MAPPING FOOD AND BIOENERGY IN AFRICA

EXECUTIVE SUMMARY

A report Prepared for FARA

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REPORT CONTENT

1. Introduction and presentation of the report.

Bioenergy interest has gained much attention in the last years due to the positive issues that it can bring specially for developing countries but at the same time because of the many concerns on risks and trade-offs that could generate. FARA considers that the production of bioenergy crops will need to take into account a) a broader understanding of the extent of the issues and concerns surrounding food to bioenergy conversion and b) the accompanying policy/institutional dimensions as input to the development of an appropriate and truly responsive food and bioenergy programs in developing economies

This report focuses on assessing Africa's ability to fulfil the following objectives:

a. Generate regional evidence on the frequency of the conversion of cash food crops to biofuels.
b. Determine perceived issues and concerns of this conversion by sector (regional, national, household).
c. Establish early indication of the impact (trends, patterns) to anticipate future scenarios.
d. Undertake policy and institutional mapping as well as analysis to better understand the policy and institutional dimensions of the food and bioenergy interphase.

Report Approach:
According to the development of, and interest in bioenergy production in Africa, this report focuses on a selection of countries in order to cover different regions from Africa:

- West Africa: Senegal and Mali
- East Africa: Kenya and Tanzania
- Southern Africa: Mozambique and Zambia

Figure 1 shows the countries assessed in the report. Mapping of policies and institutions in Ghana is included as a reference. The selected countries are those where a core sub-set of data is available and where relevant biofuel production is taking place. Other countries such as South Africa also have biofuel production, but considering the GDPs of the continent, those with more risk for impacts were selected.

Figure 1. Map of Africa and selected countries. Source: http://www.africamap.com/

According to ERA-ARD[1], the following are the expected outputs of the project:

1. Report on the impact of food-to-biofuel conversion inclusive of the;
    a. Detailed methodology, data summary and analysis
    b. Extent of cash food crops to biofuel conversion
    c. Issues and concerns of conversion phenomena
    d. Early indications of the impact of conversion on smallholder farmers' food security and livelihood sustainability.

For each country the following points were included according to availability of data.

1. Country characteristics:
2. Population size and characteristics (gender)
3. Gross Domestic Product, Human Development Index
4. Main food crops and importation / exportation of food and other agricultural products
5. Livelihoods characteristics : average income for farmers; type of property in farms (private, communal, tribal);
6. Policies: agriculture, energy, environment, land use, other. Link with the bioenergy sector
7. Biofuels industry/programmes development : main crops (potential crops), land used, projects associated, technical conversion practices
8. Crops used for biofuels:
9. Mapping of policy and institutions:

The report on institutions follows a top-bottom approach in order to map institutions involved (or not involved) in biofuel development. The focus considered was based on government (particularly ministries of energy and agriculture), private sector, NGOs, and CBOs.
If available data for case studies is possible to gather, it will be integrated for the better understanding of the development of the industry and relative impacts on food production or security.

The methodology for the mapping of policy and institutions firstly identifies the stakeholders for bioenergy crops and agriculture at national level. Then, stakeholders at the production level including NGOs, farmers, other civil organisations and the industry sector (including also farmers with different forms of participation (e.g. outgrowers).

We considered a four-way assessment matrix including stakeholders from the local government, the national government, NGOs (including other civil organisations) and industry. These last two may include also farmers but at different levels of organisation.
The links between these different bodies and stakeholders are expressed with the lines as direct, indirect or needed and the closer these lines are the closer the relationship between the stakeholders is or should be.

[1] *ERA-ARD is an FP6 Project of the European Commission's ERA-NET Scheme. The Agricultural Research for Development (ARD) and Dimension of the European Research Area (ERA) information can be found in http://www.era-ard.org/.*

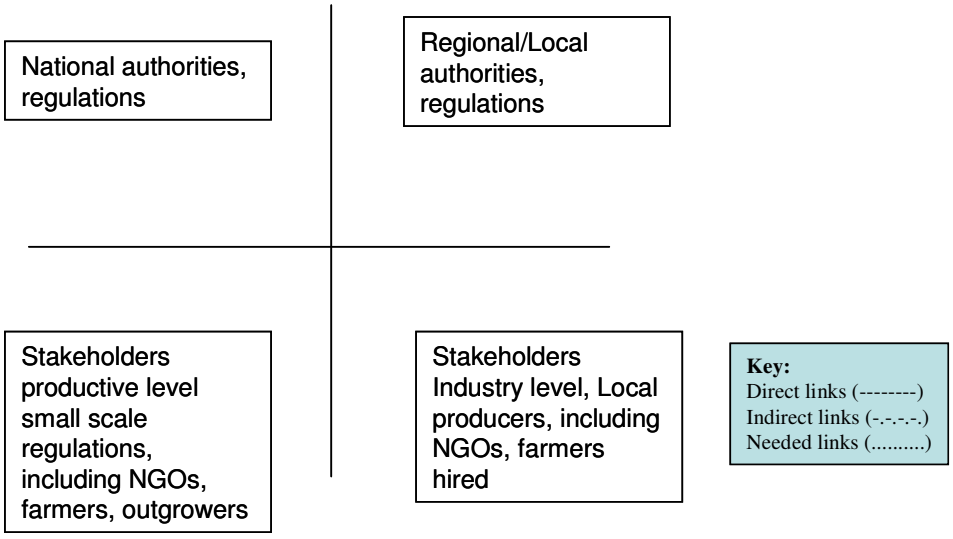


Figure 2. Diagram for Mapping of policies and institutions.

2. African bioenergy development

Africa's biomass energy resources vary geographically and are not uniformly distributed (Karekezi, et al. 2008). Biomass energy use depends on a number of issues including geographical location, land use patterns, preferences, cultural and social factors. Income distribution patterns also contribute to variations in biomass energy use, with poorer African countries relying on traditional forms of biomass, and wealthier African countries using more modern biomass energy technologies (Karekezi et al, 2008). Figure 3 shows comparative areas in different countries in Africa in 2005, where forest area and arable land extension is compared to overall land area data.

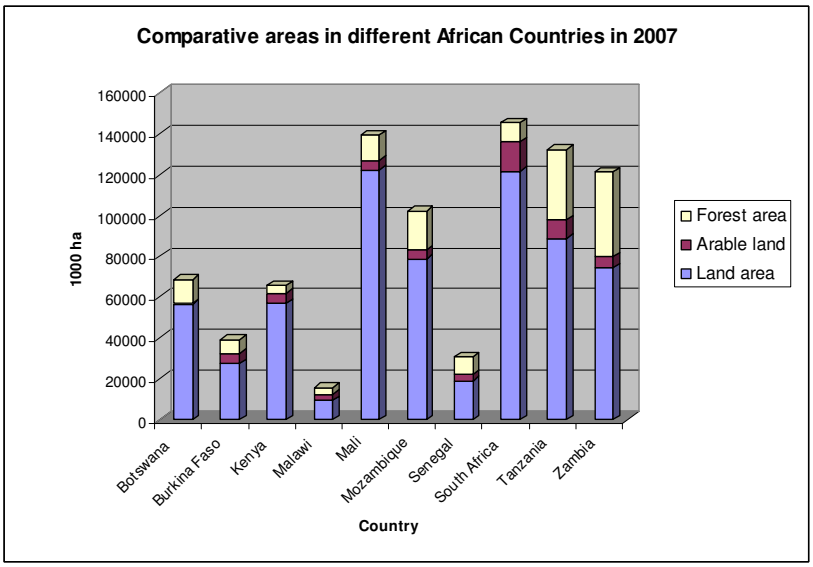


Figure 3. Land area, arable land area and forest area in different countries in Africa (Source: FAOSTAT, 2010).

The low per capita national incomes as well as the slow growth in conventional energy use, influences the heavy reliance on biomass energy in Africa which is considered unlikely to change in the near future. Estimates indicate that by 2020, traditional biomass energy use is expected to increase roughly at the same rate as population growth rates (IEA, 2003), resulting in modest changes in the share of biomass in total final energy supply (Table 1). On the contrary, the share of biomass in total final energy supply in developing countries is expected to decrease in the same period. According to the IEA (in UNIDO, 2008), the absolute number of people relying on biomass energy in Africa is also expected to increase between the year 2000 and 2030 - from 583 million to 823 million, an increase of about 27% (Table 2). However, the actual quantity of energy provided from biomass is expected to increase in all cases

Table 1. Projected Final Biomass Consumption in Relation to Total Energy Use, 2000 and 2020 (UNIDO, 2008).

Country/ Region	2000				2020			
	Biomass Mtoe	Conventio-nal Energy Mtoe	Total Mtoe	Share of biomass (%)	Biomass Mtoe	Conventio-nal Energy Mtoe	Total Mtoe	Share of biomass (%)
China	214.48	943.4	1,157.9	18.50	224	1,524	1,748	13.00
Asia	343.20	467.74	810.94	42.30	394	1336	1730	22.80
Latin America	69.34	284.96	354.30	19.570	81	706	787	10.00
Africa	221.10	1,57.37	378.47	58.40	371	260	631	59.00
Total non OECD	859.65	2,417.86	3,277.51	26.23	1,097	5,494	6,591	17.00
OECD countries	126.17	3,551.32	3,677.49	3.40	96	3,872	3,968	2.00
World	985.2	5,969.18	6,955	14.20	1,193	9,365	10,558	11.00

Table 2. Total Final Energy Supply Including Biomass Energy in Africa (UNIDO, 2008).

	2020		Annual growth Rate (%) 2002-2020
	Biomass (Mtoe)	Share of biomass in total supply (%)	Biomass
Africa	367	43	1.9
Total developing countries	1,127	18	1.1
World	1,428	10	1.4

Source: IEA, 2003 in UNIDO (2008).

The production of biofuels (bioethanol and biodiesel) in Africa is likely to increase, in order to meet local demand and also external demand for biofuels in advanced economies in the EU and the Far East (Lula Da Silva, 2007 in Karekezi et al, 2008). Nevertheless, it is necessary to apply sensitive and equitable management as large-scale modern biomass energy development can lead to further marginalisation of the rural poor. However, the growth and development of modern technologies could provide better incomes particularly for smallholders. Mauritius provides a model example of where a share of the benefits from large-scale co-generation plants that flow to low-income farmers have increased over time through direct policy interventions and an innovative revenue sharing mechanism (Deepchand, 2002; Karekezi et al, 2002 in Karekezi, 2008).

3. Policy mechanisms to encourage the use of biofuels.

Policy and regulatory support is necessary for the successful implementation of improved and modern bioenergy projects as has been recommended by some international initiatives such as the Global Network on Energy for Sustainable Development (GNESD[2]). There are a number of international, national and regional initiatives in Africa regarding policies and plans. For instance, the 2007 Addis Abba Declaration that emanated from the First High Level meeting of African bioenergy stakeholders, committed the continent to sustainable bioenergy development. The Seminar was organised by The African Union Commission along with the United Nations Industrial Development Organisation (UNIDO) and the Brazilian government. The political declaration put out will, among other things, facilitate:

[2] *http://www.gnesd.org/*

a) the development of enabling policy and regulatory frameworks for biofuels development in Africa
b) the formulation of guiding principles on biofuels to enhance Africa's competitiveness while minimizing the risks of biofuels development for small-scale producers
c) the encouragement of the engagement of development partners to enable North- South and South-South cooperation in biofuels development (Jumbe and Msiska, 2007).

