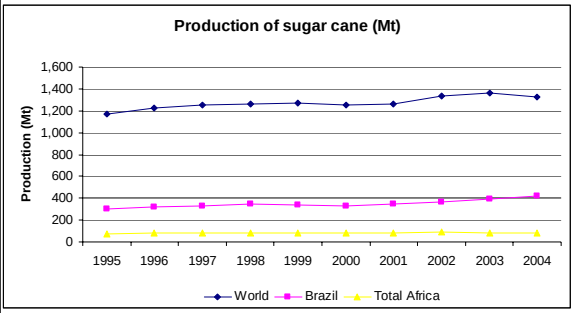
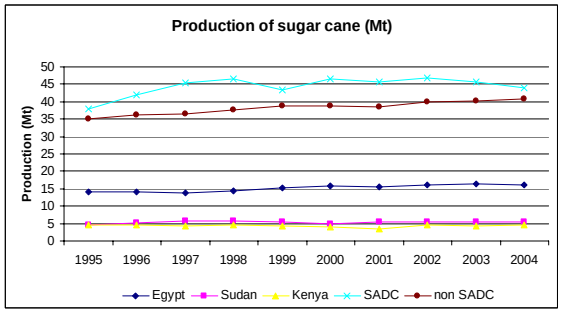
Sugar cane production: trends in Africa, Brazil and the World

Current sugar cane production is slightly lower in the non-SADC countries compared to SADC countries.

Egypt, Sudan and Kenya are the three largest producers of sugar cane in Africa outside SADC. Together they are responsible for over 60% of non SADC's sugar cane production.

The output from non SADC countries has been growing steadily, at an average rate of 1.6% per year over the last decade.





Source: FAO statistics, 2005. Data for 2004

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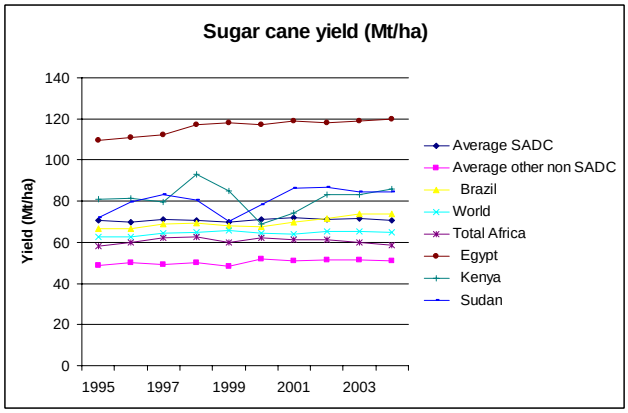
Sugar cane agricultural yields in some parts of Africa are comparable and in some cases higher than in Brazil

Average yields in Egypt, Kenya and Sudan are high in comparison to other areas, also compared to the average Brazilian yield. The river Nile runs through Egypt and Sudan, where it is used for irrigation, producing fertile land and high sugar cane yields.

However, the average for non SADC countries is low compared to Brazil and SADC countries.

Kenya and Sudan show some sharp variations in yields possibly due to climatic variations e.g. droughts.



Source: FAO statistics, 2005. Data for 2004

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Yield depends on climatic and soil conditions and agricultural practices, including use of irrigation

This table shows the yield variability in non SADC countries over the last ten years. The countries shown have either the greatest current sugar cane production, or the greatest potential to grow sugar cane in the future. Some countries experience particularly variable sugar cane yields, possibly as a consequence of extreme fluctuations in rainfall in recent years.

	Min	Average	Max	Var %
Cameroon	10	10	10	0%
Central African Republic	6	7	7	22%
Congo, Republic of	34	38	45	33%
Côte d'Ivoire	58	63	68	16%
Egypt	110	116	120	10%
Gabon	51	56	59	17%
Ghana	25	26	28	11%
Guinea	51	52	54	5%
Kenya	69	82	93	35%
Liberia	10	10	10	0%
Nigeria	18	26	31	75%
Sudan	70	81	87	24%
Uganda	12	13	13	16%

Source: FAO Statistics, 2005. Data for 2002.

