CoER : Biofuels

Department of Microbiology • Faculty of Natural Sciences

Sustainable biofuel production in southern Africa: Opportunities and Challenges

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Western Cape

Stellenbosch- Jewel of the Cape

Panoramic view of Stellenbosch

"Wine country"

Stellenbosch University

Central campus – "The Red Plane"

Value of biofuels/bioenergy to southern Africa

Bioenergy value to southern Africa

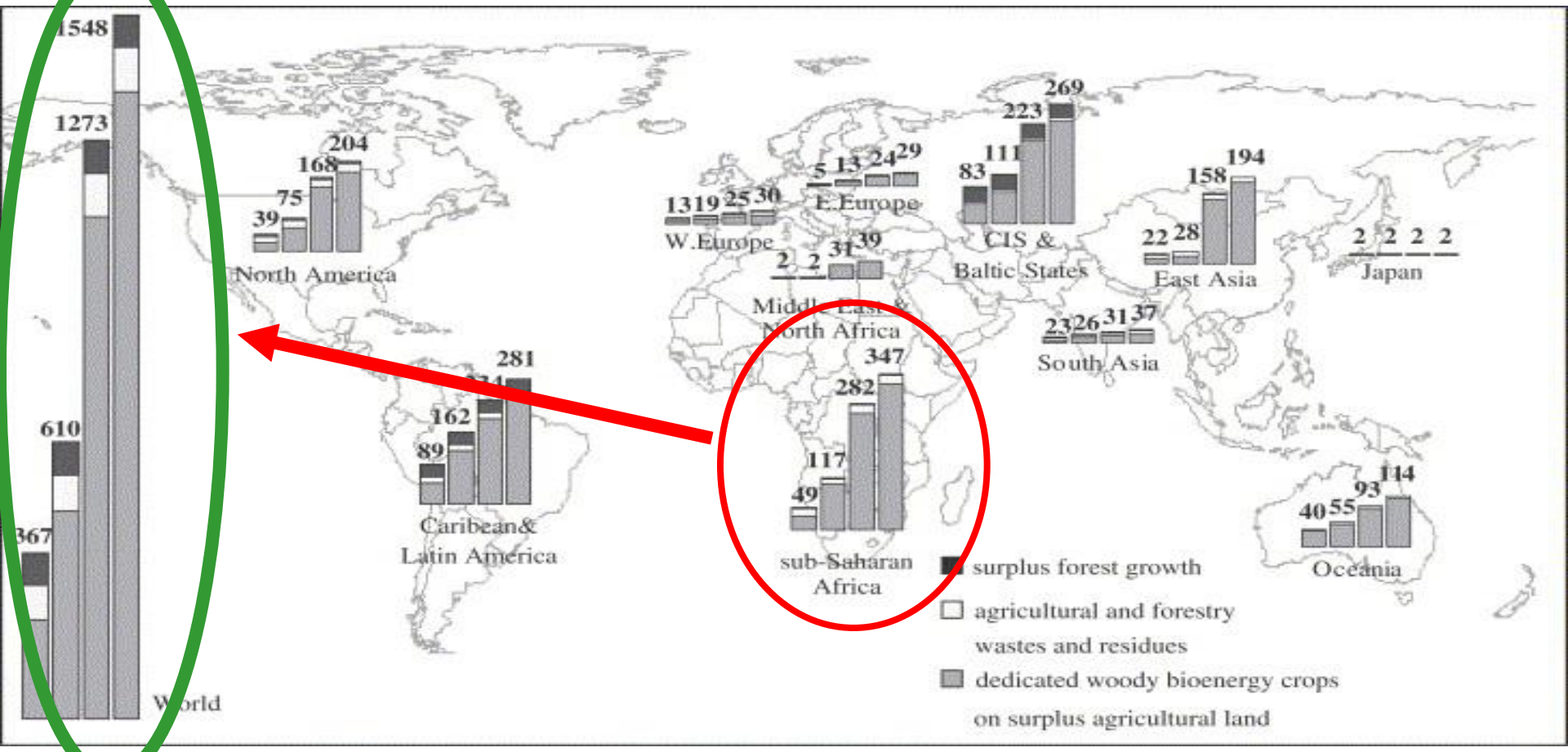
1. Energy plays a key role in the development of nations and provides vital services and means that improve quality of life, the so-call engine of economic progress.

2. With the sub-Saharan Africa population of about 800 million bound to reach >1.2 billion by 2020, living in poverty cannot be reduced *without major improvements* in the quality and magnitude of energy services in Africa.

3. Renewable bioenergy, particularly biofuels, has played a pivotal role in Africa and could help address the need for energy expansion and critical human needs in the foreseeable future.