The meeting also called for the engagement of public financing institutions to support biofuels projects and proposed the establishment of a forum to promote access to biofuels information and knowledge (IISD/UNIDO, 2007).

There are several countries in Africa which have programmes either directly related to biofuels production or related to issues regarding its production (e.g. Tanzania, Mozambique, Kenya). Furthermore, some other initiatives are present in the continent, such as the South African Biofuel Association, the Biofuels Association of Zambia, the *Programme for Basic Energy and Conservation* (ProBEC) which is a Southern African Development Community (SADC) project, implemented by the German Development Co-operation (GTZ).

In contrast to the development of bioenergy policies in other regions of the world, Africa does not have a comprehensive regional policy on biofuels to regulate the growing industry. This lack of a regional policy and strategy has led to underinvestment into biofuels research and development in Africa. The regional economic communities in Africa such as ECOWAS, SADC, AU/NEPD and EAC are playing and must play an important role in supporting the development of the biofuels industry in Africa. A number of international aid organisations are collaborating with different countries in Africa on the generation of the policies (GTZ in Mozambique, SIDA (Swedish Development Agency) in Tanzania, CIRAD - Centre de Coopération Internationale en Recherche Agronomique pour le Dévelopment- in Burkina Faso).

In terms of policies and regulations, one of the issues that deserves special attention are the land use tenure frameworks in some African countries. Land is often considered to be a national asset and can only be leased. Moreover, the right of occupancy can also be "revoked" if necessary (e.g. in Tanzania). In the case of Zambia, the National Energy Policy stipulates that there should not be sale of land involved in any development agreements entered into with the Minister of Energy. This enforces to keep the land resource rights in the country.

4. Land use

Using GIS (Geographical Information System) coupled to relevant databases, the COMPETE project - Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa (2007) , assessed the available land resource base (arid and semiarid) for bioenergy including biofuels in Africa. As a precaution against detrimental impacts on biodiversity, all categories of protected areas, closed canopy forests and wetlands were designated as **unavailable** for bioenergy crop production and filtered out from the regions shown in the base map (Figure 4; Watson, 2008). Watson concluded that the land area remaining as available and/or suitable for bioenergy crop production are: closed or sparse grassland, open grassland with sparse shrubs, open deciduous shrubland, deciduous shrubland with sparse trees, deciduous woodland, mosaic forest/cropland and mosaic forest/savanna (Figure 5). Grasslands and woodlands particularly in sub Sahara's semi arid and arid regions generally have a very high biodiversity and play a very significant role in environmental services and rural livelihoods (Watson, 2008).

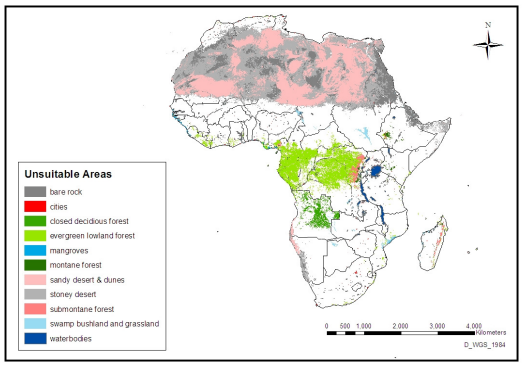


Figure 4. Land covers unsuitable for bioenergy crops in Africa

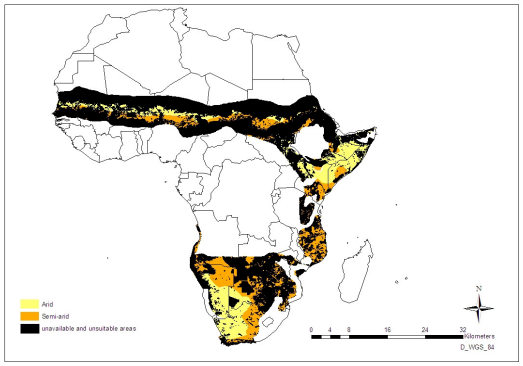


Fig. 5. Areas that are unsuitable and /or unavailable for bioenergy crops in sub-Sahara's arid and semi-arid regions

Figures 6 and 7 show the variation in arable land area and forest area between 1970 and 2005 for a range of countries. The largest variation is observed in Tanzania, where the forest area has decreased by 6.2 million ha over this period. South Africa has seen the most noticeable change in arable land, during the 1990s.

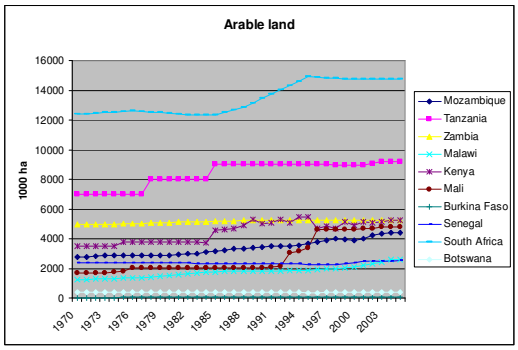


Figure 6. Arable land area evolution in selected African countries 1970-2005

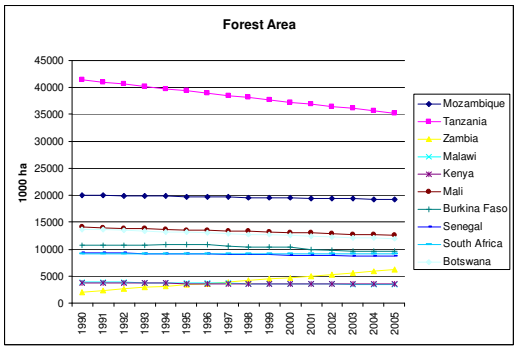


Figure 7. Forest area evolution in selected African countries 1970-2005

Furthermore, the project presented case studies in South Africa, Botswana, Zambia, Tanzania, Kenya, Mali, Burkina Faso and Senegal. A second set of maps used the semi arid and arid regions of each of these countries as a template on which available and suitable areas for bioenergy crop production, roads, railroads, rivers and populated places are sequentially shown and variously labelled (Watson, 2008). These maps also included data from ESRI (2006) on populated places.

This assessment shows that Mozambique has immense agricultural potential, with an estimated 36 million ha of arable land, of which only 10 percent is presently in productive use (figures 8 and 9). The wide diversity of soil types and the diverse climatic conditions in the country are suitable for a large variety of crops. Most of the agriculture practiced in Mozambique is non-irrigated. However, Mozambique's network of more than 60 rivers has allowed for the construction of irrigation schemes. Total potential irrigated area is estimated at 3.3 million ha. At present the agricultural sector is still dominated by the family sub-sector which accounts for 90 percent of the cultivated areas and includes 2.5 million households. This sub-sector relies on rain-fed farming using very basic techniques resulting in low yields.

The remaining arable land is cultivated by large commercial farms that concentrate on cash and export crops (SADC, 2008).

The specific habitat requirements of various bioenergy crops needs to be evaluated in order to identify the best potential candidates in different parts of each country. The current area used for the main bioenergy crops (sugarcane, jatropha and sweet sorghum) is presented in the next section.

5. Existing and potential Biofuel Crops in Southern Africa

Smeets *et al.* (2004) revealed that compared to all the world's major regions, sub-Saharan Africa has the greatest bioenergy potential as a result of large areas of suitable cropland, large areas of unused pasture land and the low productivity of land under agriculture (Watson, 2008). There are six main crops for producing conventional, so-called first generation, biofuels in Southern Africa: sugar cane, sweet sorghum, cassava, jatropha, maize, soybean and sunflower. The potential for each of these crops is assessed below.

Sugar Cane (*Saccharum* spp.)

Most of the land suitable for sugar cane production in the Republic of South Africa (RSA) is already being used as such and therefore its potential for expansion is limited (Watson, 2007). Irrigated land in RSA increased in late 1990s but now stringent legislation has been brought in to protect its scarce water resources. Therefore, unless drought tolerant varieties are introduced, this too will be a limiting factor in the country, making it an unlikely candidate for bioenergy in arid and semi-arid areas.

However, in southern Africa as a whole, Phillips (2002) estimated that a 50% increase in the region's 2000 sugarcane production, would require expansion of 200 000 ha of land and create 100 000 jobs. Using GIS, it was discovered that large areas of land are available and suitable for sugar cane cultivation, especially in Mozambique, Malawi and Zambia. The analysis suggests that 'land' is unlikely to be a limiting factor in harnessing sugarcane's bioenergy potential (Watson, 2007). Indeed, between the three mentioned countries, it was estimated that more than 3.7 million ha were available for sugar cane expansion, as illustrated in Table 4.

Table 4. Land availability in Malawi, Mozambique and Zambia (Watson, 2008).

	Malawi		Mozambique		Zambia	
	1000ha	%	1000ha	%	1000ha	%
Country area	9408		78409		74339	
Potentially suitable for sugarcane	742	7.9	4906	6.3	3546	4.8
Protected areas filtered out	595	6.3	4602	5.9	2433	3.3
Slopes > 16% filtered out	580	6.2	4530	5.8	2427	3.3
Crops & wetlands filtered out	316	3.4	3773	4.8	1726	2.3
Existing sugarcane filtered out	314	3.3	3771	4.8	1726	2.3
Areas < 500 ha filtered out	256	2.7	3470	4.4	1485	2.0
Unsuitable soils & rainfall filtered out	206	2.2	2338	3.0	1178	1.6

As Johnson et al. (2006) note, the potential of these countries alone is greater than the current production of cane in SADC. Furthermore, they draw attention to the fact that the areas identified in these countries are better suited for cane-growing than much of the land that is currently under cane in South Africa and Mauritius. The IGBP/IHDP (1995) data suggests that substantial areas of Angola are also suitable for sugarcane production. Now that the country is politically stable and cleared of landmines, a similar GIS analysis to that

described above is currently being carried out under the Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems – Africa (COMPETE, 2008).

According to a recent scoping study from E4tech (2006) for the DTI (BERR), southern (SADC) Africa and the rest of Africa have potential for sugar cane production. The scope was based on the assumption, validated by local experts from industry, academia and NGO's, that it could be feasible to expand sugar cane production in Southern Africa (SADC region) from its current 0.7M ha to around 1.5M ha in the region within the next 10 to15 years (E4Tech, 2006). This 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 (E4tech, 2006).