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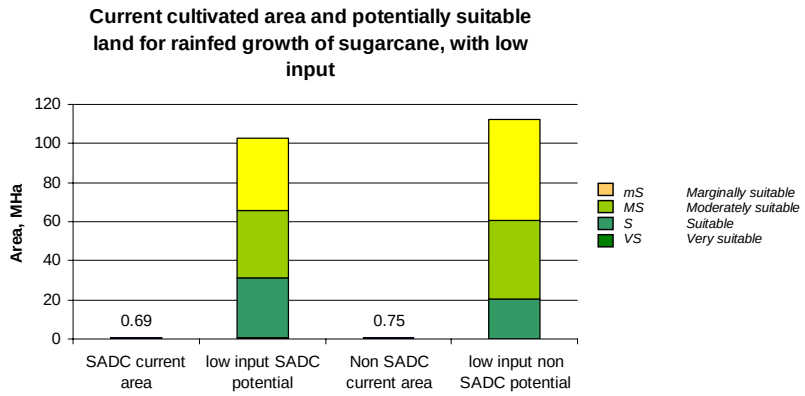
There is a large suitable land area potentially available for growing sugar cane outside SADC

Currently, sugar cane is grown on only a small fraction of the suitable land in both SADC and non SADC regions. Whilst the figures used in this analysis do exclude land currently being used for housing and infrastructure, they do not take into consideration land used for other types of agriculture or for forestry.



Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002)

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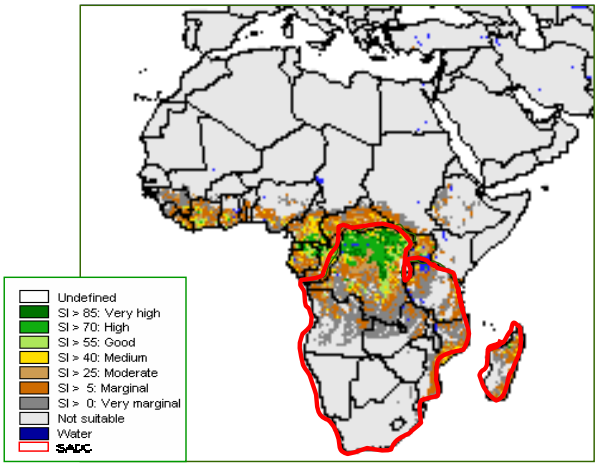
A number of countries have good potential for growing rainfed sugar cane

The most suitable land for growing **rainfed** sugar crops is mainly in the SADC countries. However, there is also significant potential in countries outside SADC, in particular in West Africa, such as Central African Republic, Cameroon, Gabon, Republic of Congo and Cote d'Ivoire.

Suitability for rainfed sugar cane, mixed inputs



Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002)

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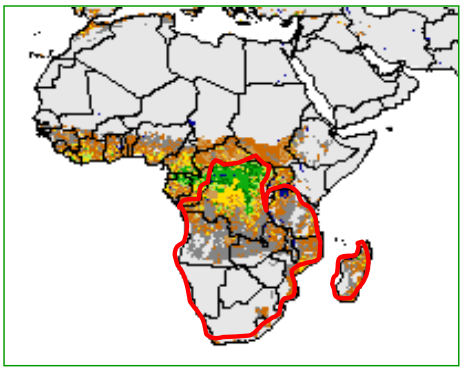
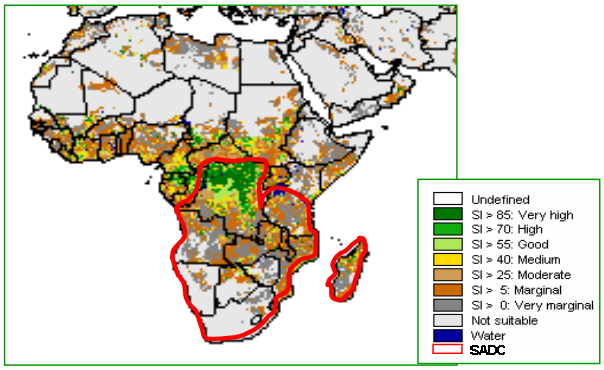
Irrigation has an important impact on the suitability of the land for growing crops