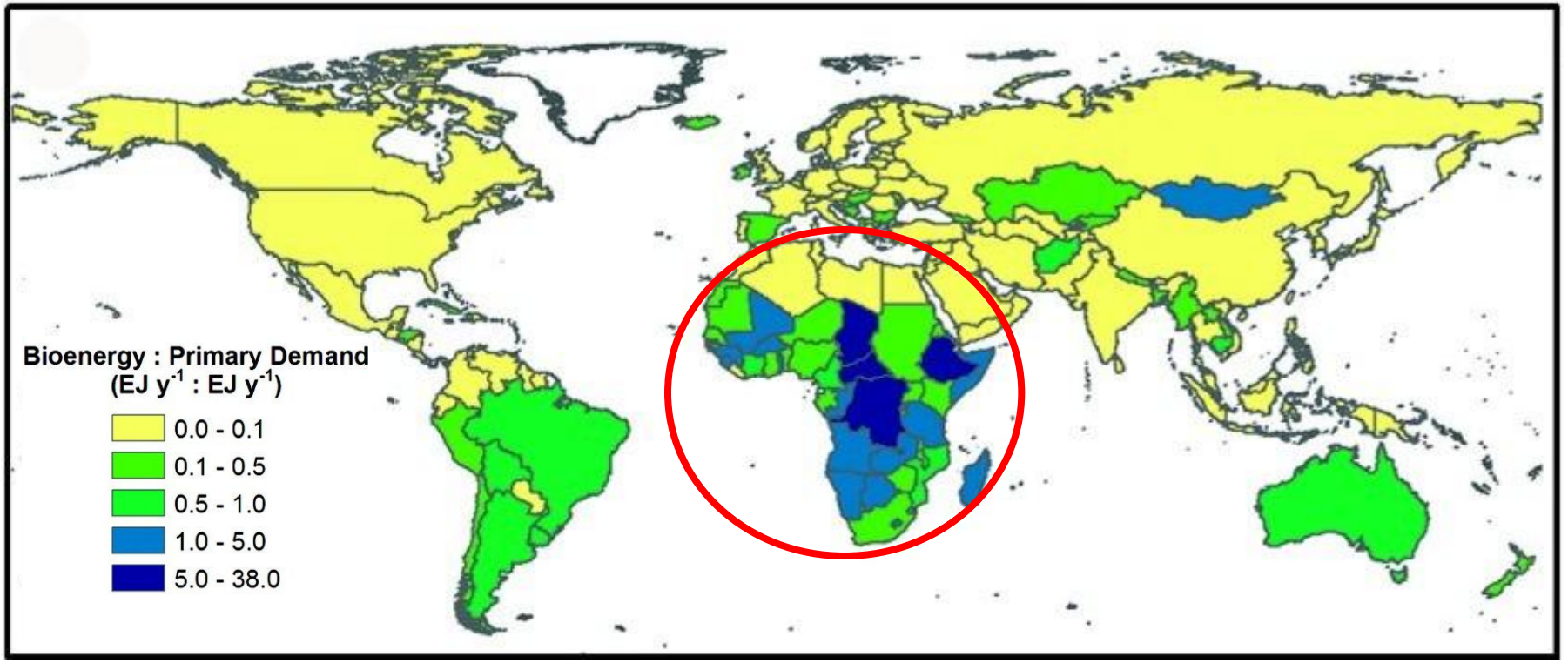
Future bioenergy potential in Africa

Bioenergy Production Potential in 2050 (Smeets, Faaij, 2004)



Total bioenergy production potential in 2050 based on different agriculture systems [expressed as EJ (10^{18} J). yr^{-1}; left to right bars – conventional to highly productive agriculture systems].

