


Potential Impacts of the Production of Liquid Biofuels on Ecosystems and Socio-Economic Sustainability: The Case of Botswana

D.L. Kgathi & K. Mfundisi

Harry Oppenheimer Okavango Research Centre, University of Botswana,
P/Bag 285, Maun. Tel: +267 686 1833. e.mail: dlkgathi@orc.ub.bw

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1.0 Introduction

Biofuels : fuels produced from biomass for a wide range of applications. They can be solid (fuelwood), liquid (bioethanol) or gaseous (biogas) (FAO, 2008). Also classified as primary (fuelwood) or secondary (biodiesel). This paper focuses on liquid biofuels: bioethanol and biodiesel . Brazil and USA are leading producers of ethanol (90% of production). EU is largest producer of biodiesel (60%), followed by USA. Worldwide, they account for 0.2% to 0.3% of TEC.

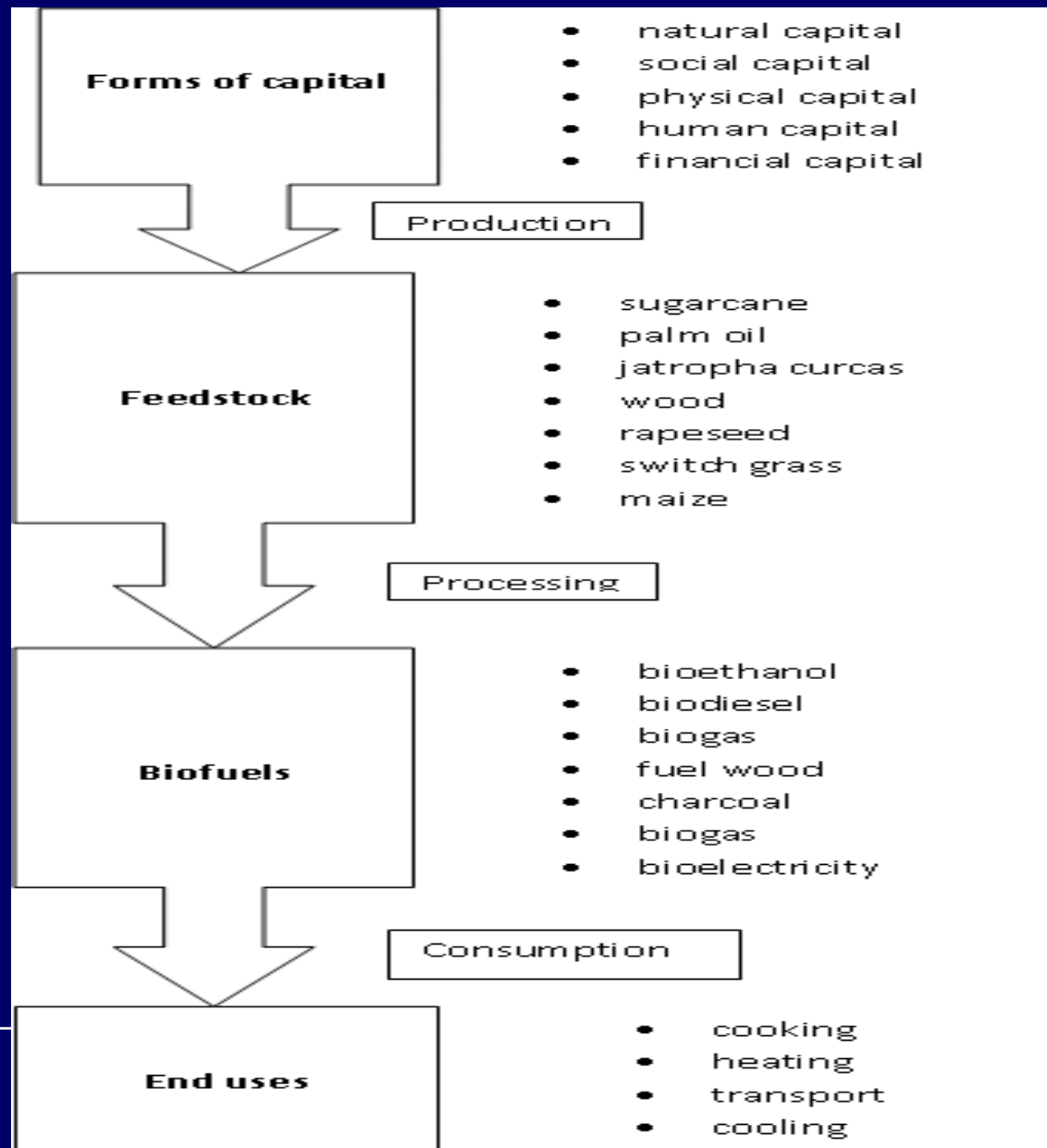
African countries have started investing on liquid biofuels.