If irrigation is taken into consideration, many more countries have potential for growing sugar crops, e.g. Egypt and Sudan. Whilst diverting water from rivers has been a serious cause of dispute in many African countries, it is likely that some countries would be able to grow crops on irrigated land, if managed carefully.

Suitability for rainfed sugar crops, high input



Suitability for rainfed + irrigated sugar crops, high input



Source: IIASA – FAO (Global agro-ecological assessment for agriculture in the 21st century, 2002)

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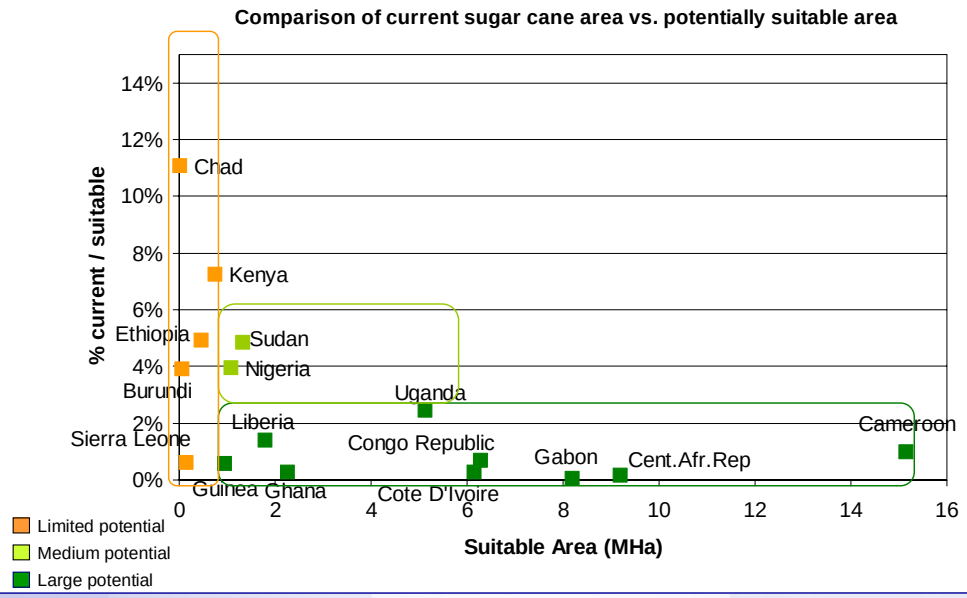
It is possible to identify three groups of non SADC countries according to the level of rainfed sugar cane expansion potential



Contents

Discussion

- The current level of sugar cane cultivated area is similar for SADC and non SADC countries. Although some non SADC countries have very high yields, the average yield is significantly lower than for SADC countries.
- A number of non SADC countries have established sugar and ethanol industries, with some companies operating in different countries e.g. SOMDIAA.
- The African countries outside SADC have a large area potentially suitable for rainfed sugar cane at low levels of technical input, similar to that calculated for SADC.
- The analysis in this report shows that countries with particularly good expansion potentials, under rainfed conditions, include Cameroon, Central African Republic, Gabon, Republic of Congo, Cote D'Ivoire and Uganda.
- However, the potential for expansion in these countries would have to be considered in the context of constraints such as sustainability, infrastructure, political instability, as discussed in a preceeding analysis.
- Furthermore, the average yield in the countries with a significant potential for sugar cane expansion is currently low, probably as a result of poor agricultural practices.
- Some sources (e.g. International Livestock Research Institute) predict a significant growth in the sugar cane industry in non SADC countries.
- Therefore, this analysis indicates that the concept of a bioethanol partnership could be expanded to include African countries beyond the SADC region.