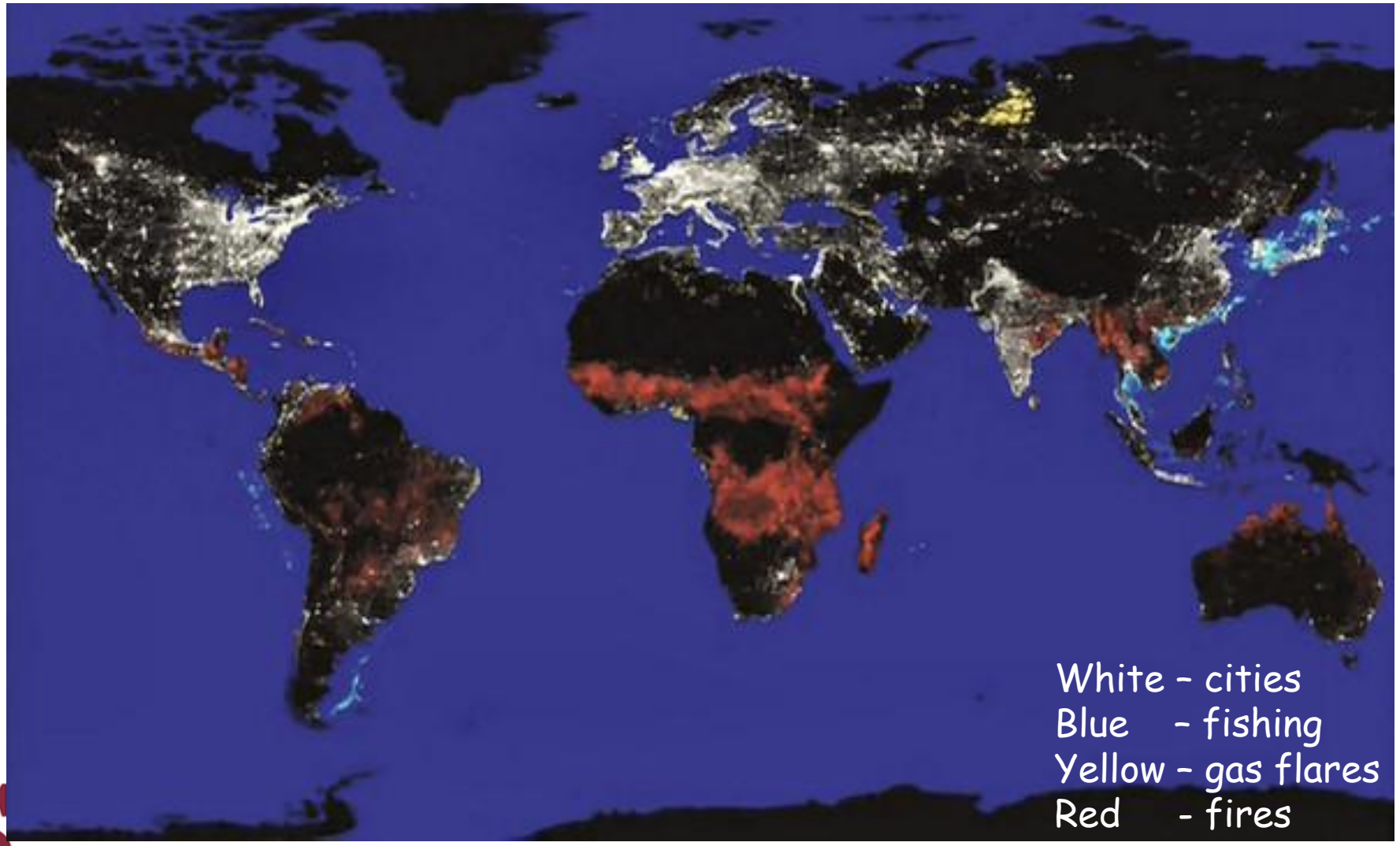
Future bioenergy potential in Africa



Ratio of the energy content of the biomass on "abandoned/ degraded" (under-utilized) agriculture lands relative to the current primary energy demand at the country level. The energy content of biomass is assumed to be 20 kJ g^{-1}. [Campbell *et al.* 2008. The Global Potential of Bioenergy on Abandoned Agriculture Lands. *Environ. Sci. Technol.* 42: 5791-5794]

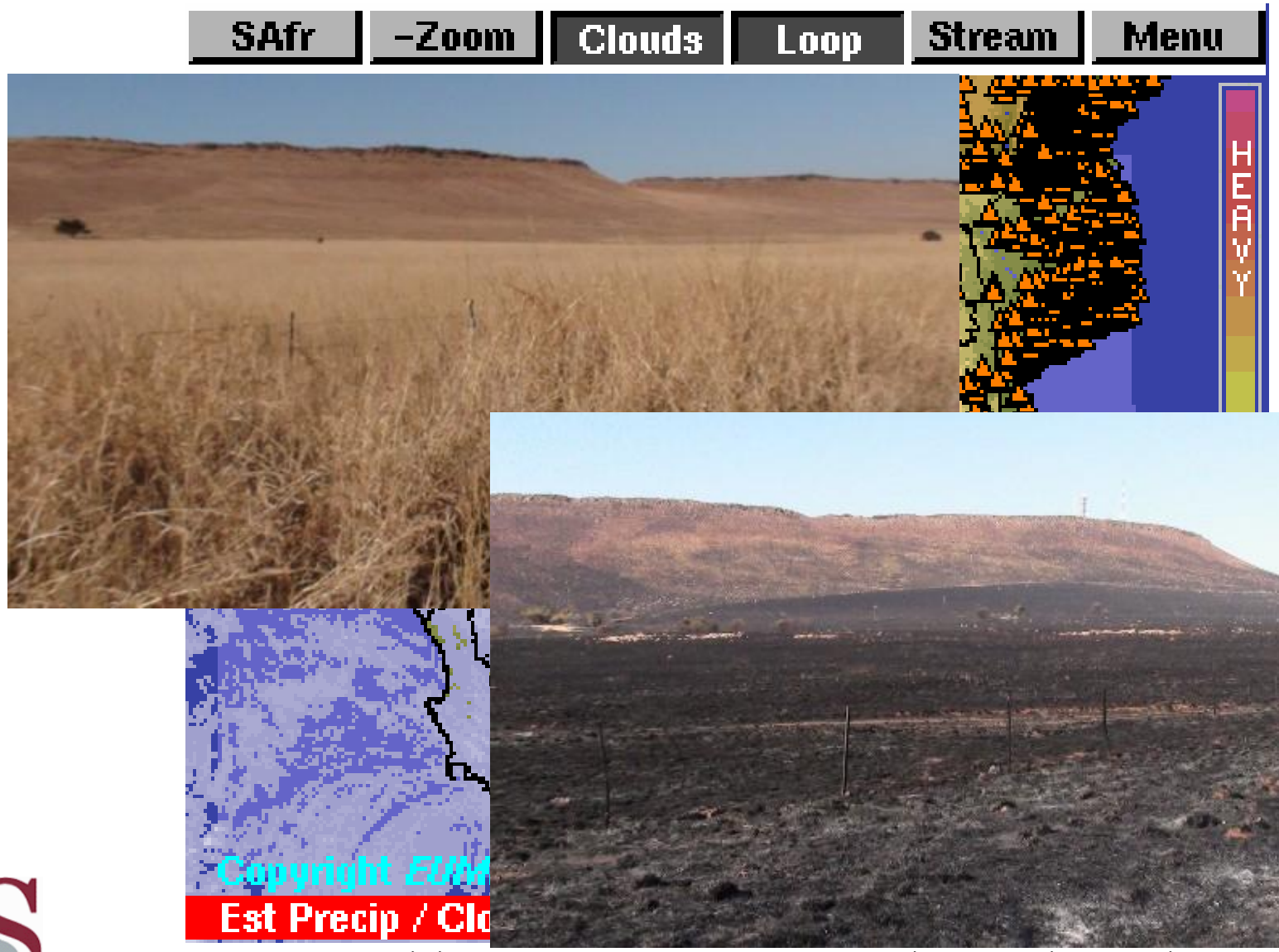
Why is southern Africa not thriving on its agricultural resources?

Cultural habits of the past



From Al Gore: "*The Inconvenient Truth*"