Key driver -rural development. However, there are concerns about the potential risks associated with the production of liquid biofuels.

This presentation examines opportunities and risks associated with liquid biofuels with particular reference to Botswana.

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Figure 1.1: Biofuels, production to end use





2.0 WHY Biofuels?

- **Energy security:** concerns about the increasing prices of fossil energy sources . Need to find alternative fuels to fossil fuels
- **Climate change.** Biofuels can be CO₂ neutral: **CO₂ released in combustion may be replaced by one absorbed by biofuel plants** (Smeets et al, 2008). Wide range of ghg savings, depending on feedstock. It is crucial undertake a “well to wheels” (life cycle analysis) of the GHG emissions of the production and use of biofuels.
- **Rural development.** Production of feedstocks can increase incomes of rural households and also create employment opportunities. Jatropha production- **restoration of degraded lands**. Production of biofuels of great relevance to energy policies of developing countries (Smeets *et al*, 2008).



3.0 Biofuel Generations

Classified into Generations: Type of technology and feedstocks

□ First Generation

-Bioethanol- **Food crops** (maize, Sugarcane).

-Biodiesel-**Food oils plants** (sunflower) and **non-food oil plants** - (e.g.Jatropha curcas). The technologies for their production are mature.

- #### □ Second generation: These technologies are under development. Based on **lignocellulosic biomass from a wider range of non-food feedstocks**: whole plant biomass or waste streams: wood, cellulosic energy crops (e.g.miscanthus), residues and waste (Bridgewater, 2007). According to FAO (2008), “**cellulosic biomass is the most abundant biological material on earth**”. However, the **conversion of cellulose to ethanol is challenging**.



4.0 Opportunities and Challenges

4.1 Biodiversity and Ecosystem impacts (+ve and –ve impacts).

- Conversion of agricultural systems biofuel plantations may lead to the following impacts: 1) habitat loss 2) loss of agro-biodiversity due to introduction of monocultures (some species may be invasive) 3. restoration of degraded lands.
- Large amounts of water may be needed to convert biomass into fuel. Although *Jatropha* is drought resistant, its yields may be reduced in marginal lands as compared to high rainfall areas (FAO, 2008). More land may be needed to grow energy crops.