Cassava (*Manihot esculenta*)

Cassava also called manioc, tapioca or yuca, is one of the most important food crops in the humid tropics, being particularly suited to conditions of low nutrient availability and drought prone areas (Tonukari, 2004). Compared to other crops, cassava excels under suboptimal conditions, offering the possibility of using marginal land to increase total agricultural production (Cock, 1982, in Tonukari, 2004). Cassava is also used to produce starch for industrial use and other products used in processed food. Sub-Saharan Africa is expected to experience the most rapid growth in food demand in root and tubers averaging 2.6 percent per year through 2020 (Scott et al. 2000 in Tonukari, 2004). This growth will account for nearly 122 million metric tons with most of the increase coming largely from cassava, 80 million metric tons (66% of the total). Table 5 shows the Cassava production and use in 1993, and projected to 2020 (Scott et al. (2000) in Tonukari, 2008).

Table 5. Cassava yields, production and use in 1993, and projected to 2020 (Scott et al. 2000) in Tonukari, 2008).

Country Region	Area (million ha)		Yield (mt/ha)		Production (million mt)		Total use (million mt)	
	1991	2020	1993	2020	1993	2020	1993	2020
Sub-Saharan Africa	11.9	15.9	7.4	10.6	87.8	168.6	87.7	168.1
Latin America	2.7	2.7	11.3	15.6	30.3	41.7	30.3	42.9
South East Asia	3.5	3.5	12.1	13.7	42.0	48.2	18.9	24.4
India	0.2	0.2	23.6	28.4	5.8	7.0	5.7	7.3
Other South Asia	0.1	0.1	9.4	13.5	0.8	1.3	0.9	1.4
China	0.3	0.3	15.1	20.2	4.8	6.5	5.1	6.4
Other East Asia	na	na	na	na	na	na	1.8	1.9
Developing	18.8	22.9	9.2	12.0	172.4	274.7	152.0	254.6
Developed	---	---	12.1	14.7	0.4	0.4	20.7	20.5
World	18.8	22.9	9.2	12.0	172.7	275.1	172.7	275.1

Ethanol can be produced from three main types of biomass raw materials: (a) sugar-bearing materials (such as sugarcane, molasses, and sweet sorghum); (b) starches (such as corn, cassava, and potatoes) and (c) celluloses (such as in wood and agricultural residues) whose carbohydrate form is more complex and therefore more difficult to convert to ethanol (Thomas and Kwong, 2001).
Some scenarios highlight the potential for a major future expansion of bioenergy, particularly in the domestic cooking market, in which ethanol – made maize, sugar cane, sweet sorghum, cassava, and sweet potatoes – would be used to make gelfuel that would

substitute for fuel-wood or charcoal (Utria, 2004, in Johnson and Matsika, 2006). For ethanol production purposes, the higher costs of producing ethanol from starch than form sugar need to be considered when evaluating the promotion of different supply pathways (Thomas and Kwong, 2001).

Sorghum and Sweet Sorghum (*Sorghum bicolor* L. Moench)

Sweet sorghum can be grown over a larger area of the RSA and can achieve high yields. It is currently grown for food and for alcohol by small scale farmers and trials started in the Eastern Cape in 2007 to assess its bioenergy potential.
Sorghum has shown low production in some countries in southern Africa, for instance, in Botswana (Figure 8.a). In contrast, trials in Mozambique showed an increasing yield and production without increasing the area harvested (Figure 8.b). In Zimbabwe, the three aspects of production, yield and area harvested showed great fluctuation, which Eriksen et al (2004) considered the result of climatic conditions (Eriksen et al, 2004).

Sweet sorghum is more drought tolerant than sugar cane and can therefore be grown over a wider area whilst still achieving high yields. Trials have also been undertaken in other southern African countries where it has been used as a supplement to sugar cane for ethanol production. It has been shown capable of complementing sugar cane ethanol by extending the production season. Furthermore, the non-sugar fractions of the crop can be used as feed for livestock and the seeds are already a common staple food, helping to address the issues of biofuels competition with food production. Thus, sweet sorghum is seen as a biofuels crop with high potential for the future in the semi arid tropics, including southern Africa.

Jatropha (*Jatropha curcas* L.*)*

By 2004, 400 million *Jatropha curcas* L. trees were planted on 45,000 ha in North West Province of the Republic of South Africa. The South African Government then called for a moratorium on further commercial planting until it was convinced that (a) the plant was not at risk of becoming an invasive alien species, and; (b) its toxicity does not pose an environmental and health risk. Commercial plantings were given the go-ahead in 2007. Some companies have invested in jatropha in Africa.

Maize (*Zea mays spp*)

In 2006, Ethanol Africa (with Ecofields, Grain Alcohol Investments and Sterling Waterford as key shareholders) became South Africa's first bioethanol producer using surplus maize. Due to increased and improved inputs and improved cultivars, the country's maize production exceeds domestic demand in most years– a demand that includes the needs of Botswana, Lesotho, Namibia and Swaziland as part of an agreement of the long standing South African Customs Union. In December 2007, Parliament decreed that maize would no longer be used for this purpose as it was considered a staple food crop.

Soybean (*Glycine max* or *G. soja)*

Soybean has been cultivated in several countries in Africa though in some of them the data shows it has only recently been incorporated into the agriculture systems. The only country which has shown an increment in area harvested, since the mid 1990s, has been South Africa. The production of soybeans in South Africa has increased from 770 t/year in 1970 to 424 000 t/year in 2006. The second ranked country in terms of harvested area is Zambia

which also increased its production from 173 t/year in 1973 to 12 000 t/year in 2006 (FAOSTAT, 2008).

Sunflower (*Helianthus annuus*)

Sunflower production data is not reported for most of the countries reviewed in this report Nevertheless, South Africa has the greatest reported area harvested for sunflower seed (FAOSTAT, 2008). It is not clear if the fluctuations respond to the market or to internal changes in the agriculture system experienced in South Africa, especially at the end of the Apartheid (Eriksen et al, 2004).
In the FAO statistical system (2008) there is reference to some countries production of oil crops but it is not clear which crops are included (e.g. Zambia and Tanzania).

Palm Oil (*Elaeis guineensis* Jacq.)

The palm oil tree (*Elaeis guineensis* Jacq.) is indigenous to West Africa, with natural stands occurring along a 300-mile wide coastal belt ranging from the Gambia to Angola. Oil palm also extends eastward through central Africa and into eastern Africa. In 2002, the African countries which held large areas covered by oil palms were Nigeria (2.6 million ha), Guinea (310,000 ha), D.R. of Congo (formerly Zaire) (220,000 ha), Cote d'Ivoire (190,000 ha), Ghana (125,000 ha), Cameroon (80,000 ha), and smaller areas in Benin, Burundi, Central African Republic, Republic of Congo, Equatorial Guinea, Gabon, Gambia, Guinea Bissau, Liberia, Senegal, Tanzania, Togo, and Uganda (USDA, 2002).
This area of palm oil has extended especially since a number of private initiatives have acquired land to plant oil palm and some international organisations, such as the World Bank, have promoted palm growing in Africa as well as the Malaysian Government (World Rainforest Movement, 2002).
With the controversy over palm oil and rainforest clearance, it is worth noting that FAO, in collaboration with breeders at ASD in Costa Rica, planted cold-tolerant palms in Africa. These palms were able to survive outside of rainforest areas and were planted in Malawi, Zambia, Ethiopia and the highlands of Kenya and Cameroon. In addition to not competing with rainforest, the precocious hybrid showed improved drought tolerance and gave high yields with minimal inputs (Griffee et al., 2004).

Potential Indigenous Biofuel Crops

Pappea capensis Eckl & Zey. and *Ximenia caffra* Sond. are trees indigenous to southern Africa. In 2006, South Africa's Department of Mineral and Energy Affairs suggested that oil from their seeds may have potential for biodiesel production. This suggestion is based on their being able to grow in arid regions and their seeds containing high oil concentrations. Individual trees of both species can potentially produce up to 10 kg of seed, 65% of which can be converted into bio-oil or biodiesel. One ha of trees could supply 2400 l of oil, or 1560 l of biodiesel per year. Trees are more cost effective to cultivate than herbaceous crops, as they need fewer inputs.

5.1 Food and bioenergy crops in Africa.

The debate on fuel versus food that developed with the food prices in 2008 has produced some reports that have been looking at the potential problems at regional level. For instance, the report from UEMOA (2008) conducted in West Africa. The report concluded that region has the land, resources and demand to improve their agricultural and bioenergy production.

This report also considered that policy changes that improve agricultural productivity and include more arable land into sustainable use have the potential to improve food and fuel production. Furthermore, the use of waste and residues for bioenergy also contributes to the reduction on the problem of fuel and food production (UEMOA, 2008)

The following section covers the case studies considered for the report. These case studies look at the country characteristics, their potential for bioenergy crop productions including the stakeholders involved and the possibilities for food and fuel production without jeopardizing the current and future food production in Sub-Saharan countries.

CASE STUDIES

6. SENEGAL CASE STUDY

Country characteristics

Location
Senegal is the most western country in Africa and is bordering at south with Guinea and Guinea Bissau, at East with Mali, at North with Mauritania and at West with the North Atlantic Ocean.

Geographical characteristics:
- Area: Total surface: 196,190 km² with 192,000 km² of land and 4,190 km² of water. Coastline is of 531 km.
- Terrain: The country is generally flat with hills in Thies and foothills in the South oriental part.
- Climate: The country is characterized by a dry tropical climate. Temperatures are moderate along the coast (16-30°C) and rise gradually as one moves away towards the continent (35-45°C).

Environmental characteristics: The key environmental challenges are illustrated by a fauna and a flora threatened by poaching, deforestation, overgrazing, soil erosion, desertification and overexploitation of fishing resources

Population size and characteristics
- Population: 12,893,259 habitants in 2008
- Population density: 65 hab/km²
- Urban population: 51%
- Rural population: 49%
- Women in 2008: 51%
- Men in 2008: 49%

Gross Domestic Product, Human development Index:
- GDP (official exchange rate): 13 900 million USD (2008)
- GDP per habitants : 1600 USD (2008)
- Human development index : 0.499 (2005)
- GDP - Composition per sector (2008):
  - Agriculture : 16.1%
  - Industry : 19.3%
  - Services : 64.6%

Population below poverty line: 54% (2008)

Main food crops(FAOstat, 2009)

Product	Has	tons
Peanuts	607,195	331,195
Millet	686,892	318,822
Maize	143,769	158,266
Sorghum	155,919	100,704
Rice	80,312	193,379
Tomato	6,594	178,600
Onions	5,100	142,000

Main crops in Senegal by hectare and tons (FAOstatdata, 2009).