Future bioenergy potential in Africa

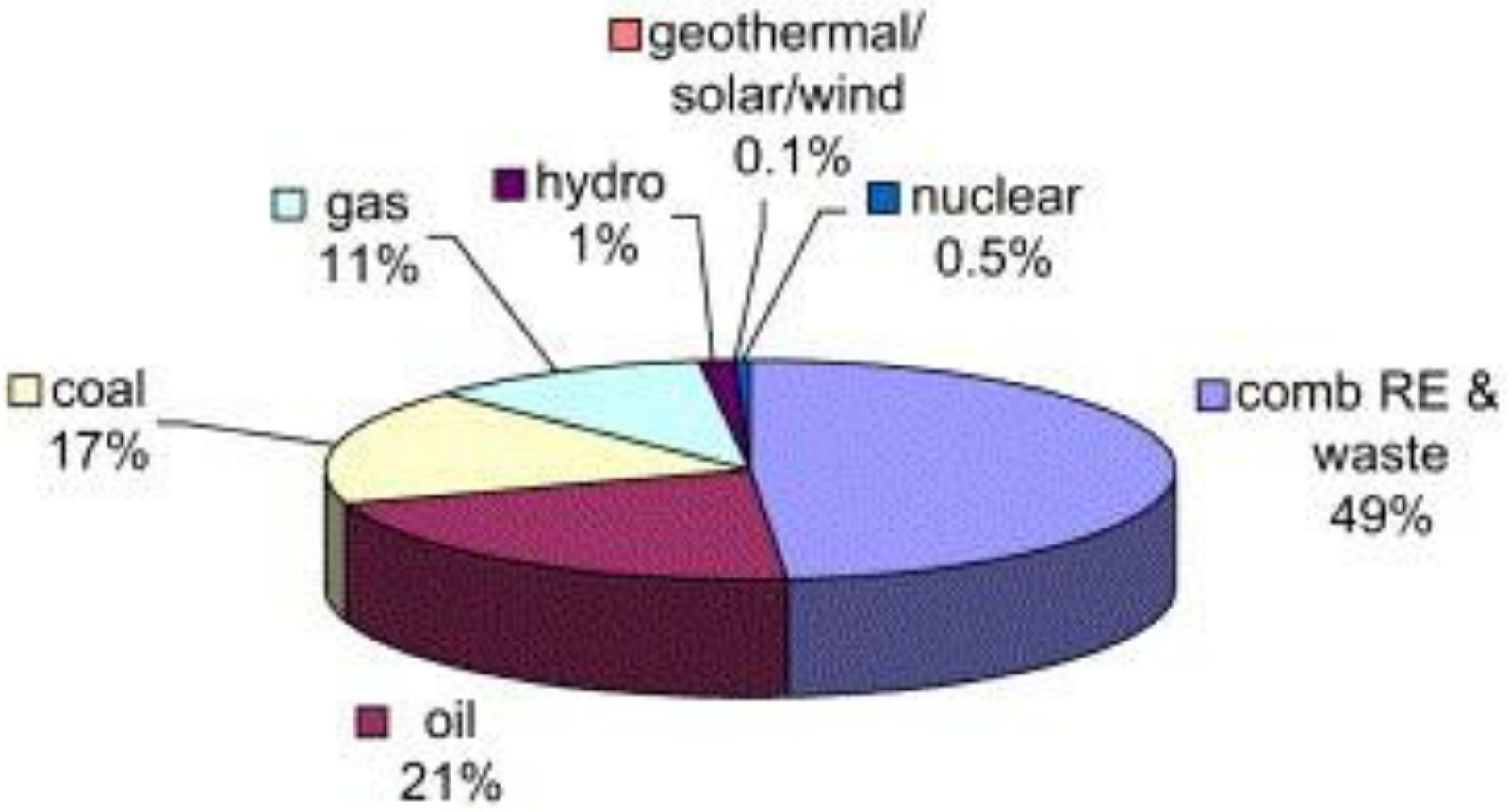


http://www.ssec.wisc.edu/data/paw/

Traditional use of bioenergy in Africa

1. Africa still remains a large consumer of traditional sources of energy, mainly fuel wood, and a greater proportion of its population faces energy insecurity.
2. The availability and accessibility of socially and environmentally acceptable sources of energy are still very low and disproportionate between rural and urban areas.
3. With the exception of fuel wood, other energy sources (primarily coal, crude oil with limited natural gas and hydro) have been the major sources of power driving the transport and industry sectors.

Traditional use of bioenergy in Africa



Share of total primary energy supply in Africa (2001)
[Amigun *et. al.* 2008. Commercialisation of biofuel industry in Africa: A review. *Renew. Sust. Energ. Rev.* 12:690-711]

Availability of biomass (Malawi as example)

Malawi today

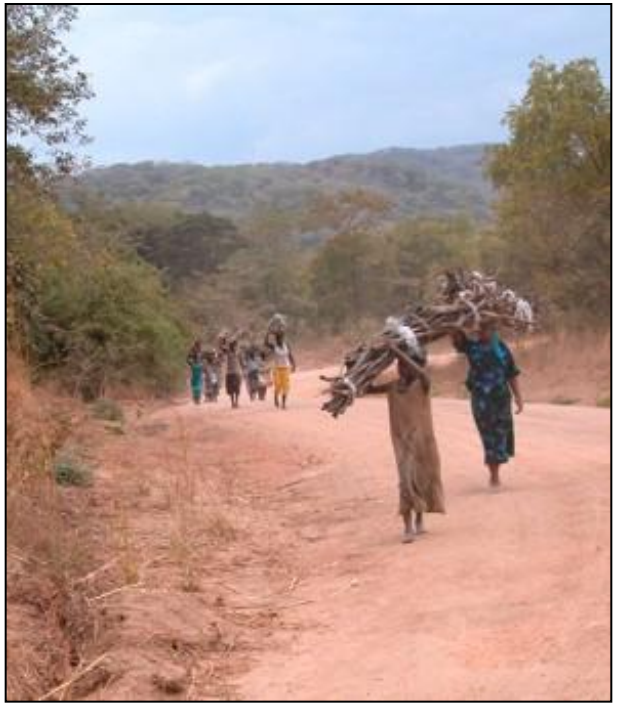
Malawi in the past

Brick-making using woody materials

Charcoal

Collecting of biomass (Malawi as example)