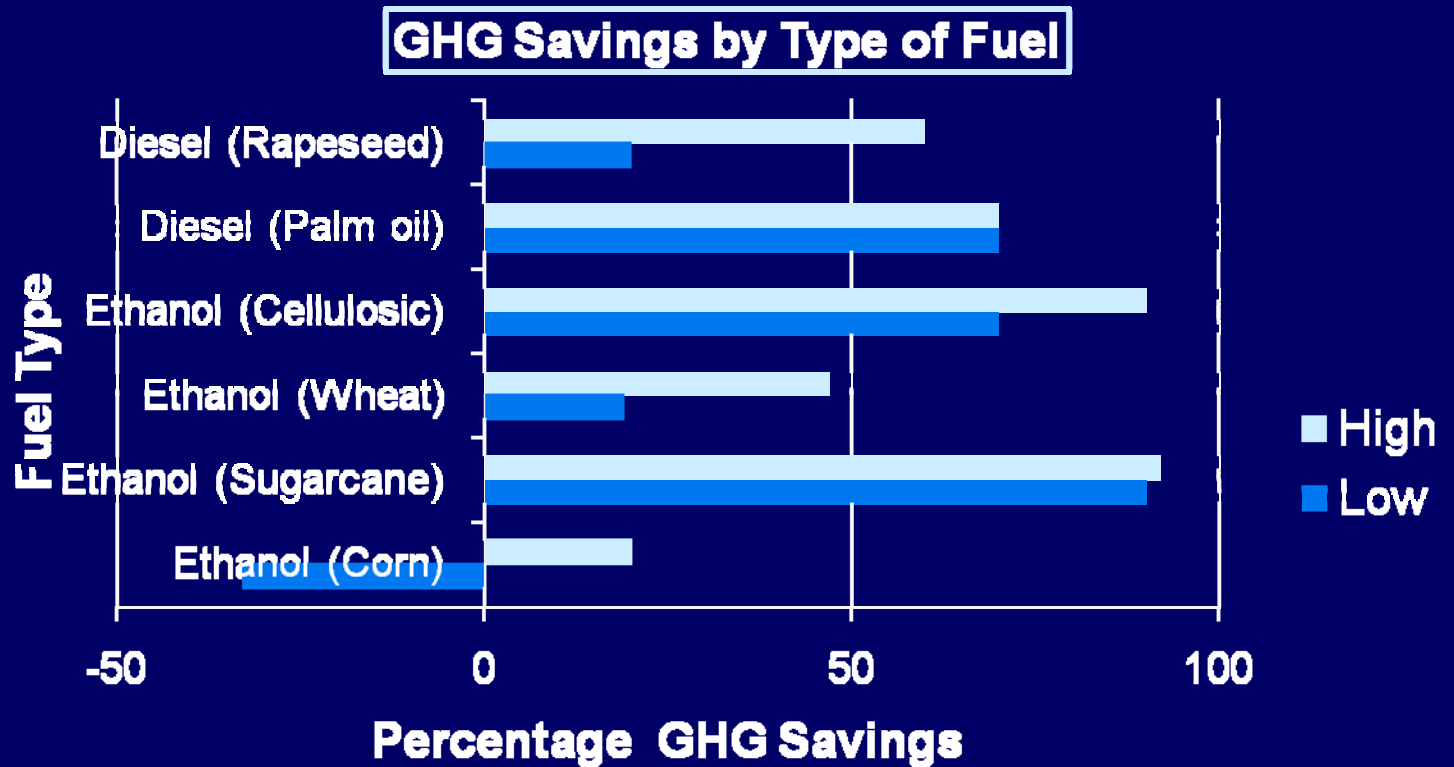
4.0 Opportunities and Challenges, cont.

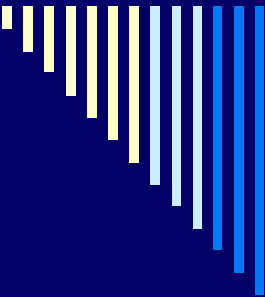
4.2 Greenhouse gas Savings. The amount of ghg savings by biofuels depends on the type of feedstock used, methods of cultivation and conversion technologies used (Dufey, 2006; Smeets, 2008). Examples are as follows:

1. Bioethanol (corn-based), Negative 33% to 20%, averaging 13%. (Dufey, 2006)
2. Bioethanol (wheat-based), 19% - 47% (Dufey, 2006).
3. Sugar-based bioethanol (Brazil), 92% (Dufey, 2006).
4. Lignocellulosic bioethanol, 70% to 90% (Dufey, 2006)
5. Diesel from Palm oil, 70% (Smeets, 1998).
6. Diesel from Rapeseed or sunflower, 20%-60% (Smeets,2008)