Product	Has	tons
Peanuts	607,195	331,195
Millet	686,892	318,822
Maize	143,769	158,266
Sorghum	155,919	100,704
Rice	80,312	193,379
Tomato	6,594	178,600
Onions	5,100	142,000

Main agricultural and food crops imports(Faostat, 2009)

Rank	Commodities	Quantity (tonnes)	Value (1000$)
1	Rice Broken	1018729	350397
2	Wheat	395742	133974
3	Soybean oil	101776	93160
4	Milk Whole Dried	21444	79722
5	Malt Extract	17455	54255
6	Food Prep Nes	20204	53684
7	Sugar Refined	69387	41377
8	Palm oil	34885	30454
9	Tobacco, unmanufactured	3276	28481
10	Maize	97272	24421

Main agricultural and food crops(Faostat, 2009)

Rank	Commodities	Quantity (tonnes)	Value (1000$)
1	Groundnut oil	68675	67617
2	Food Prep Nes	11627	32189
3	Cotton lint	21415	28522
4	Rice Broken	73139	24729
5	Tobacco Products Nes	1337	16972
6	Tobacco, unmanufactured	1758	15984
7	Cigarettes	1783	13710
8	Tomatoes	8858	8639
9	Beans, green	6685	6512
10	Pastry	6581	6069

Land characteristics and tenure
Agriculture is 77 %f the economically active population. Only 12 % of the land area is cultivated (NADEV, 2009).
Tenure system is largely a customary. The *Chef de Terre, or Land Chief*, acts as custodian of community land and distributes it among households. Land is inherited through family lineage

Characteristics of livelihoods
Rural areas are characterized by poverty making 75% of the rural population poor. They are mainly farmers, women and young people who survive on subsistence crops and livestock on small plots that are often not sufficient to cover the needs of their families.
Groundnut production accounts for around 40 per cent of cultivated land, taking up 2 million hectares, and provides

from father to son. In recent decades, a shift to intensive agriculture and private tenure has reduced the powers of the lineage land chief. Yet the practice of collective management of family land is still largely observed (Platteau *et al.* 2000 in Platteau et al 2005).	employment for as many as 1 million people
Policies in place and link with the bioenergy sector • Agro-forestry-pastoral Guidance Law" (2004) • Plan REVA (2006) and the GOANA (Great Agricultural Offensive for Food and Abundance, 2008). • Energy Policy • Sustainable Development Strategy and a Sector Policy Letter for Environment (LPSE)	**Biofuel program** National Program for Biofuel Production, with the aim of contributing to national energy self-sufficiency in the production of bio energy alternatives. This program provides, by 2012, to cover 321000ha of Jatropha plantation in the 321 Rural Communities that form the country, with a production goal of 1190.000.000 litres of refined oil from seeds. Phase 1: Production of raw material (Jatropha seeds) 2007 - 2012. Phase 2: Processing Jatropha seeds into oil Phase 3: Biofuel distribution
Crops used for Biofuel *Jatropha curcas* for biodiesel and crude oil fuel; Sugarcane for ethanol production For its second phase (processing Jatropha seeds into oil), the National Biofuel Program has the intention to use oil presses or light expeller units for on-farm or community Biofuel production. Biodiesel production plants will be used at industrial level. Market: The Biofuel program is actually at plantation stage.	**National Ministries/Secretariats involved:** - Ministry of Agriculture and Aquaculture and Biofuel (2007) - Ministry of Scientific Research and Biofuel (2008 – September 2009) - Ministry of Energy and Biofuel (October – December 2009) - Ministry of Biofuel and Aquaculture (since December 2009) APIX – Agence Nationale pour la Promotion des Investissements et des Grands Travaux

Implications for land tenure, water and employment:

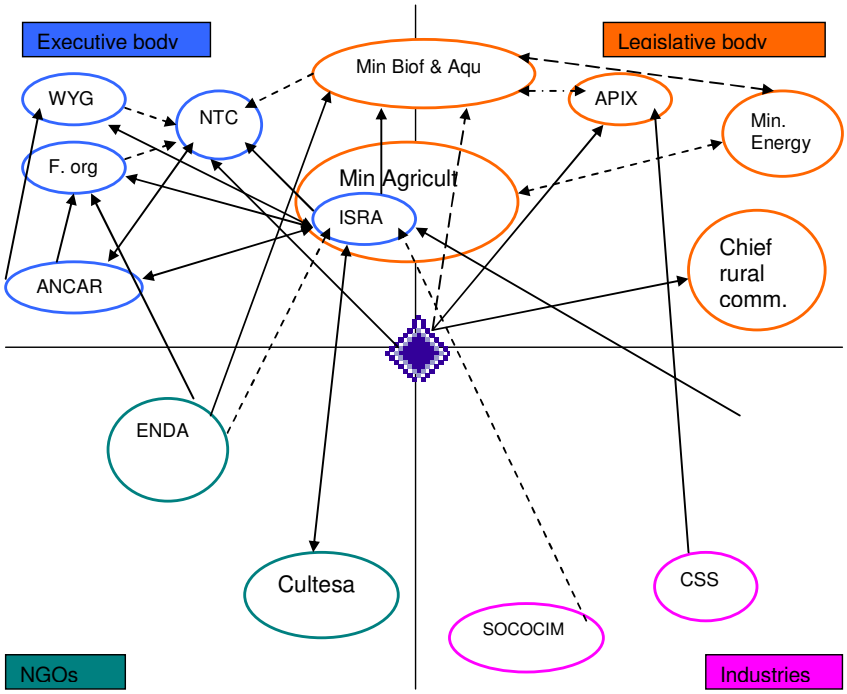
The national Biofuel program has planned to cover 1 000ha of Jatropha in each rural community. This very arithmetic orientation may create land tenure problems because, some of the rural communities do not have enough land to host 1 000ha for this new additional crop, unless there is land expropriation or potential conversion from land-for-food crops to land-for- energy crops.

Food security may also be affected when good oil price conditions can attract peasants to switch their traditional food crops to Jatropha cash crop. National Biofuel program's approach should give consideration to this situation and reformulate its position about land tenure.

Water: In order to mitigate water problems or conflicts with food crop irrigation, Senegal has opted for rain fed cultivation of Jatropha which is a plant with less water need. Though it is important to notice that, in areas with rainfall less than 700mm, young Jatropha plantations, for survival, need to be watered in the first two years. Water problems may then occur in most rural communities comprised within these isohyets. In these agro-pastoral areas, conflicts in water affectation can be expected if Jatropha is planted at large scale as planned in the Biofuel program.

Employment: The National Biofuel Program has the aim to boost employment in rural areas.

Mapping of policy and institutions



Legend:

Direct ——————→ (Documents/product submission required)

Indirect ——————

Needed - - - - - - - - - -

Min Biof & Aqu	: Ministry for Biofuel an Aquaculture
Min. Energy	: Ministry for Energy
Min Agricult	: Ministry of Agriculture
Chief rural comm.	: Chiefs of rural communities
APIX	: National agency for the promotion of investment and major works programs
ISRA	: Senegalese Institute for Research in Agriculture
NTC	: National Technical Committee
WYG	: Women and Youth groups
F. org	: Farmers organization
ANCAR	: National Agency for Rural and Agricultural Advisory
Cultesa	: Centre for Research in Biotechnology – Tenerife - Spain
SOCOCIM	: Local cement industry
CSS	: Senegalese Sugar Company
SFTX	: Cotton industry

Summary of biofuels activities implications in Senegal

Issues	- Enough marginal lands suitable for Jatropha cultivation. - Jatropha is locally adapted and well known as fence crop. - Raising demand from farmers to join the national Biofuel program (NBP).	Biofuel conversion technology from Jatropha seed has not started yet	- No market supply yet; untested market - Real market potential for local consumption.
policies	- Strong Government political will, illustrated by a new ministry for Biofuel and by the NBP implementation - The NBP provides seeds and seedlings with high yield varieties to partners. It offers also technical support - Many on-going agricultural research.	- NBP has opted for light expeller units for on-farm biofuel production and encourage the development of biodiesel production plants at industrial level - Government through APIX (Agency for the promotion of Investments) provides needed administrative, informative and counseling supports to investors.	- In NBP conditions, biodiesel will be sold to the State or to private market organizations in a price fixed by a State/partners agreement. -
Emergent patterns/relationships	- Professionalization of the Biofuel sector: A Biofuel chain network has been launched in 2009. - Emergence of new private Jatropha nurseries run by trained rural women groups and youth groups. - Land tenure based on protection of national patrimony: land belongs to the state and is not subject for sale or lease.	- Expansion of small scale expelling units is expected in rural areas. - Raising interest and demands from local and foreign investors, on investing to biofuel - For biodiesel plants, two types of feedstock from farmers is planned: oil and seeds	Private actors and structures are already organizing themselves into a professional network in order to anticipate and prepare future market dispositions
Impact/ future implications	- Valorization of poor lands in this desert margin country. - Soil fixation against land erosion. - New income generation for rural population. - Risk for food to Biofuel conversion because of a lack of policy protecting food production areas.	- Acquisition of new technical skills for rural populations involved in on-farm biofuel production. - Boost employment and increase income in rural areas. - Protection of the national economy: For any biodiesel industry establishment, 51% of the capital should belong to Senegalese (according to the NBP conditions).	- New source of income for Jatropha seed and oil rural producers. - Significant reduction of mineral oil invoice at national level

Conclusions

Senegal's interest in promoting a biofuels programme (NBP) responds to the ongoing activities mainly with Jatropha. The country does have restrictions on energy access and most of the fossil fuel needs to be imported.
There are areas in Senegal where water availability does not represent a problem for agriculture while the extension of the Sahel continues to be a problem. Considering the development of biofuels as an activity in the agriculture sector, there is still a need to link the objectives and in-field activities of the Agriculture Ministry, the Biofuel Ministry and with the Energy Ministry.

According to the research more rural communities are engaging in the cultivation of Jatropha but there is still little evidence of the mechanisms necessary to fully incorporate farmers in a more skilled manner in these activities. Despite the imports on food products (e.g. rice) there is also no evidence of a threat of food production regarding the biofuels activities in the country. Nevertheless, the future activities (considering the Biofuel Program) need to be cautious for large scale production. The Biofuel Programme is focused on one single crop

(Jatropha) and despite that one of the objectives is to look for crop diversification, there might be the risk of putting all efforts into one single crop.

However, Senegal should take opportunity from this less water needed crop (Jatropha) to revalorize its marginal Sahelian lands. Large scale production and the increasing number of demands from foreign investors could be oriented toward these lands. While in rural farms and in food production areas policy should be better focused to crops that can assure food and energy. Sweet sorghum and *Moringa oleifera* are adapted and well known by local farmers. These two food/energy crops will at the same time contribute to the achievement of diversification objectives.

The country is continuing an Agricultural reform process focused on food products but also on other crops (e.g. groundnuts). These reforms may have a benefit in terms of agricultural production such as improving the yields. If adequate measures are taken there is no need to compromise food and biofuel production at the farm level, benefiting the farmers with additional income and if possible access to electricity.

7. MALI CASE STUDY

Country's characteristics.

Location
Located in West Africa, Mali is lying between 10° and 25° N and 4° and 12° E. Neighbouring countries are Algeria, Niger, Burkina Faso, Ivory Coast, the Republic of Guinee, Mauritania and Senegal.

Geographical characteristics
Surface: 1,241,328 km2 out of which 65% is desertic or semi-desertic. Country divided in three decentralised layers of government: regions (8), cercles (49) and communes (703) plus the capital district of Bamako.