Grass collection for roofs and fences



Firewood collection

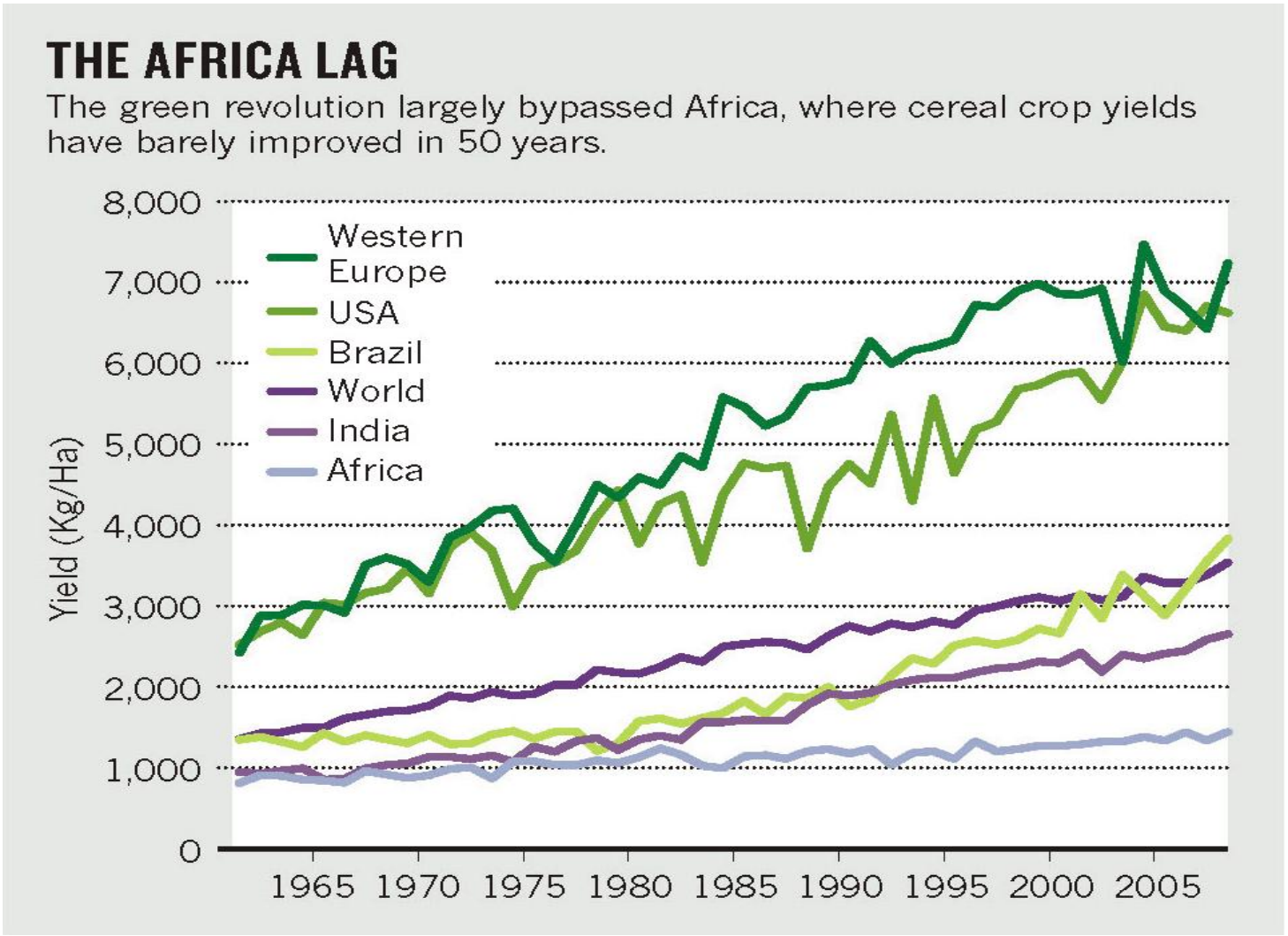
Green revolution by-pass Africa (August Temu)

1. India with a population of **1.1 billion** people is currently producing enough food to feed itself. Distribution is a problem!
2. Africa has **12 times the land area of India** and has just **~800 million** people and cannot feed itself? The land quality is very similar…
3. What explanation do we have?
4. Why did the green revolution by-pass Africa?

Due to serious organizational and institutional weaknesses.

Africa is not poor, but poorly managed!"

Green revolution by-pass Africa



[Lynd and Woods. 2011. A new hope for Africa. *Nature* 424:S20-S21]

Current and future role for biofuel production in southern Africa

Biofuel production in southern Africa

1. In developed countries, the main thrust for ethanol production is the replacement of fossil fuels in the transportation sector.
2. Africa has a great potential to produce and meet the growing demand to phase-out fossil fuels for transport.
3. *However*, the situation is different for developing countries, such as the SADC region because of their unique socio-economic needs, especially:
   a) the chronic food and energy insecurity;
   b) extreme poverty;
   c) high unemployment rate, and
   d) degradation of the natural environment.

Biofuel production in southern Africa

4. Biofuels in Africa attract much attention recently, apart from replacing fossil fuels and reducing GHG emissions, also to:

   a) Open new markets for agricultural surplus (thus additional revenue for farmers);

   b) Provide employment opportunities and local economic development opportunities in rural areas;

   c) Address energy and fuel security in land-lock countries.

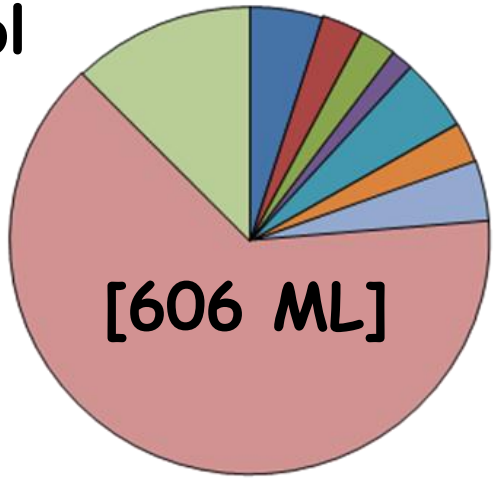
[Van Zyl *et al.* 2011. Next-generation cellulosic ethanol technologies and their contribution to a sustainable Africa. *Interface Focus* 1: 196–211]

Biofuel production in southern Africa

5. In SADC, sugarcane production is growing steadily (2.5% per annum).
6. Current figures for cultivated land (6%) are very low and suggest that availability of land may not be a constraint to increasing production of biomass for fuel production.
7. For bioethanol, many production plants in Africa are in SADC and active participants include South Africa, Malawi, Swaziland, Mauritius and Zimbabwe.

