AGRO-INDUSTRIAL LOW-CARBON DEVELOPMENT OPTIONS IN SOUTHERN AFRICA: THE CASE OF BIOENERGY FROM SUGARCANE

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&
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Stockholm Environment Institute
• The African sugarcane network and its key outcomes
• Growing sugarcane in Africa
• Sugarcane resources and utilizations
• Socio-economic impacts
• Environmental impacts
• International trade
• Climate change
The Network and its Key Outcomes

Agriculture
- Agronomy and Land Resources
- Harvesting and Delivery
- Process Systems Analysis
- Fibre Resources
- Sugar Resources
- Policies & Regulations
- Trade, Financing & Investment
- Implementation & Strategies
- Socioeconomic Impacts
- Environmental Impacts
- Contributions to Sustainable Development
- International Experiences & Comparisons
- Risk Analysis & Competitiveness
- Industry Perspectives

Industry

Markets

Impacts

Integration

14 international partners, 5 thematic reports, 6 journal articles, workshops, etc.

EARTHSCAN book - in press

2-3 years, 44 contributors, 18 chapters

14 international partners, 5 thematic reports, 6 journal articles, workshops, etc.
Growing Sugarcane in Africa

- Most promising agricultural source of biomass energy in the world: *photosynthetic efficiency of 1-3.3% - high energy-to-volume ratio*
- **Wide adaptation** in different environment and geographic locations: *C4 crop and genetically improved*
- **Greatest bioenergy potential in sub-Saharan Africa** among the major world regions
- Average area under agricultural cultivation of about 6% in the region is low by international standard: *abundant land availability & well-suited for expansion*
- **Suitable and available land** – with few detrimental environmental and socio-economic impacts: *many models – ACRU-Thompson, FAO, MARI, IGBP/IHDP, BAEZP, ....*)

<table>
<thead>
<tr>
<th></th>
<th>Angola</th>
<th>Malawi</th>
<th>Mozambique</th>
<th>Tanzania</th>
<th>Zambia</th>
<th>Zimbabwe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country land area</td>
<td>1 246 700</td>
<td>94 080</td>
<td>784 090</td>
<td>878 690</td>
<td>743 390</td>
<td>386 670</td>
</tr>
<tr>
<td>Potentially suitable</td>
<td>16 260</td>
<td>7 420</td>
<td>49 060</td>
<td>16 940</td>
<td>35 460</td>
<td>29 350</td>
</tr>
<tr>
<td>Protected areas</td>
<td>13 950</td>
<td>5 950</td>
<td>46 020</td>
<td>12 230</td>
<td>24 330</td>
<td>18 600</td>
</tr>
<tr>
<td>Slopes &gt; 16%</td>
<td>13 890</td>
<td>5 800</td>
<td>45 300</td>
<td>12 170</td>
<td>24 270</td>
<td>18 550</td>
</tr>
<tr>
<td>Available and suitable</td>
<td><strong>11 270</strong></td>
<td><strong>2 060</strong></td>
<td><strong>23 380</strong></td>
<td><strong>4 670</strong></td>
<td><strong>11 780</strong></td>
<td><strong>6 200</strong></td>
</tr>
<tr>
<td>% of country land area potentially suitable</td>
<td>1.30</td>
<td>7.89</td>
<td>6.26</td>
<td>1.93</td>
<td>4.77</td>
<td>7.59</td>
</tr>
<tr>
<td>% of country land area available and suitable</td>
<td>0.90</td>
<td>2.19</td>
<td>2.98</td>
<td>0.53</td>
<td>1.58</td>
<td>1.60</td>
</tr>
</tbody>
</table>
Sugarcane Resources & Utilizations

- **Sugarcane**
  - Molasses/juice
    - Commercial Products
    - Ethanol
    - Stillage
    - Fertilizer
    - Methane
  - Sugar/solids
    - Special Sugar
    - Raw Sugar
    - Fertilizers
  - Refined Sugar
    - ~100 kg sugar/tonne cane
  - Industrial Uses
    - Steam & electricity
    - Agricultural Products
    - Industrial Products
  - Crop residues/fibres
    - Fuel Briquettes
    - ~130 kWh/tonne cane (exportable electricity) with potential up to 4 times the given benchmark

- **Sustainable Development Strategies**
- **Environmental & Social Impacts**
- **Global Competitiveness**
- **Techno-economic options**
- **Electricity**

- **Environmental & Social Impacts**
- **Global Competitiveness**
- **Techno-economic options**
- **Electricity**
Socio-Economic Impacts

- **Key drivers** are energy access/security and agro-industrial development: geared towards local needs and appropriate scales (small, large or decentralised)
- **Small-scale uses** and **alternative markets**: transportation fuel (domestic/export), cooking fuel, rectified spirits, pharmaceutical products
- **Employment** and **income generation**: rural jobs (agro-industrial, commercial, new products), rural income and industry, access to modern energy services, improved access to health and education, curbing urbanisation
- **Other benefits**: agricultural diversification to biofuels, savings in fuel bill and foreign exchange, diversified energy mix, less vulnerable to supply disruptions, improved reliability