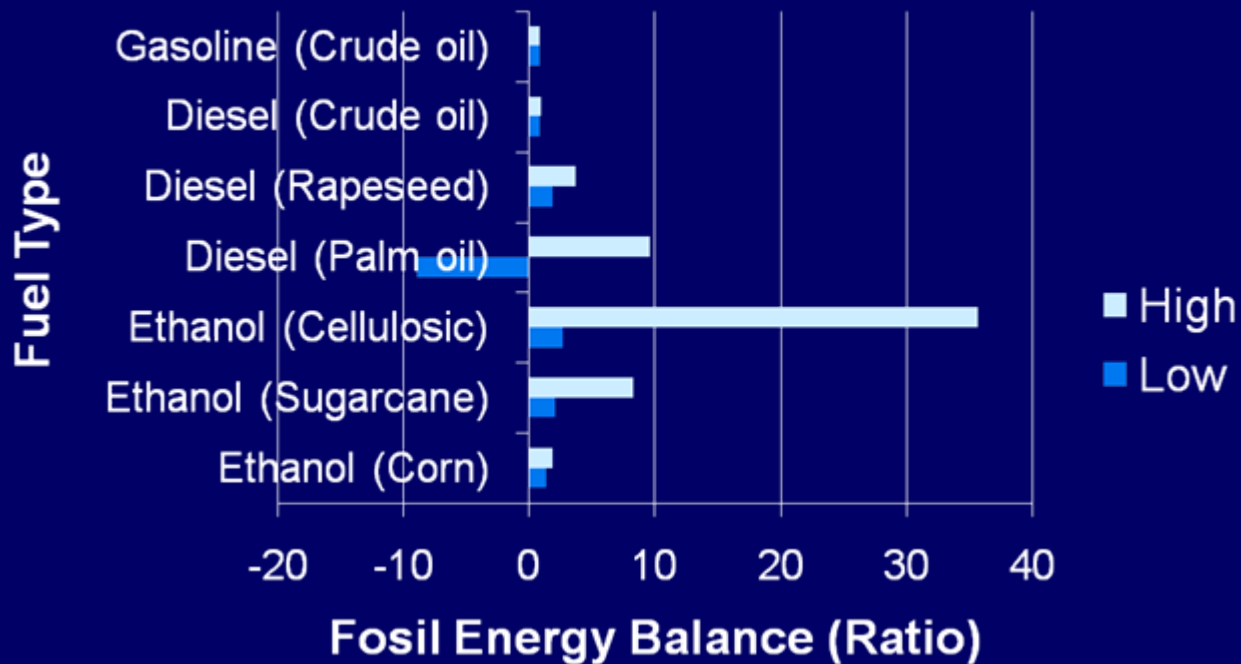
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Fig 4.2a: Greenhouse gas savings





Fossil Energy Balance of Selected Fuel Types



Source: Worldwatch Institute (2006)



4.0 Opportunities and challenges, cont.

4.3 Rural development

- Biofuel production can create employment opportunities . However, working conditions may be poor.
- Biofuel production may also improve rural livelihoods.
 1. The growing of crops such as Jatropha may lead to restoration of degraded areas, and hence improve rural livelihoods of the local communities
 2. Biofuel projects may also qualify for carbon credits of the Clean Development Mechanism of the Kyoto Protocol. Livelihoods may improve because of these projects.



5.0 Opportunities and challenges, cont.

4.4 Fuels versus food debate: The arguments (Dufey, 2006):

- ❑ Use of land for biofuel development will negatively affect food production and increase food prices
- ❑ Land is available for biofuel production
- ❑ Fuel production can restore degraded lands by growing crops such Jatropha