Current biofuels production in southern Africa

Ethanol



- Egypt [30 ML]
- Kenya [17 ML]
- Malawi [15 ML]
- Mauritius [9 ML]
- Nigeria [30 ML]
- Swaziland [17 ML]
- Zimbabwe [25 ML]
- South Africa [388 ML]
- Other Africa [75 ML]

Sugar

[10 Mt]
[~6 BL]

Sources: RAF Outlook (2007) and Hassan (2008).

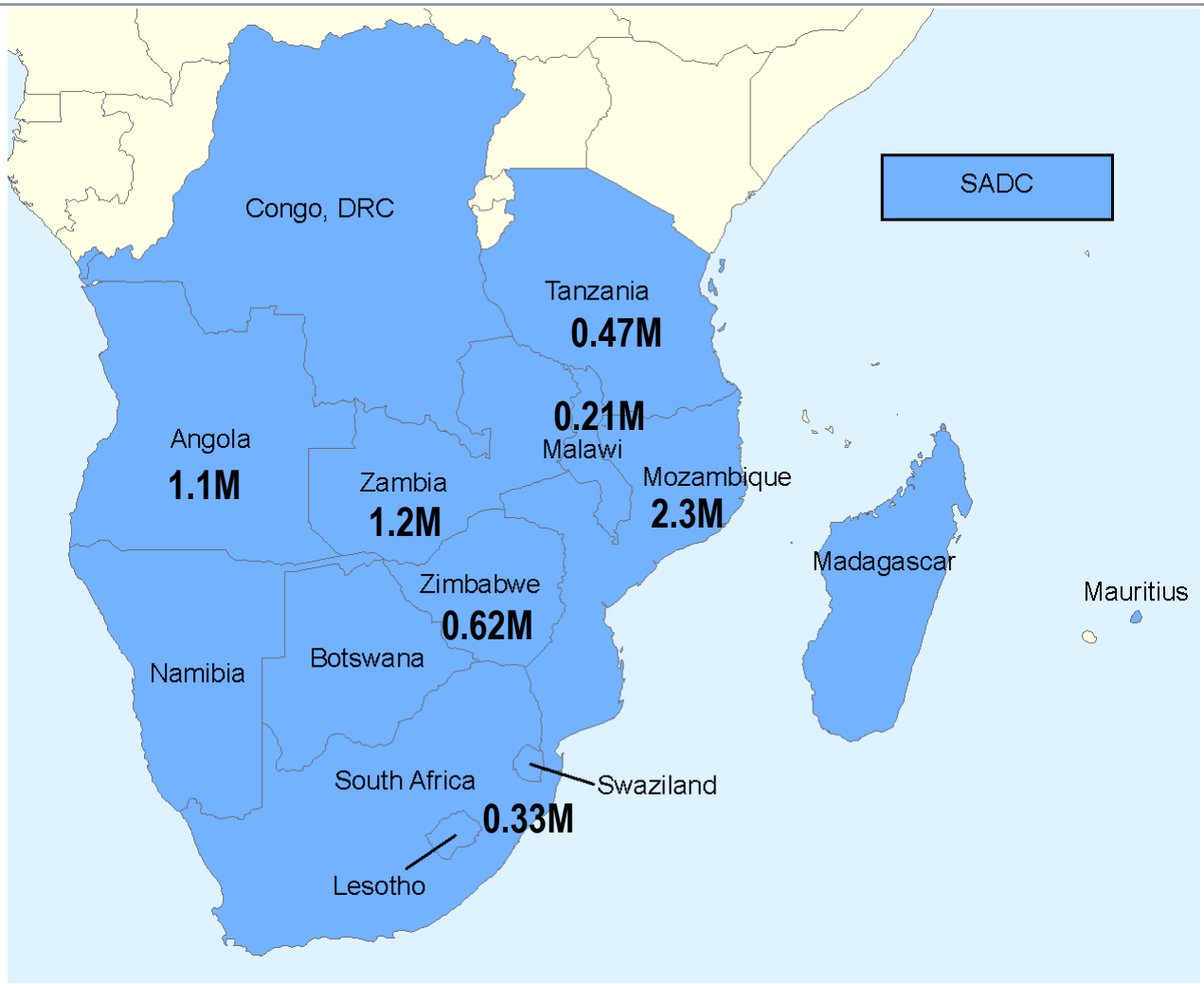
[Ambali *et al.* 2011. A review of sustainable development of bioenergy in Africa: An outlook for the future bioenergy industry. *Sci. Res. Essays* 6: 1697-1708]

Opportunities for sugarcane in SADC

1. Currently, Africa only produce a fraction of the world ethanol, and even Africa's sugar production is rather modest with South Africa been the biggest producer, producing about half of the sugarcane in SADC (~20 Mt/annum), using an area of ~325 000 Ha!
2. However, a recent study (Watson, 2011) estimated that about 6 MHa of arable land in SADC countries (primarily Mozambique, Angola, Tanzania, Zambia, Zimbabwe and Malawi) are suitable for sugarcane production at an average yield of >65 t/Ha or more.
3. Conservatively, this means that the total South Africa sugar industry can be replicated every year for at least 15 -20 years in southern Africa!

[Watson. 2011. Potential to expand sustainable bioenergy from sugarcane in southern Africa. *Energy Policy* in press (doi: 10.1016/j.enpol.2010.07.035).]