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Co-product</th>
<th>Strategies</th>
<th>Impacts</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>High oil prices</td>
<td>Ethanol: large scale</td>
<td>Fuel blending, Export</td>
<td>Foreign exchange savings</td>
<td>Quantity petrol imported</td>
</tr>
<tr>
<td>Pressure on foreign currency reserves</td>
<td>Ethanol: large/small scale</td>
<td>Decentralised production, local appliances</td>
<td>Lead emissions</td>
<td>% Ethanol in blend</td>
</tr>
<tr>
<td>Limited energy access</td>
<td>Ethanol: small scale</td>
<td>Kerosene substitute in liquid and gel form</td>
<td>Improved access to modern energy</td>
<td>Lead level in soil, air</td>
</tr>
<tr>
<td>Need for greater energy security</td>
<td></td>
<td></td>
<td>Cleaner indoor air</td>
<td>Lower particulates</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Health risk – abuse</td>
<td>% Reliance on traditional fuels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Land use changes</td>
<td>Incidence of upper respiratory complaints</td>
</tr>
<tr>
<td>Power shortage in SADC region</td>
<td>Electricity (bagasse)</td>
<td>Sell to grid, Local mini grid</td>
<td>Facilitates productive activities</td>
<td>Range of income generating activities, incomes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(welding, power tools, cooling, ....)</td>
<td></td>
</tr>
</tbody>
</table>
Environmental Impacts

- Main ones relate to **GHG benefits, water use, water pollution, soil impacts, air pollution and land use change**
- **Good agricultural practices, use of better technology, local regulations and zonings** can address these impacts
- Compared to other commodity crops, **pesticides use is relatively low and chemical application is restricted to herbicides**
- **Land use change** as a result of expansion can be viewed in **comparison to alternative land-use activities**
- Cane biomass possesses **excellent energy balance for electricity/ethanol production**
- Bioethanol is a **cleaner burning fuel** with fewer hydrocarbon emissions, mitigating local air pollution
- Efficient cogeneration systems result in **low fly ash, sulphur, GHG emissions** compared to fossil based systems
- Impacts are however very localised and needs to be monitored (limited for some impacts such as fertilisers uses and run-off or land use change potentials)
International Trade

- Biofuels programmes tend to target local markets and to substitute expensive imported oil, but can also be export-oriented
- Economies of scale are important to lower costs and become internationally competitive: energy balance and environmental impacts of market expansion need to be evaluated
- Policy decisions easier at national level but more complex at global scale for international trade
- Inadequate/inconsistent policy measures and unstable markets: investors looking for long-term investment/contract/stability to ensure economic return, high-volume contracts leading to efficient low cost logistics
- International biofuels trade barriers: tariffs in large markets (US, EU & Japan), can result in incentives to promote export of feedstock (e.g. unprocessed cane molasses)
- Specifications and classification systems: lack of technical specifications and import regulations for biomass and, lack of clear classification of biofuels within multilateral trading system
- Logistical barriers: high transport costs, bulkiness of feedstock (e.g. molasses)
- Standards and certification - key in ensuring sustainability: a number of available voluntary schemes, ‘Bonsucro’ in line with ISO 65 for sugarcane products (sugar, ethanol & electricity), SADC-specific framework for sustainable biofuel development in Member States
Climate Change

- **African countries** face impacts of **climate change** and concurrently need to look for **development pathways** less constrained by **rising oil prices and scarcity of the resource**
- **No full assessment of climate impacts and scenarios** for sugarcane in Africa exists, given that there is no fully integrated bioenergy/sugarcane production facility in the region
- **Brazilian experience**: *ethanol average net GHG emission 34.5 kg CO2 eq/tonne cane*
- **Prototype baseline emissions assessment in South Africa** using Brazilian methodology:

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<thead>
<tr>
<th></th>
<th>Rain-fed areas (CO2/tc)</th>
<th>Irrigated areas (CO2/tc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farming</td>
<td>12.1</td>
<td>50.2</td>
</tr>
<tr>
<td>Burning</td>
<td>4.7</td>
<td>5.1</td>
</tr>
<tr>
<td>Soil emissions</td>
<td>17.6</td>
<td>12.2</td>
</tr>
<tr>
<td>Agrochemicals inputs</td>
<td>17.6</td>
<td>14.3</td>
</tr>
<tr>
<td>Cane transport</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>56.3</strong></td>
<td><strong>86.2</strong></td>
</tr>
</tbody>
</table>

- **Net GHG emissions higher in South Africa**: but potential GHG savings much higher because of coal electricity in irrigated areas – potential savings of 160 kg CO2/tc
- **Climate impacts** relate to **crop productivity, water scarcity** and the likelihood of **drought** in the future: *will require management strategies including breeding of more resistant varieties, water use, similar alternative crops (e.g. sweet sorghum)*
- **Adaptation is less explored**: for example, how **increased energy access can improve adaptive capacity**
Thanks to the many collaborators within our network

&

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**MERCI**

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