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Section 4: The global potential for biofuels

Brazil:UK:Africa bioethanol partnership

Follow-up work: The global potential for biofuels

London

May 2006

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Introduction – Why look at the global potential for biofuels?

- Developing biofuels production and use is attracting significant interest worldwide
- It is important to understand if the emerging biofuels sector has the potential to expand to supply a significant proportion of transport fuel demand
- In the context of the Brazil:UK:Southern Africa project, it is also useful to consider whether the potential for producing biofuels in Africa is material, compared with other world regions

Contents

There are many studies of global biomass potential

- Most of the studies take one of two approaches:
  - a resource based approach, building up from a range of biomass resources, or
  - a demand based approach, working backwards from a set level of energy supply
- We have focused on those studies that take a **resource based** approach to finding the technical potential for biofuels. We have not considered studies that used a demand based approach, or include economic considerations. We did this in order to avoid comparing studies with differing major assumptions about future world energy markets e.g. oil price, which would lead to false comparisons
- The studies looked at generally estimated the biomass potential from:
  - energy crops, such as eucalyptus, poplar, or willow grown on several land types (abandoned cropland, degraded land, and some land use conversion)
  - agricultural residues
  - forestry residues
  - organic municipal solid waste
  - animal wastes

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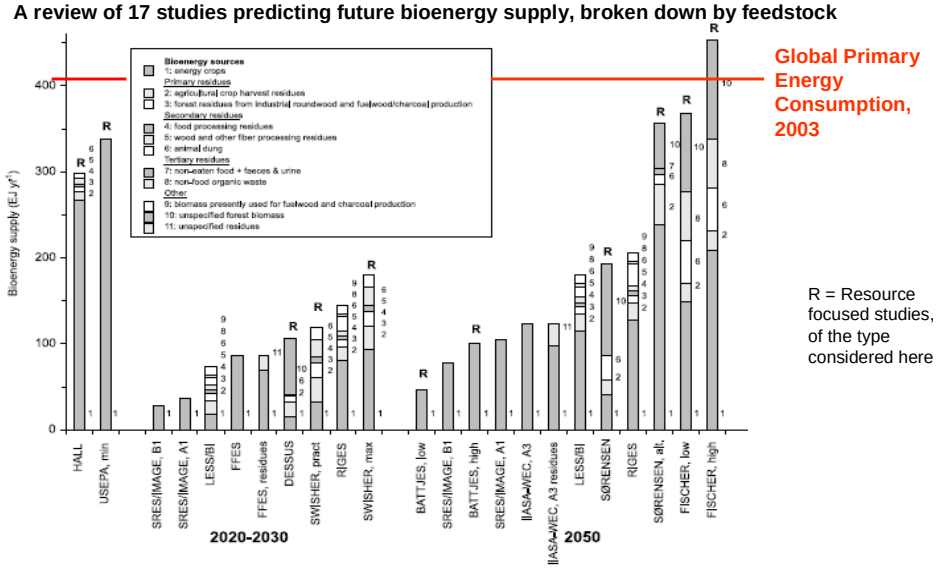
However, their results vary considerably, depending on the assumptions made

A review of 17 studies predicting future bioenergy supply, broken down by feedstock



Source: Berndes et al. (The Contribution of biomass in the future global energy supply: a review of 17 studies, 2003)

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We have considered in detail four recent studies estimating global technical biomass potential

We focused on four recent studies, selected because they consider a comprehensive range of feedstocks, and have detailed approaches to estimating available area for energy crops