Environmental characteristics
Food production in Mali has historically been highly variable due to fluctuating rainfall, which also influences river levels and hence irrigated as well as rainfed agriculture. This variability, combined with a low percentage of total production entering the market, makes market rises and quantities highly volatile

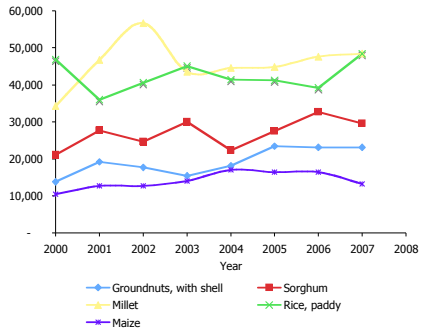
Population Size and Characteristics
Total 14,517,176 inhabitants.
Population growth of 3.6%
Male 48%
Female 52%

Gross Domestic Product and Human Development Index
GDP 8.4 USD billion
GDP per capita $840 USD
Agriculture 45
Industry 17
Services 38
HDI for Mali is 0.371 Rank 178

Agricultural production in Mali (Thousands of Tons)
(FAO Stats, 2009)

Product/Year	2005	2006	2007
Ground nuts	23,426	23,138	23,170
Millet	44,875	47,588	48,464
Rice, paddy	41,248	39,186	48,391
Sorghum	27,511	32,707	29,591
Maize	16339	16396	13160

Evolution of selected agricultural products in Mali



Land characteristics
Total area 124 million has
Forest 5.5 million has
Suitable for agriculture and livestock 43.7 million has
Desert 74.8 million has
Irrigation 2.2 million has
Pastures 49 million has
Land tenure is governed by the "Code domanial et foncier" of 2002 (Ordonnance, 2002). This law in principle recognises customary law but grants ownership of land to the State, while individuals or groups of individuals only have the right of usufruct. Land can be accessed in three ways: renting, allocation or grant.
Although women represent the majority of the agricultural work force less than 2% of women have registered property rights (Foncier, 2009).

Characteristics of livelihoods
Mali depends on small family exploitation (68% of farmers cultivate less than 5ha) (Samake et al, 2009). Mali's agricultural sector is thwarted by numerous constraints relative notably to: a) its physical and institutional environment characterised by: (i) a deficit in rainfall, drought and irregular water levels; (ii) repeated locust outbreaks and invasion by floating plants ; (iii) insufficient water control and non-mastery of the technical conditions of production, attested by a low level of productivity and agricultural wages ; and b) issues relative to land security, factor costs and financing.
It is estimated that a fourth of the households in Mali are in a chronic situation of food insecurity with cereal consumption representing around 50% of household expenses (UNDAF, 2009).

Policies in place and link with the bioenergy sector
The Poverty Reduction Strategy of the GoM (IMF, 2008)
Mali's Investment Code (Code, 2005)
Agriculture Orientation Law (Loi, 2006)
Code of Water (Loi, 2002).

Biofuels industry/programmes development
National Strategy on Biofuels implemented by the National Agency for the Development of Biofuels (ANADEB) legally established on 5th June 2009[3].will develop and then oversee a legal framework to promote investments and development on biofuels

[3] *ANADEB was crated with the law N° 09-006/P-RM agreed by the General Assembly (Parliament) on 04 march 2009 and promulgated by the President on 05 June 2009.*

National Strategy on Renewable Energy, promoted by Ministry of Energy and Water (MEE)	
Biofuel crops: Programme centred on 1) small scale production of Jatropha Curcas oil and biodiesel through groups of farmers and small private farms; 2) industrial ethanol production as by-product of sugar production, from irrigated sugar cane plantations on the Office du Niger (ON) zone. Other vegetable oils, such as cotton and peanut oil, have a high demanded (and margins) in an unsatisfied local alimentary oil market, which makes them unsuitable candidates for biofuel operations. Sorgum and millet are also considered in pilots.	**Ministries and Directions involved** - National Agency for the Development of Biofuels (ANADEB) - The Office du Niger zone (ON) - The West Africa Economic and Monetary Union (UEMOA) - Secretary of State in charge of the Integral Development of the Zone Office du Niger (SEDIZON) National Research Centre on Solar and Renewable Energies of Mali CENESOLER - AMADER is the Malian Agency for the Development of Domestic Energy and Rural Electrification - EDM SA - Electricité du Mali SA - The Agency for the promotion of the investments (API) - Multifunctional Platform Program (PTFM) - Ministry of promotion of Women, Child and Family (MPFEF) - Ministry of Environment and Sanitation (MES) - Agency for the basin of the Niger River (ABFN) - Ministry of Agriculture (MA) Institute of Rural Economy (IER)

Implications of conversion of Biofuel raw material

Land tenure

A recent review of four small Jatropha producers projects and ventures (Mali Folkecentre's Garalo project, Mali Biocarburant SA, the Jatropha Mali Initiative, and GERES) showed that the impacts of these programmes on land tenure and food security, are inexistent, albeit in the medium term (Palliere and Fauveaud, 2009). In all these initiatives, land ownership remains with small Jatropha farmers who normally produce less than 1 ha (many times on intercropped fashion). However, Jatropha adoption is slow due to the land delimiting character of Jatropha (internal land claims need to be solved before planting and limit the number of adopters) and extension services need to be offered, which translates into higher costs for these projects. Land tenure in the ON for biofuel production is through long term land concessions or holdings, which many times include the development of land for irrigation.

Water use

Mali Biocarburant SA has identified water access as one of the main barriers for Jatropha adoption, as it produces overlapping of agricultural calendars between Jatropha and cash crops. However, after cultivation, water use for Jatropha fields outside the ON is likely to negligible impact as few or no irrigation would be implemented.

Farmers in the ON region have large family-based plots cultivating in a low-risk environment as part of a commercial strategy. They produce two crops a year, with rice only in the main season and a mix of rice and shallots or onions in the counter season. The main problem for family farmers in the ON is a high water loss and inadequate drainage. Channel irrigation maintenance in the ON is carried out by 3 layers of responsibility, with the State in charge of the principal channels, the ON of secondary channels and private farmers of tertiary channels that irrigate their fields. However, a recent evaluation of the maintenance objectives found that none of the parties respects their contractual commitments (31% by farmers, 45% by the ON and 70% by the State) (Office du Niger, 2007). Further conflicts with water allocation can exist when the water requirements by the new large projects at the ON

start to become operational in the following 2 to 3 years, especially during the counter season.

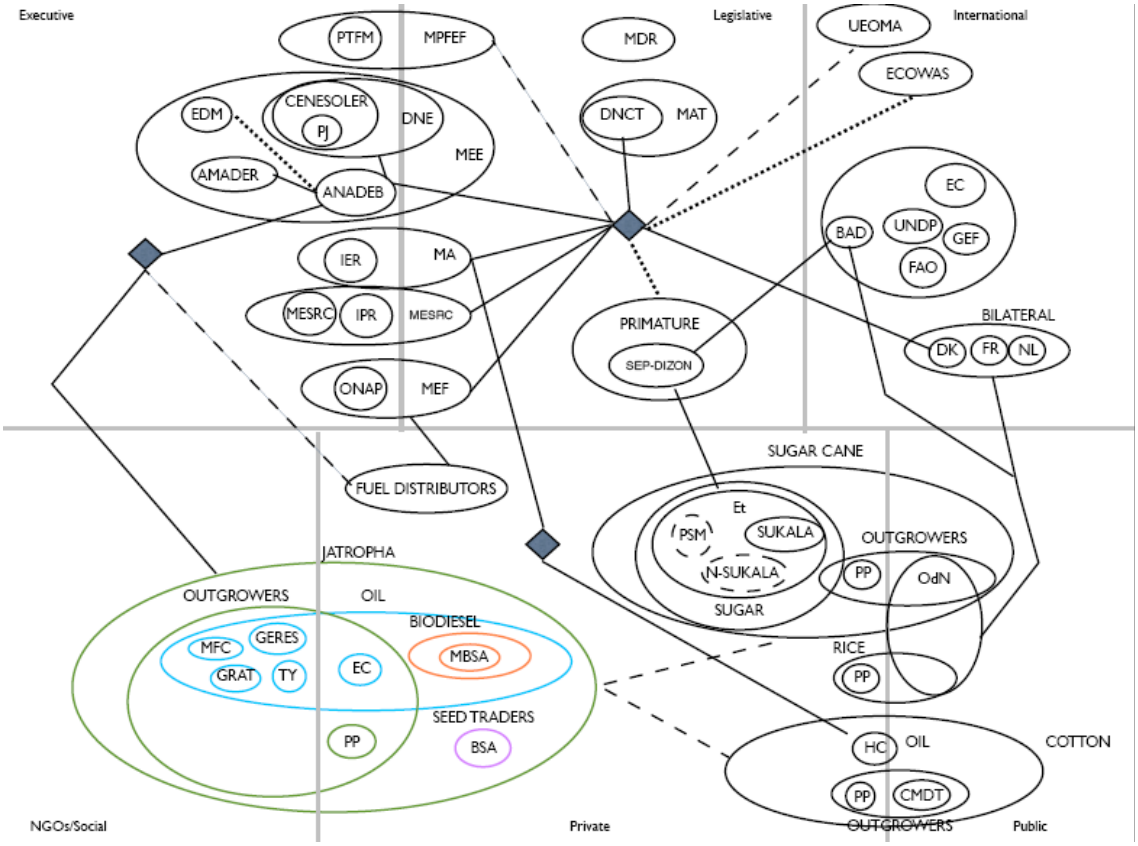
Employment
Jatropha based projects produce direct employment through extension services and oil extraction. Mali Biocarburant SA, for example, has around 50 salaried personnel for its operations. Indirect employment, through seed production, collection and commercialization has great potential to generate real sources of income. Most of the players in the Jatropha sector in Mali agree that a price of 50 FCFA per kg (0.08 EUR/kg) of Jatropha seed is necessary to make competitive straight vegetable oil extraction and biodiesel production in relation to Diesel costs[4]. Comparative studies value the Jatropha production costs for small farmers between 18 and 42 FCFA, hence producing real benefits to farmers(Latapie, 2007).
One of the key elements of the projects at the ON is that local farmers will be hired as seasonal workers. The Malian law guaranties a minimum professional salary close 28 460 FCFA (43.4 EUR) per month[5]. However, an informal labour market for non-skilled and seasonal workers is likely to pay less than this.

Market
The demand for Jatropha grains greatly surpasses the supply. As mentioned before, the Jatropha seed market is virtually inexistent outside the areas of the different project interventions, where most of the seeds are used to sustain planting campaigns and local soap production. Due to this weakness, it has been reported that informal buyers trade seeds up to 10 times more expensive the price the buy with local farmers (usually less than 50 FCFA per kg). In order to meet its fossil fuel reduction targets, the Ministry of Energy estimates that 75,000 ha of Jatropha need to be planted, which would displace 84 million liters of Diesel (Klarsfield at al, 2009). Mali Biocarburant, has started biodiesel production on its 2000 litres per day facility since the summer 2009, albeit supplemented with imported palm oil from Ivory Coast. The actual Sukala ethanol production is 2.3 million litres of ethanol pear year. However, none of this ethanol production is used as fuel.