Potential sugarcane production in southern Africa

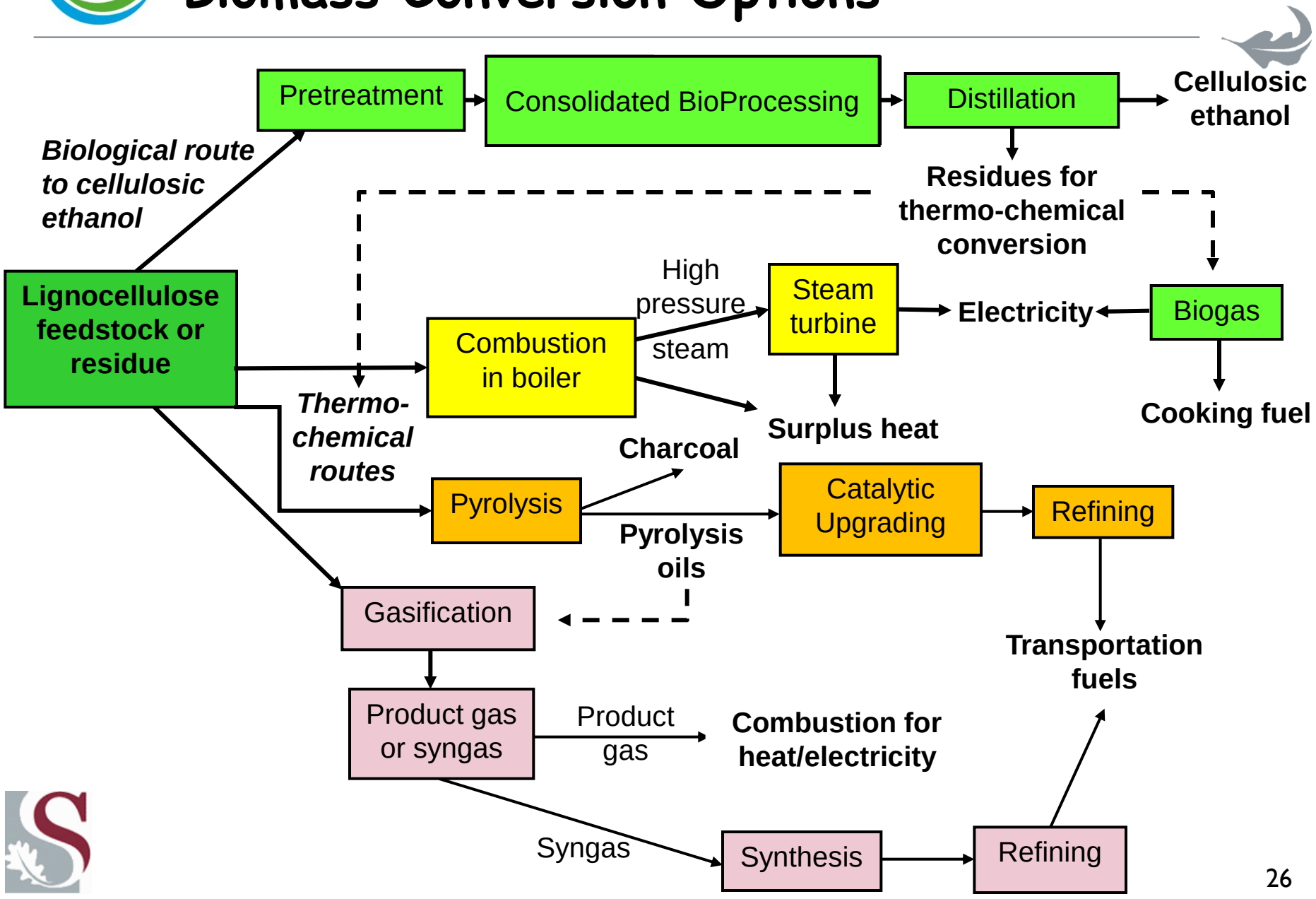


[Watson. 2011. Potential to expand sustainable bioenergy from sugarcane in southern Africa. *Energy Policy* in press (doi: 10.1016/j.enpol.2010.07.035).]