Source	Feedstocks and assumptions	Estimated bioenergy potential in 2050, EJ/yr
Smeets et al. (2004) *A quickscan of global bioenergy potentials to 2050*	Uses surplus agricultural and pastoral land to grow short rotation woody bioenergy crops, (e.g. eucalyptus, poplar, willow), harvesting and processing residues of agricultural and forestry, felling of trees, organic urban waste and dung. Assumes current best agricultural practices become globally available by 2050.	296 – 1497
Hoogwijk et al. (2003) *Exploration of the ranges of the global potential of biomass for energy*	Use of degraded land for reforestation, land for dedicated fuel crops (eucalyptus, grasses and willows), agricultural wastes, forestry wastes from mills and manufacture, animal manure and organic waste. As well as taking into consideration competition of land for food, it takes into consideration competition with production of biomaterials.	33 – 1130
Fischer and Schrattenholzer (2001) *Global bioenergy potentials through 2050*	Assumes an improvement in food crop yields, resulting in an increase in land available for growing energy crops. Also uses agricultural and forestry wastes, MSW, grassland and animal waste.	370 - 450
Parikka (2004) *Global biomass fuel resources*	Figure estimated from available land to grow energy crops, agricultural and forestry residues.	104

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The most significant uncertainties concern land availability and future crop yields

- The estimates of potential biomass production in 2050 differ primarily in their estimation of the amount of land available on which to grow energy crops
- The amount of land available for growing energy crops depends on a number of factors, around each of which much uncertainty exists[1]:
  - Population growth and economic development
  - Global diet and food demand
  - Efficiency of food production
  - Competing land uses
  - Yields of energy crops on surplus agricultural land and degraded land
  - Future developments in competing products, e.g. biomaterials
- Nevertheless, we can use the results of these studies to estimate the future technical potential for biofuels

[1]Hoogwijk et al, (2003)

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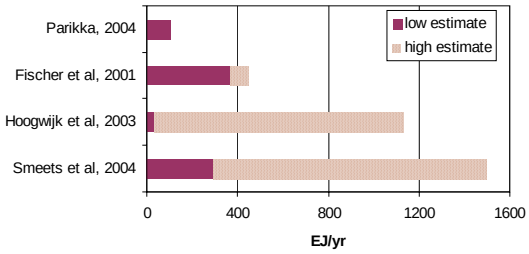
The biomass resource potentials can be translated into large technical potentials for biofuels in 2050

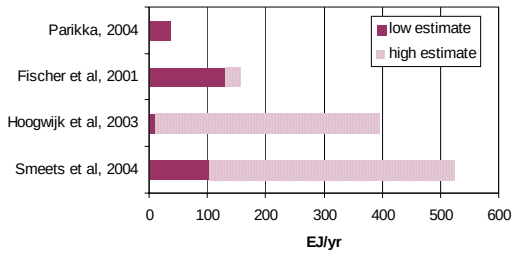
- It is important to note that these estimates assume that the whole biomass potential is used for biofuels: with no use for other energy production (heat and power) or for biomaterials. It also assumes that all of the biomass potential is recoverable – i.e. physically possible and economically viable to grow or to collect, and to convert to biofuels at a commercial scale
- Different technologies will have different conversion efficiencies but we have assumed a single 35% conversion efficiency. This is a reasonable simplification, given that the feedstocks considered are predominantly lignocellulosic, with lignocellulosic ethanol production having a projected conversion efficiency of 30-44% and Fischer-Tropsch diesel production a conversion efficiency of 25-42%, depending on the products produced.

35% conversion efficiency

Global biomass potential in 2050



Global biofuel potential in 2050



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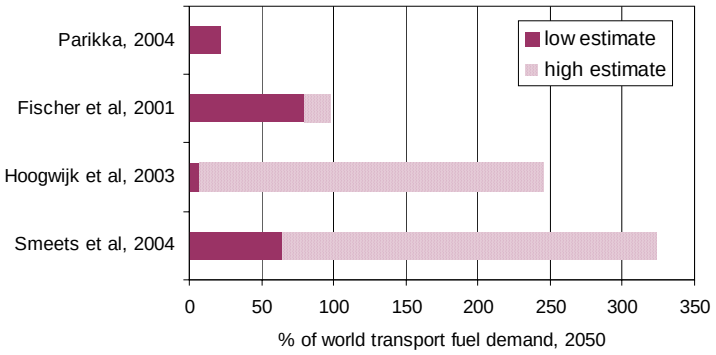
These potentials are significant when compared with projected transport fuel demand

- Total transport fuel demand is projected to increase to **162 EJ/yr** by 2050 (IEA modelling for IEA, (2004) Biofuels for transport – An international perspective)
- Biomass potentials from the studies we looked at translate into biofuels potentials of **11.5 – 524 EJ/yr.** The biofuel estimates are shown here as a percentage of the world transport fuel demand in 2050.