End use
As mentioned before, most Jatropha projects are intended for local production of energy and local consumption of biodiesel. At least 3 factors promote this type of use: 1) the costly and logistically difficult exportation of goods from Mali (land-locked country), 2) projected internal growth and energy needs superior to fuel production, 3) Strong euro value which makes the exportation, if possible, unattractive outside the ECOWAS region. The actual ethanol production is consumed in Mali and Burkina Faso for the pharmaceutical and beverage industry. The biodiesel produced by Mali Biocarburant is mainly sold locally to private users and Grands Moulins du Mali (Flower mill). Mali Biocarburant also supplies straight Jatropha oil to a pilot programme of 10 Multifunctional Platforms (MFP) in collaboration with the National Multifunctional Platform Programme

[4] For comparison the official cost of 1L of Diesel on January 2010 was 555 FCFA (8.84 EUR). In average, around 4kg of Jatropha seed are needed to produce 1L of oil.
[5] Information from the Agency for the Promotion of the Investments in Mali (API)

Mapping of policy and institutions



Acronyms

MA		Ministre de l'Agriculture
	IER	Institute d'Economie Rurale
MIIC		Ministre de l'Industrie, des Investissements et du Commerce
MEE		Ministre de l'Energie et de l'Eau (MEE)
	DNE	Direction National d'Energie
	CENESOLER	Centre National des Energies Solaires et Renouvables
	AMADER	Agence Malienne pour le Développement de l'Energie Domestique et l'Electrification Rurale
	PJ	Jatropha Project
	EDM	Electricité du Mali SA
	ANADEB	Agence National de Développement des Biocarburants
MET		Ministre de l'Equipement et des Transports
MAT		Ministere de la Administration Territoriale
	DNCT	Direction National des Collectivités Territoriales
MEF		Ministre de l'Economie et des Finances
	ONAP	Office National des Produits Pétroliers
MEA		Ministre de l'Environnement et de l'Assainissement
SEP-DIZON		Secrétaire d'Etat auprès du Premier ministre, chargé du Développement Intégré de la Zone Office du Niger
MPFEF		Ministre de la Promotion de la Femme, de l'Enfant et de la Famille
MESRC		Ministre des Enseignements Supérieur et de la Recherche Scientifique
MMEIA		Ministre des Maliens de l'Extérieur et de l'Intégration Africaine'
OdN		Office du Niger
	IPR	Institute Polytechnique Rurale de Formation et de Recherche Applique

International		
BAD		African Development Bank
UN		United Nations
UNDP		UN Development Programme
FAO		UN Food and Agriculture Organization
GEF		
EC		European Comision, External Cooperation Programmes
UEOMA		West African Economic and Monetary Unio
ECOWAS		Economic Community Of West African States
Bilateral		
FR		France Agence Française de Développement (AFD)
NL		The Netherlands cooperation
PRIVATE		
Sugar cane		
	PSM	Project Sucrier Markala
	SUKALA	Complexe Sucrier Du Kala Superieur SA
	Et	Ethanol
	OdN	Office du Niger
	PP	Private Producers
Cotton		
	CMDT	Compagnie Malienne du Développement des Textiles
	HC	Huicoma SA
Jatropha		
	MBSA	Mali Biocarburant SA
	GERES	Groupe Energies Renouvelables Environnement et Solidarités
	BSA	Bagani SA
	MFC	Mali Folke Centre Nyeeta
	GRAT	
	TY	AEDR/Teriyabougou
	EC	Jatropha Mali Initiative Eco-carbone

Summary of biofuels activities implications in Mali

	FARM Predominance of small and marginal farmers	**INDUSTRY** Jatropha for oil and biodiesel Sugarcane for ethanol	**MARKET** Direct sell of Jatropha oil, Biodiesel and Ethanol
Issues	• Low land productivity and poor water access challenges Jatropha adoption • Water management and relations between small producers and the ON • Land tenure conflicts is exacerbated with a young decentralization process • Inefficient agricultural markets	• Low availability of Jatropha and other oilseeds • Sugarcane production dependant on irrigated land development at ON • Actual production is for hydrous ethanol after sugar production • Poor infrastructure and weak supply chains increase production costs	• Missing biofuel regulation • High demand of fossil fuels for energy production • Lower fossil fuel prices in landlocked Mali than in the coastal neighboring countries • Unsatisfied demand of alimentary oil
Policies	•Biofuel Policy highlights sustainable production and food security • Development of irrigated land at the ON	• Promotion of renewable in country energy strategy • Promotion of investment and improved operations at the ON assisted by international donors	• Export of biofuel after national objectives are met • Regional integration • Biodiesel but not straight oil mixing with diesel allowed
Emerging Patterns/ relationships	• Long term leaseholds for agribusiness at the ON • R&D related to pro-poor benefits, environment and agronomic techniques	• Pro-poor strategies (outside ON) and large industrial developments (inside ON) • Public Private Partnerships • Regional approach	• Local energy projects driving interests for Jatropha • Sugar demand driving ethanol production
Impact/ future implications	• Increase in food output thanks to development of irrigation potential • Increase of income and diversification of rural economies	• Assured feedstock sources from farms and village level production • Synergies with the alimentary oil extraction industry	• Substitution of fossil fuel importation • Viability of rural energy projects

Conclusions

Biofuels play an important role in the energy strategy and growth in Mali. Political support favours food security, economic development and environmental protection. However, the relative young government decentralisation process, lack of resources and low administration capacities hinder good natural resources management.

Sugarcane production is intended to satisfy sugar demand. Ethanol is not yet used as fuel but for the pharmaceutical and beverage industries.
In terms of natural resources, particularly water availability, Mali presents large developments of irrigated land at the ON which can boost food and fuel production. Nevertheless, water and environmental management are main concerns in the country due to the Sahel area.

Mali is one of the countries in West Africa with more experience on the use of biofuels for electricity generation at community level. International donors follow with particular attention these developments. The experience with Jatropha programs has shown that it can benefit small holder farmers without compromising food production at local level. These developments include commercial production of Jatropha (e.g. Mali Biocarburants) and not only community level initiatives (e.g. Mali Folk Center).

Although Mali has a number of initiatives for pro-poor energy production, Jatropha seed supply is still very limited.
The challenge for Mali is also in the agriculture sector, specially for the efficient use of water, water access, costly extension services in need and low yields for all crops and not just energy crops.

8. TANZANIA CASE STUDY

Country Characteristics

Location
Tanzania is located in Eastern Africa between longitude 29^0 and 41^0 East, Latitude 1^0 and 12^0 South. It is situated in East Africa just south of the equator; It contains a total area of 945,087 sq km including 59,050 sq km of inland water. The section of the United Republic known as Zanzibar comprises the islands of Zanzibar and Pemba and all islets

Geographical Characteristics
Tanzania is the biggest of the East Africa countries (i.e. Kenya, Uganda, Tanzania, Rwanda and Burundi). Tanzania contains three of Africa's best-known lakes. Tanzania is divided into 26 administrative regions (21 on the mainland and 5 in Zanzibar) and 130 administrative districts (Zanzibar has 10 and Mainland has 120 administrative districts).

Environmental Characteristics
Tanzania has a tropical type of climate. In the highlands, temperatures range between 10^0c and 20^0c.during cold and hot seasons respectively. The rest of the country has temperatures never falling lower than 20^0c. Two rainfall regimes exist over Tanzania. The country has extensive forest cover, most of which is savannah woodland and montane forest, with scattered patches of lowland forest. Environmental problems include issues of soil degradation, deforestation, and desertification.

Population Size and Characteristics
Total 41,048,532
Growth rate of 3.0%.
Women 51% of the country's population
46% under the age of 15
Population Density (pop./sq. km) 46

Gross Domestic Product, Human Development Index
GDP
GDP per capita $424 USD
Agriculture and fishing 27%
Industry and construction 21%
Services 52%
The HDI 0.530 (rank 151 of 174)

Main crops

Crop	Production in '000 Metric tons				
	2004	2005	2006	2007	2008
Sisal fibre	27	28	31	33	34
Coffee	39	34	46	55	44
Tobacco	44	57	51	51	55
Cashew nuts	80	90	88	91	98
Pyrethrum	1	3	2	2	1
Green tea leaves	1278	133	123	159	148
Seed cotton	140	378	131	131	201

Food crops
The main agricultural products including food and non-food crops are coffee, sisal, tea, cotton, pyrethrum, cashew nuts, tobacco, cloves, corn, wheat, cassava (tapioca), bananas, fruits, and vegetable
Small holder crop production is very much dominated by maize. Other important food crops are cassava, bananas, paddy, beans and groundnuts.

Land Characteristics
The total planted area with annual crops was 7,818,620 hectares and 1,234,999 hectares for permanent crops giving a total planted area of 9,053,619 hectares.
The percent of utilised land compared to available land is high and in some regions all available land is utilised. Land ownership through formal titles/deeds is at a very low level with most of the land under customary rights.

Livelihoods
The crop sector plays an important role in the Tanzania economy providing jobs, sustenance and income to 4,858,810 rural households growing crops (representing 99% of the total number of farming households in the rural areas and 95 percent of the total rural households).

Policies in Place and Link with the Bioenergy Sector
National Biofuels Task Force (2006)
Agricultural Policy
The National Energy Policy (1992)
The Forest policy (1998)
The Land policy of (1997)
The Environmental policy of (1997)
The Environment Management Act (EMA) No. 20 of 2004, Wildlife Conservation Act No. 12 of 1974 (as amended in 1978);
Protected places and areas Act (1969) and Local

Biofuels Industry/Programmes Development
Programme on Integrated Wood-fuel Services for Poverty Reduction
Program for Biomass Energy Conservation (PROBEC)
Liquid Bioenergy Initiatives
Experts agree that Government policy should focus on non-staple food crops as a feedstock like Jatropha and pongamia in mitigating the direct impact of biofuel on food security.

Government Act of 1982 (Urban and District Authorities).	
Crops Used for Biofuels Current efforts are mostly focused on biodiesel from jatropha Tanzania has ideal geographic and climatic conditions for growing a wide range of biofuel crops: sugar cane, sorghum, cassava, palm oil, jatropha, soy, cotton, pongamia, croton and others.	**Government ministries and other government institutions** Tanzania Investment Centre (TIC) Attorney Generals chambers, (AGC) Tanzania Petroleum Development Corporation (TPDC) Community Finance Limited (CFC). . Business Registration and Licensing Agency (BRELA) - Ministry responsible for Planning, Economy and Empowerment, - Ministry of Energy and Minerals - Ministry responsible for Agriculture and Food Security - Ministry of Labor, Employment and Youth Development, - Ministry of Finance, - Vice President's Office –Division of Environment - Ministry of Water and Irrigation, - Ministry of Lands, Housing and Settlement Development, - Attorney General's Chambers, - Tanzania Investment Center, - Tanzania Petroleum Development Corporation, - Community Finance Limited, - Tanzania Sugar Producers' Association

Implications for land tenure, water and employment

Tanzania has over 88 million hectares of suitable agricultural land, of which less than 6% is currently utilized. Unlike many alternative countries, the vast majority of land in Tanzania that is available for cultivation is not virgin forest or environmentally sensitive. A recent study (FAO, 2007) estimated Tanzania to have more than 30 million hectares of land suitable for the cultivation of energy crops, whereby corresponding areas for sugarcane, cereals and root crops are 570,000 ha, 24 million ha and 14 million ha respectively.