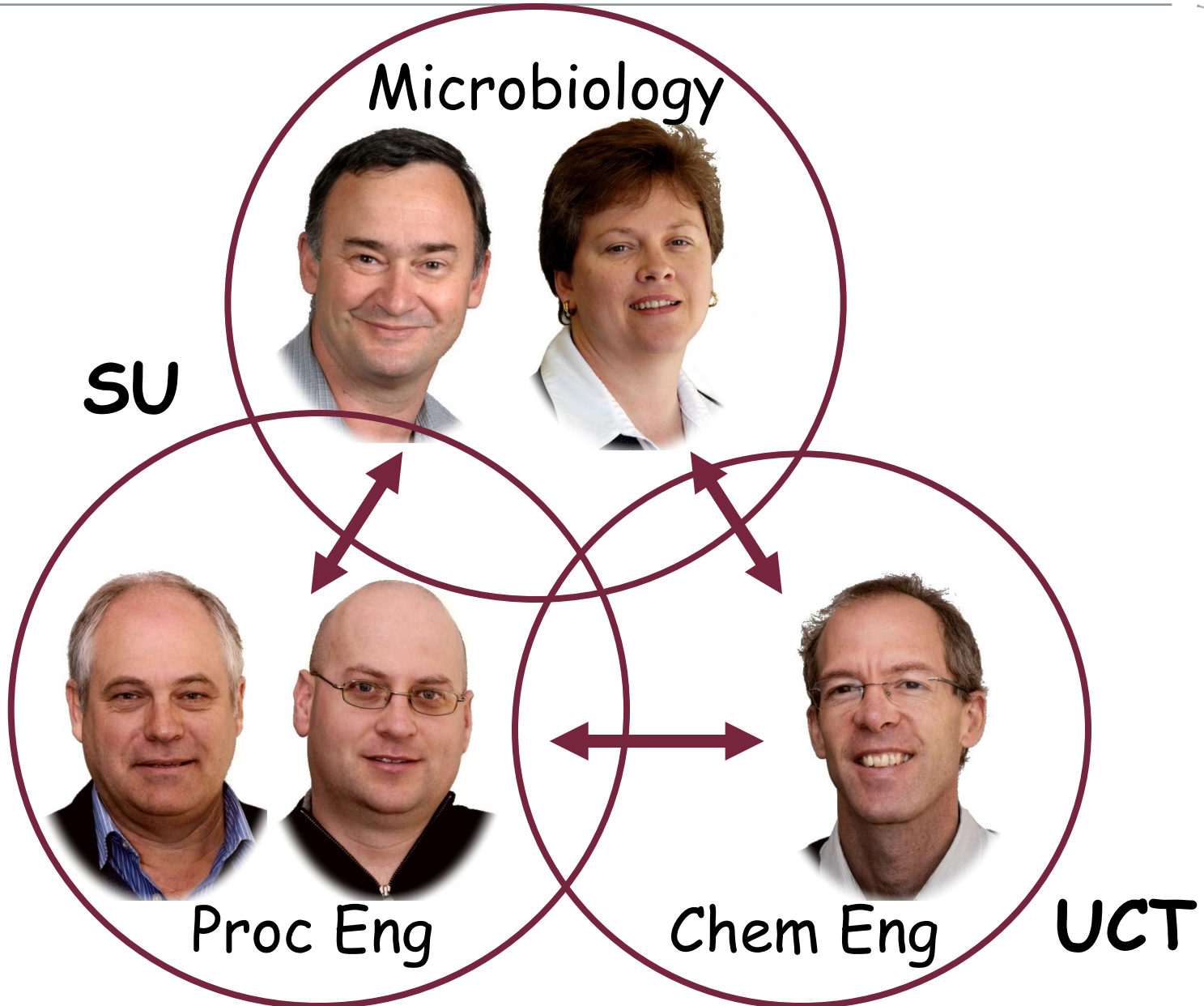
Biofuel production in southern Africa

Integrating 1st and 2nd generation technologies could create opportunities for southern Africa

Biomass Conversion Options



DST Senior CoER : Biofuels (members)



Examples of 1st & 2nd generation integrated

Considering 6 MHa at ~65 t/Ha = ~400 Mt/an of a commercial variety sugarcane yielding per wet ton*

- 120 kg sucrose = 68.4 L EtOH = 1.45 EJ (30%)
- 40 kg molasses = 22.8 L EtOH = 0.63 EJ (13%)
- 150 kg dry matter = ±42.0 L EtOH = 2.70 EJ (57%)

1. If only fermenting molasses = 9.12 BL ethanol
2. If fermenting all sugars = 36.5 BL ethanol
3. If fermenting all sugars & bagasse = 53.3 BL ethanol
4. Can still use the remaining lignin and waste materials for energy/electricity and biogas production

[* Information from Frikkie Botha – SASRI, South Africa]
[Assume ethanol yield from sucrose 570 L/t and bagasse 280 L/t]

Opportunities for sugarcane in SADC

1. Currently, Africa is producing 606 ML;
2. If the total current sugar production is converted to ethanol, Africa can producing 6 BL, one order of magnitude more!;
3. However, if optimal sugarcane is produced in 6 SADC countries only and total biomass converted to biofuels, the potential can increase with another order of magnitude, +50 BL, *representing 20% of Africa's total petroleum consumption!*
4. Theoretically, Africa is producing at present only 1% of its potential and can, together with Brazil, be a major player in the future!

Bioenergy Resolution for Africa

17 – 19 March 2010, Stellenbosch

The geographical potential of Africa to produce plant biomass is *at **least as large*** as any other continent and ***far exceeds*** *the **requirements for food*** and ***basic needs*** for the African population.

This situation gives rise to an ***opportunity*** to use ***agriculture*** and ***forestry*** to produce, in addition to food, ***bioenergy*** (transport or domestic fuels or electricity) using clean and efficient biomass conversion technologies.

Bioenergy Resolution for Africa

GSB
AFRICAN CONVENTION

Actions need to be taken to ensure that Africa benefits along the full value chain of bioenergy supply and utilisation. These include, among many worthy actions, development of:

1. More ***analysis, understanding,*** and ***consensus*** on the **potential of bioenergy** to realize a sustainable Africa;
2. African ***scalable demonstration projects*** using latest state of the art technologies and African raw materials for learning perspectives e.g. training to strengthen local manpower;
3. Needed ***human capacity*** and ***career opportunities***, including creating an African ***intellectual base***, reducing *brain drain* and ***engaging existing African traditional knowledge systems***;

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Bioenergy Resolution for Africa

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Actions need to be taken (continued):

4. The institutional resources to foster ***coordination*** across Africa for ***stakeholder interaction***, and ***suitable strategies, policies*** and ***initiatives***;
5. Pilot projects to ***show best practices*** in energy efficiency and resource protection in transport, electricity supply, cooking and other household needs;
6. ***International, regional*** and ***local policies*** on ***trade, aid, land tenure***, and ***development needs*** to be ***aligned now*** to develop integrated value chains of agriculture and forestry for food and bioenergy in Africa.

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Bioenergy Resolution for Africa

Bioenergy is one of the most cost effective solutions for a global sustainable low carbon energy future. This future demands ***sustainable agriculture*** and ***forestry*** in Africa to supply ***food and bioenergy*** in support of Africa and the world.

http://academic.sun.ac.za/biofuels/Convention/Draftresolution.html

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Bioenergy Resolution for Africa

A sustainable globe needs a sustainable Africa!!

Future for Africa??

Thank you