Global biomass potential in 2050 as a percentage of world transport fuel demand



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Achieving these potentials will rely on technical development and rapid growth in production capacity

- Commercialisation of new conversion technologies which are currently at the demonstration stage would be required. These include lignocellulosic ethanol routes, and gasification of biomass followed by Fischer-Tropsch synthesis of diesel. The exploitation of the potential will also be limited by the rate at which conversion plants can be constructed
- Improvement of yields and management of lignocellulosic energy crops would be required. Lignocellulosic crops would also need to be planted at greatly increased planting rates. For example, 4.5Mha/yr of forest plantations are currently planted globally. In order to reach 500Mha for fuel production by 2050 (as used in several of the studies reviewed by Berndes (2003)), 10Mha would need to be established annually, in addition to that established for non-fuel purposes.

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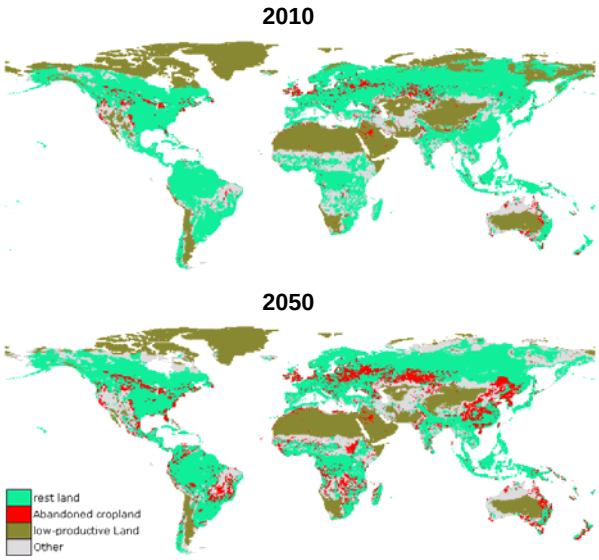
The short term potential for biofuels is much lower than in the long term

- This is principally because lignocellulosic energy crops and their conversion technologies are not yet commercial, and so short term potentials are based on conventional sugar, starch and oil based routes
- Also, more land is estimated to be available in the long term, as a result of increased food crop yields, and the potential to grow crops on poorer land



Maps showing the increase in abandoned cropland from 2010 to 2050. This land type is likely to have the highest productivity for energy crops

Source: Faaij (2005) Emerging international biomass markets and the potential implications for rural development

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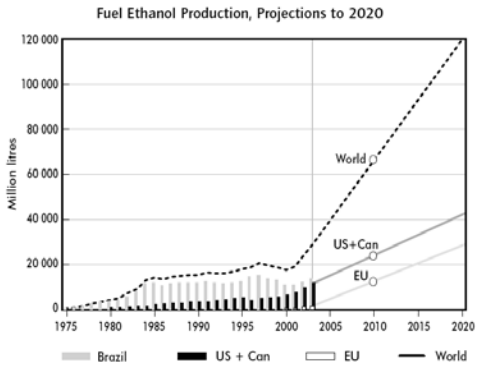
However, short term ethanol production is still projected to be reasonably high