However, opportunities exist for income generation and diversification by producing and selling biofuel feedstocks. Employment opportunities will be created through agro-industrializations. This will lead to improved standard of living and linkages with others sectors in the economy. Energy supply in rural areas will also stimulate rural development and reduce pollution caused by fire wood. Reduced time spent by women and children on basic survival activities (gathering firewood, fetching water, cooking, etc.). The development of biofuel as a source of energy, when grown on a large scale, could also represent a paradigm shift in agricultural development.

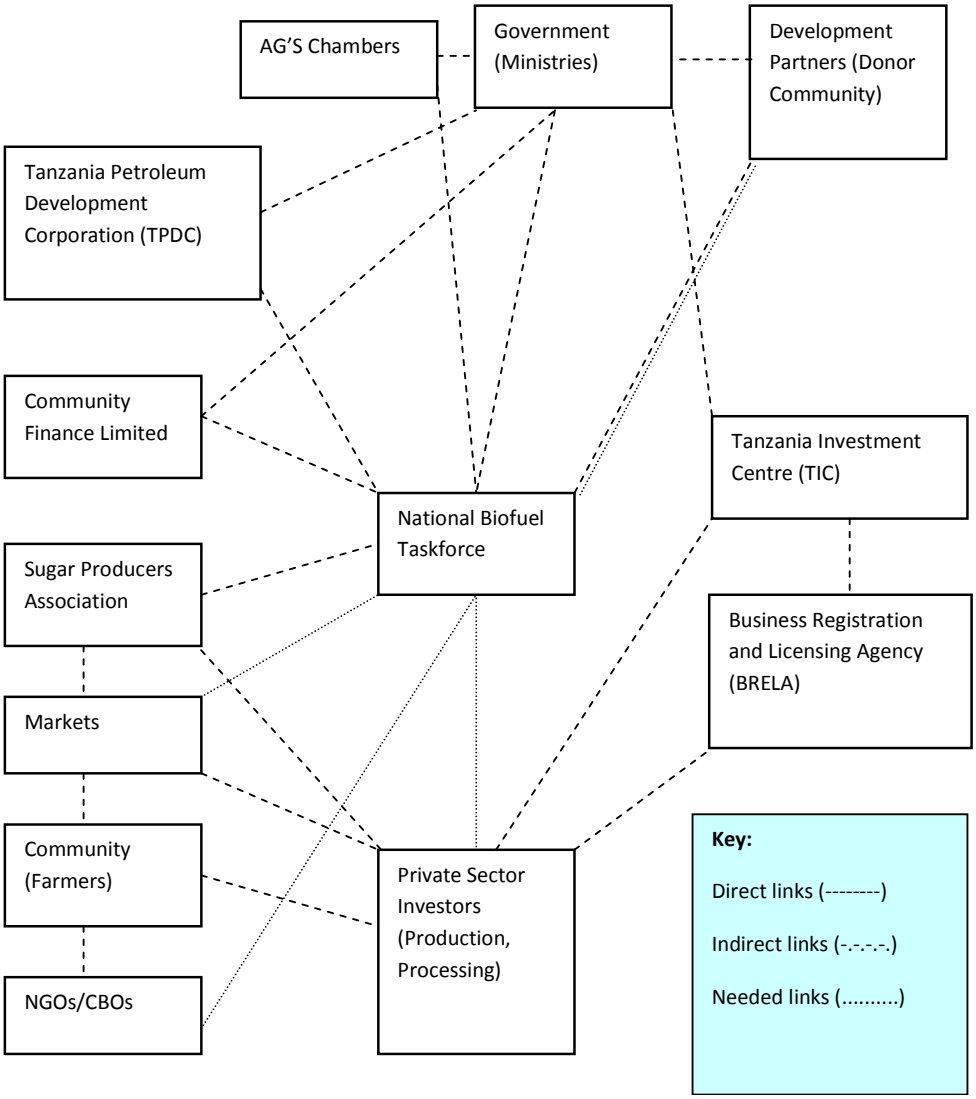
Three of the ten largest lakes in the world are found in Tanzania, and a large network of rivers, making most areas of Tanzania suitable for irrigated agriculture. Tanzania has significant potential for irrigated land and several areas apt for oil palm and jatropha have already been identified.

Mapping of Policy and Institutions and Links with Bioenergy

The institutions involved in the development of biofuels in Tanzania include a variety of
There are several Developmental organizations that are at the forefront of the development of biofuels, they include, TaTEDO, Sugar Producers Association, Envirocare and several

other locally based NGOs and CBOs. Also there is increasing private sector participation from inside and outside the country. Some of such companies include Felisa, Kakute, Sun Energy LTD, Deligent, Wilma, Prokon, Bio-Alcohol Fuel foundation (BAFF), SEKAB

Mapping of policies and institutions



Summary of the biofuels activities implications in Tanzania

	FARM Typically subsistence farming with low capital investment. Land area per household ≈2ha. Ownership of formal titles/deeds very low	**INDUSTRY** Still in nascent stages. Current efforts mostly focused on biodiesel from jatropha.	**MARKET** Potential exists at all levels (households, public facilities, transport and industry including power generation).
Issues	• Low crop yields due to non-existent/low investment in crop production. •Average planted area of 1.61 hectares per household for annual crops is low to support an average size smallholder households •The best crop producing areas have less available land for cultivation.	•Insufficient feedstock supply •Few processing facilities •No technical capacity •Economic feasibility still not assured •No commercial facilities established yet	• Market information lacking •Dramatic increase in demand for biofuels but no commercial supply
Policies	•Liberalization of agricultural sector •Focus on food security •Policy promotes cash crops and production of industrial raw material sustainably •Promote integrated and sustainable use of natural resources. •Land policy of 1997 clearly recognizes and clarifies customary and other use rights to land	•Limited interface between energy policy and plans relating to national economic planning. •Biofuels Task Force is working on the preparations of policies & regulations on biofuels. •Energy Policy encourages commercialization and private sector participation.	• Energy policy aims to promote economic energy pricing. •Develop domestic energy resources which are shown to be least cost options
Emerging Patterns/ relationships	•Several actors (e.g. multinationals, NGOs, institutions and small holders farmers) are implementing biofuel projects. •Significant potential for irrigated land and several areas apt for oil palm and jatropha.	•More than ten companies establishing farms for biofuels farming •Investors have started biofuel production at on the experimental stage	•A statement on blending biofuels with mineral petrol has been slotted in the New Petroleum Supply Act.
Impact/ future implications	•Improved standard of living and linkages with others sectors in the economy •Employment opportunities will be created through agro-industrializations •Opportunities for income generation and diversification by producing and selling biofuel feedstocks •Energy supply in rural areas will stimulate rural development and reduce pollution caused by fire wood •Reduced time spent by women and children on gathering firewood, fetching water, cooking, etc. •May generate new pressures on land tenure arrangements, leading to alienation •Poor households may either sell or be forced to relocate as the rush to meet increasing demand gathers momentum •Competition for inputs (e.g. land, water, fertilizers) that might be diverted from food production might precipitate a food crisis.	•Growth in agro-industrialization •Private-sector-led development	•Initiatives started will create market opportunities •Tanzania is a net fuel importer hence high potential to become a significant biofuel producer. •Biofuel development could represent a paradigm shift in agricultural development.

Conclusions

Tanzania has received major attention from investors for large scale biofuel production forcing the government to accelerate the process of the creation of a Biomass Task Force in the absence of a biofuel policy. As in the previous case studies, the problem in the country lays in the issues regarding the willingness to grow bioenergy crops in the absence of low or non-existant investment that reflect in low yields.
There is also a will to expand production arising in the industrial sector with major investors for this area. Nevertheless, issues regarding land tenure and the average size of farms for small holders will make difficult in certain areas to work with large scale initiatives. This could

be related to the issue of either displacement of farmers or convincing the farmers of an alternative crop to work as out-growers.

The stakeholder assessment demonstrated that there is need for cross-cutting activities at policy and planning level and with main actors such as farmers, in-spite of the existence of the Task Force.

The potential market for biofuels is big at all levels in Tanzania and with adequate enforcement of the policies and guidelines, it will be possible to produce bioenergy crops without jeopardising food production. At any rate, a case-by-case approach to each of the initiatives need to be adopted.

9. KENYA CASE STUDY

Country characteristics

Location

Kenya is located on the eastern part of the African continent. It lies across the equator at latitude of 4° North to 4° South and Longitude 34° East to 41° East. It contains a total area of 582,650sq km sq including 13,400 sq km of inland water and a 536km coastline

Geographical Characteristics

The coast is a low-lying area and extremely fertile. It has a coral reef supported by a dry coastal plain that is covered by thorny bushes and savannah. The terrain of the country gradually changes from the low-lying coastal plains to the Kenyan highlands. The Great Rift Valley is located in the central and western part of the country and basically dissects the Kenyan highlands into east and west. The highlands have a cool climate and are known for their fertile soil, forming one of the major agricultural regions of the country. However, about 80% of the land area is Arid and Semi Arid. A large number of rainforests are found in the east of the country Kenya is divided into 8 provinces; the provinces are subdivided into more than 71 districts which are then subdivided into more than 260 divisions. The divisions are subdivided into about 2500 locations which in turn are sub-divided into more than 6,600 sub-locations.

Environmental Characteristics

Kenya's climate is fairly warm throughout most of the country. Most of the country has a tropical climate. Exceptions to this are the coastal belt and the northern parts, which are generally arid and hot. It is hot and humid at the coast, temperate inland and very dry in the north and northeast parts of the country.

Kenya is divided into seven agro-ecological zones ranging from humid to very arid. Less than 20% of the land is suitable for cultivation, of which only 12% is classified as high potential (adequate rainfall) agricultural land and about 8% is medium potential land. The rest of the land is arid or semi-arid. Furthermore, only 60% of the high potential land is devoted for crop farming and intensive livestock production while the rest is used for food and cash crop production, leaving the rest for grazing and as protected. The most important current environmental issues include water pollution from urban and industrial wastes; degradation of water quality from increased use of pesticides and fertilizers; water hyacinth infestation in Lake Victoria; deforestation; soil erosion; desertification; and wildlife poaching for game meat and animal trophies.