5.6 Large scale versus small scale production



5.0 Biofuels Development in Botswana

- Important Indicators
- Botswana's Energy Balance
- Biofuels in Botswana

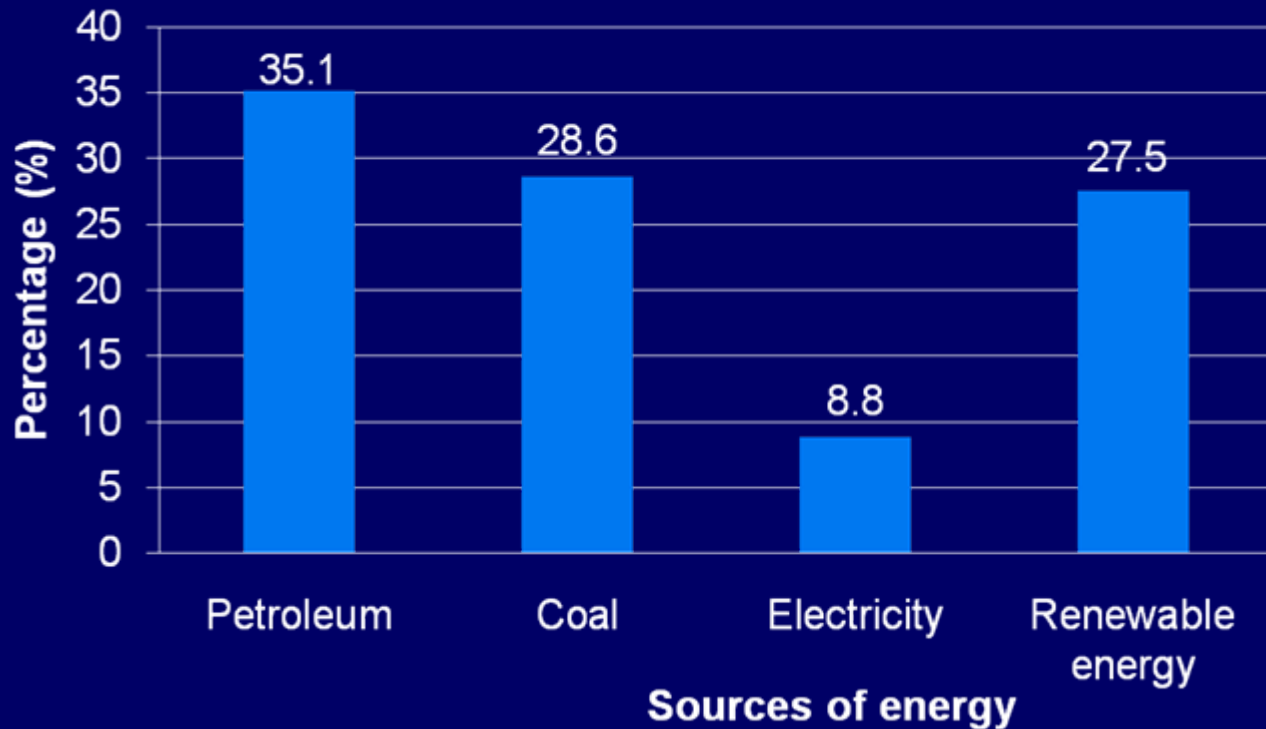


5.1 Table 1: Botswana: Important Indicators

| Indicator | Magnitude | Comments |
|---|-------------------------------|--|
| Land area | 582 000 km ² | Land locked country; same size as Kenya or France |
| Mean annual rainfall | 475mm | Semi-arid climate; rainfall ranges from 250 to 650mm |
| Population (2006) | 1.8 (million) | |
| GNI per capita (2006) | 5 900 USA \$ | Economy very dependent and vulnerable to external factors |
| PPP GNI (2005) | 12 250 USA \$ | |
| HDI Ranking (2005) GDP per capita-HDI rank | 124 -70 | Indices for 177 countries (Iceland being number 1 and Sierra Leone being number 177). Human development lower than it was in 1990. |
| CO ₂ Emissions | 2.3 per capita metric tons | The Figures for SA and Zambia are 7.9 and 0.2 |

5.0 Biofuels Development in Botswana (cont.)

5.2 Botswana energy balance, primary energy supply (2005)





5.0 Biofuels Dev in Botswana

5.3: Biofuels in Botswana

5.3.1 Feasibility study on biofuels

- A feasibility study was undertaken in 2007 on behalf of the Ministry of Minerals, Energy and Water Resources to assess the potential for the production and use of liquid biofuels for transport in Botswana.
- The following crops were investigated as possible feedstocks:
 1. Jatropha curcas, palm oil, sunflower, sugarcane, maize, and sweet sorghum.
- Results summarised in Tables 2a and 2b



Table 2a: Summary main findings

| | Ethanol | Biodiesel |
|-----------|--|--|
| Market | Potential market for blending with petrol ratio E5. Demand: 24 million litres in 2008; 40 million litres in 2017. | Potential market for blending ratios of B5 and B10; demand will be 20 million and 40 million litres in 2008 and 28 million and 56 million in 2017. |
| Feedstock | Sweet sorghum and sugarcane have been identified due to their low production of bioethanol. Farming suitable for large scale farmers. Production cost is P50 to P60/ton. | Jatropha; produced by small-scale and large scale farmers. Production cost is P530 to P610 for plantations producing seed |



Table 2b: Summary of Main Findings

| | Ethanol | Biodiesel |
|---------------------------|---|---|
| Land availability | Suitable land identified in Chobe District . Plant to be located in Kasane | The most suitable land is found in Central District . Plant could be 150 million litres |
| Technology and plant size | Plant size of 20 million litres of bio-ethanol/year. Should be centralized and be within a radius of 25 km of the feedstalk plantations | Plant size 50 million litres/year |
| Financial analysis | Ethanol will be competitive with fossil fuel if there is 50% reduction in levies | Bio-diesel will be viable if there is a reduction of levies by 75% that currently apply to fossil diesel. |