- There is continued potential for expansion in ethanol production from sugar cane, corn, sugar beet and wheat.
- In areas suitable for sugar cane growing, the ethanol potential is not restricted by availability of lignocellulosic technologies, as sugar cane has high crop and conversion yields using conventional processes, and a similar cost and CO2 balance to that projected for lignocellulosic technologies. However, in other areas, and where there is potential from residues, lignocellulosic technologies will be needed
- Most estimates of short to medium term growth in ethanol production are based on the share of petrol that fuel ethanol could displace.
- Several studies, including Berg (2004) and IEA (2004), estimate that ethanol consumption could reach 65-75 Gl in 2010. This is equivalent to 4% of global gasoline demand. As shown on the graph, extrapolating this to 2020 gives 120bn litres, or 3% of total road transport energy use



Source: IEA, (2004) Biofuels for transport – An international perspective

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Brazil and North America would continue to have the greatest share of production

- Global demand is thought likely to be determined principally by EU and Chinese markets :
  - EU market estimated 8-14Gl/yr by 2010
  - China has a rapidly growing vehicle market, and is pursuing alternative transport fuels as part of a diversification strategy
- Supply is expected to continue to be dominated by Brazil and North America, as shown by a scenario considering displacement of 5% of gasoline with ethanol:

Country/region	Feedstock	2010 (Gl)	% of total 2010
Brazil	sugar cane	21.0	24.3
Rest of Latin America	sugar cane	4.4	5.1
India	sugar cane	5.9	6.8
Africa	sugar cane	1.6	1.9
Asia, except China	sugar cane	5.6	6.5
China	sugar cane	1.9	2.2
Middle East	sugar cane	0.3	0.3
EU	grain + beet	12.1	14.0
North America	grain	28.9	33.5
Rest of world	grain	4.6	5.3
Total	All feedstocks	86.3	100

Source: Rosillo-Calle and Walter (2006) Global Market for bioethanol: historical trends and future prospects

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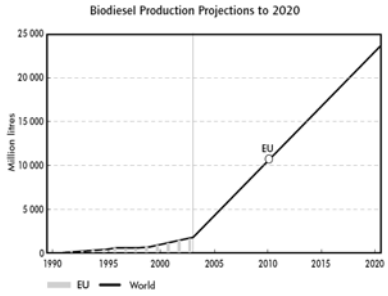
Short term biodiesel projections are heavily dependent on EU policy

- In 2005, Europe produced 88.6% of the world's biodiesel, from rapeseed and sunflower and some waste oils. Over half of the biodiesel was produced in Germany.
- With Western Europe consuming three times as much diesel as gasoline and with targets for biofuels to make up at least 5.75% of the market share by 2010, Europe is expected to continue to dominate the biodiesel market.
- IEA projections for biodiesel in the short term show growth attributed to the EU voluntary target of 5.75% transport fuel displacement with biofuels, assuming EU countries meet this commitment proportionately with biodiesel and ethanol.
- 24,000 million litres of biodiesel as shown in IEA projections in 2020 would be equivalent to 0.8% of world transport fuel demand
- The potential for further expansion of conventional biodiesel is likely, however, to be restricted by:



Source: IEA, (2004) Biofuels for transport – An international perspective

  - land availability - producing biodiesel from oil crops requires more land per unit energy delivered than producing ethanol from sugar or starch crops ethanol or FT diesel from lignocellulosic crops
  - population growth and changing diets in developing countries leading to increased vegetable oil demand for food, potentially pushing up world prices.

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Contents

Summary

- Resource-based estimates of global biomass potential from the literature vary considerably, depending on the resources included, and on assumptions about land availability and yields for energy crops
- Several recent studies estimate that the global biomass potential in 2050 could be between 30 and 1497 EJ/yr.
- If converted into a biofuels potential, this is equivalent to a technical potential to supply between 20 and 320% of world transport fuel demand. Even at the lower end of these ranges, biofuels could make a significant contribution to transport fuel supply
- Achieving this potential will rely on development and planting of energy crops, and technical development of conversion technologies to produce ethanol and biodiesel from lignocellulosic materials
- In the short term, the use of ethanol and biodiesel is unlikely to be constrained by the biomass resource, and will depend heavily on policy support. In the medium term, development of new conversion technologies will be required to enable use of further biomass resources

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