5.0 Biofuels Development in Botswana (cont.)

5.4 Current Government Initiatives:

5.4.1 Biofuels Policy on Biofuels .

- The Government is still developing biofuels policy. **Statements on biofuels are included in the BEMP, Draft Energy Policy, and NDP 10.**
- **The absence of the policy is holding back biofuel development .**

5.4.1 Proposal for Biodiesel Development

- Biodiesel plant: 50 million litres which will use jatropha as a feedstock will be established (Mabowe, 2009).
- The plant will cost P100 and 150 million, and will be located at Kgatleng District, where the Government is building a strategic oil reserve (Mabowe, 2009).
- A 20 000 ha of land will be identified in order to grow Jatropha

5.4.2 Research Activities: germplasm dev. to processing; envir impacts



6.0 Potential impacts of Biofuel Prodn in Botswana

6.1 Biodiversity and Ecosystem Impacts (+ or –ve)

- In marginal lands, the impacts on biodiversity may be positive as biofuels will restore these lands.
- Land conversion of land from forest or grassland to crop production will create biodiversity loss.
- Since the plantations of biofuels will be of single species, there might be problems of new pests and diseases. However, Van Eijk (2007) notes that no known diseases or pests are associated with *Jatropha*.
- *Jatropha* is also not invansive, according to information from the COMPETE Project field trips and seminars in Mexico.



7.0 Potential impacts of Biofuel Prodn in Botswana

6.2 Food Security

- ❑ The impact on food security may be limited as the feedstocks of Jatropha and sweet sorghum will be grown on marginal land. Out of a total of 682 000 arable land, about 200 000 (29%) is marginal land and the rest (71%) is suitable land.
- ❑ Jatropha requires an average rainfall of 300 to 1000 mm per year (FAO, 2008).
- ❑ However, as the demand for biofuels increases, there might be pressure to use good land for biofuels.
- ❑ There is idle land which could be used for biofuels. Out of 432 000 ha of suitable land in Botswana, only 120 000 ha (28%) is tilled; the rest (72%) is idle land (Modise, 2009). Land is not readily available to those who need it because it communal (Modise, 2009).
- ❑ Biofuels production may contribute to high commodity prices (compete for inputs with food crops) and therefore have a (-) effect on food security.



6.0 Potential impacts of Biofuel Prodn in Botswana

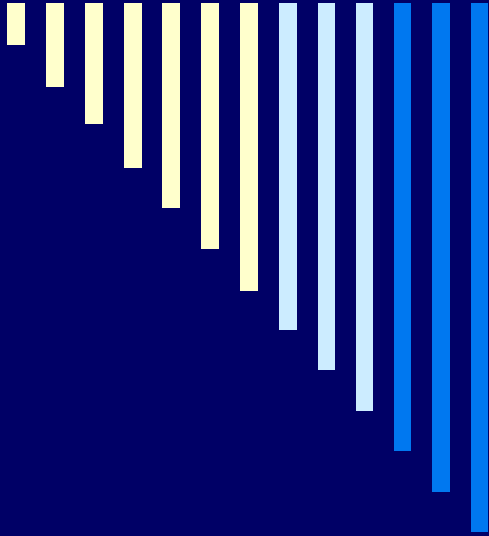
6.3 Local livelihoods

1. Biofuel development in Botswana may lead to:
 - access to energy in remote areas outside the electricity grid.
 - enhancement of agricultural production in the long run.
 1. high food prices may give farmers an incentive to increase food production, if there are no market distortions
 2. Biofuels crops are cash crops, and therefore increase agricultural output.
 - Restoration of degraded or marginal areas as drought resistant crops may be grown on these lands.



7.0 Concluding Remarks

- Production of first generation biofuels should be tried in Botswana, but measures should be taken to ensure that production is sustainable in social and ecological terms.
- The Department of Energy should promote research on the development of second generation biofuels in Botswana.
- The use of marginal land or land with low opportunity cost should be promoted as suggested by the Government.
- Water resources likely to be a major constraint : location for biofuel activities should be well planned.
- Need to avoid conflict with other landuses (forest reserves, wildlife conservation tourism) in areas such as Chobe and Okavango Delta with abundant water resources.



Thank you for your attention