Population Size and Characteristics

Total 39, 423, 264
Growth rate 2.7%
Population density of 67 people per km2
70% are young people (15-30) from these 57% women constitute 60% force labour

Gross Domestic Product, Human Development Index

The GDP 61.83 billion US Dollars,
GDP per capita is 1, 600 US dollars
Agriculture 24%
Industry 17%
Services 59%
HDI in 2009 is 0.541 (rank 147 out of 182)

Main food crops

Maize is the main staple food and on average 1.5 million hectares is planted with maize annually

Rank	Commodity	$1000USD	MT
1	Sugar cane	108091	5204214
2	Cow milk, whole, fresh	1124926	4230000
3	Maize	325398	2928793
4	Potatoes	102115	850000
5	Sweet potatoes	81550	811531
6	Cabbages and other brassicas	89504	609292
7	Vegetables fresh nes	106960	595000
8	Bananas	169122	593370
9	Plantains	134195	593370
10	Tomatoes	132605	559680

Agriculture products

Major cash crops produced in Kenya include tea, horticultural produce, coffee, pyrethrum, cotton, cashew nuts, and coconuts among others. In addition to coffee, tea and horticultural produce, Kenya is the world's largest producer and exporter of pyrethrum. Most of these are produced in small holder farming systems. Sugarcane and wheat are mainly produced for the local market. Kenya also produces sisal, tobacco, and *Bixa natto* (a natural food coloring agent) for export.

Characteristics of land

Land tenure in Kenya falls into four different entities namely government (public), County councils (local authorities), Individuals (private) and groups (communal). Different legal instruments govern different categories of land and owners thereof. To date, land ownership in over 40% of Kenya still remains informal.

Land Policy (2009) designates all land in Kenya as either Public, private or Communal land.

Livelihoods

The bulk (98%) of the farm holdings in Kenya are small (<10 ha) and lie mainly in the high potential areas. The medium and large scale farms account for about 2% of the holdings, but cover about 54% of the area farmed. Nationally, the average farm size is about 2.5 .

Typically a farmer grows several different crops together in the same field: a grain such as corn; a legume such as beans; and perhaps a few trees producing coffee, bananas, or mangoes.

Policies in Place and Link with the Bioenergy Sector

The Energy Policy is contained in Sessional Paper no. 4 of 2004 and focuses on all forms of energy including bioenergy.

the Energy Act 2006

Agricultural policy

Kenya Forest Policy of 2005

Land Policy 2009

Draft National Environmental Policy (NEP), 2008 Environmental Management and Coordination Act No. 8 (EMCA) of 1999.

Biofuels Programmes

Bioenergy Policy

National Biodiesel strategy

National Bioethanol strategy

National Task Force on Accelerated Development of Green Energy

Crops Used for Biofuels

Ethanol and Yield T/Ha	
Cassava	9.6
Sorghum	35.0
Sugarcane	33.4
Biodiesel	
Castor	0.23
Coconut	1.64
Cottonseed	0.6
Croton	2.50
Jatropha	2.50
Rapeseed	2.00
Sunflower	0.92

Ministries/Secretariats Involved in the Bioenergy Planning/Applications

The Ministries involved include the Ministry of Energy, Ministry of Agriculture, Ministry of Trade and Industry, Ministry of Immigration, Ministry of Finance, Ministry of Environment and Mineral Resources, Ministry of Lands. Other agencies which although inked to parent ministries are autonomous bodies include National Environment Management Authority (NEMA), KEBS, KEPHIS, KIA and the various agencies under the lands Ministry.

Implications of Conversion of Biofuels Raw Material

Water :Although there are numerous environmental benefits of using biofuels, the processing of feedstock requires large amounts of water. Data shows that 1, 000 – 2, 000 litres of water is required to process one tonne of sugar to ethanol. Kenya is already classified as a water-stressed country with very little stored water per capita. When severe droughts occur, water storage areas are rapidly drawn down; and where boreholes and wells have been dug up, these dry up during droughts due to poor or low recharge. Additionally, huge investments need to be made in treatment plants to ensure compliance with established water quality standards. Information from Agro-Chemical and Food Complex Company, one of the largest ethanol manufacturers in Kenya shows that the spent wash from ethanol production has a malodorous smell and dark colour that often attracts complaints for the surrounding community.

Employment. Potential employment and incomes benefits are enormous for Kenya. A 2008 report showed that the jobs-to-investment ratio for biofuels is about 100 higher than for petroleum refineries. Employment opportunities will be created through agro-industrializations. Additionally, there are opportunities to provide farm jobs as well as expanded income through adoption of new cash crops.

Data from Mumias Sugar Company, the biggest sugar producer in Kenya, shows that producing an additional 93 million litres of ethanol in Western Kenya (as is planned for 2013) would create 500 -1000 new jobs in the manufacturing and transport sector. In Mumias alone, up to 100 people including 20 professionals earning an average of Ksh 100, 000 (1, 430 USD) will be required. The other workers would earn 15, 000 – 35, 0000 kshs (214 –

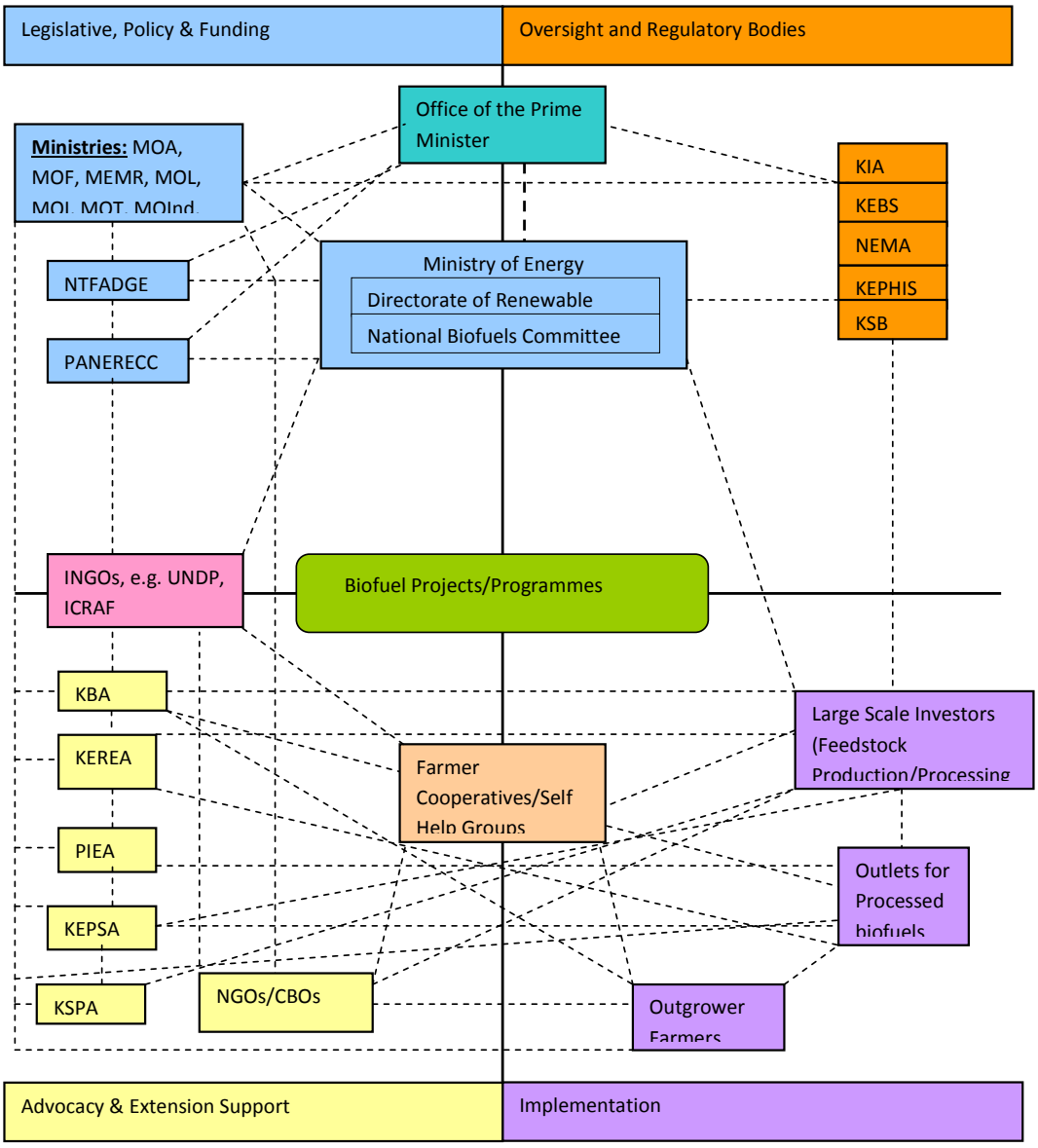
500 USD). It is estimated that one wage farm job will be created for every 54.9 hectares planted with ethanol feedstock, and one casual farm job for every 30.4 hectares planted. For biodiesel, it is estimated that one non-farm job will be created for every 100, 000 – 180, 000 litres of biodiesel produced.

Land. Analysis shows that depending on the type of feedstock, there might or might not be enough land to produce enough feedstock to meet the required fossil fuel substitution/blending. Some feedstock can only grow on high potential arable land, while others can be grown in low potential land and therefore not compete with food crops for land. For example, growing more sugarcane will require one fifth of potentially suitable land that is not currently being used for food or cash crops. The analysis also shows that not enough land exists for producing the required amount of ethanol from molasses. However, ample, non-competitive but suitable land exists for cassava and sorghum. For biodiesel, ample land exists for croton, jatropha, sunflower and castor. Cottonseed, rapeseed and coconut are limited by land availability.

Mapping of Policy and Institutions

Legend

CBO - Community Based Organization	MEMR – Ministry of Environment & Mineral Resources
ICRAF – International Centre for Research in Agroforestry (World Agroforestry Centre)	MOA – Ministry of Finance
INGO - International Non-Governmental Organization	MOI – Ministry of Immigration
KBA - Kenya Biodiesel Association	MOInd - Ministry of Industrialization
KEBS – Kenya Bureau of Standards	MOL – Ministry of Lands
KEPHIS - Kenya Plant Health Inspectorate Service	MOT - Ministry of Trade
KEPSA - Kenya Private Sector Alliance	NEMA -National Environment Management Authority
KEREA - Kenya Renewable Energy Association	NGO - Non – Governmental Organization
KIA – Kenya Investment Authority	NTFADGE – National Task Force for Accelerated Development of Green Energy
KSB - Kenya Sugar Board	PANERECC – Parliamentary Network on Renewable Energy & Climate Change
KSPA - Kenya Sugar Producers Association	PIEA – Petroleum Institute of East Africa
	UNDP - United Nations Development Programme



Key:

- Government office performing both policy development and oversight functions – Prime Minister's
- Government Line Ministries, Parliamentary Committees and Taskforces responsible for policy development & securing funding
- Autonomous Government Agencies performing regulatory and oversight functions including licensing and compliance
- International Agencies providing support to Government programmes through funding and capacity development
- Industry representative bodies and NGOs responsible for advocacy and extension services to farmers and industry
- Investors and farmers responsible for actual implementation of biofuel projects including growing and processing
- Various biofuel programmes and initiatives being implemented by various entities

Summary of the biofuels activities implications in Kenya

	FARM About 20% of the land is suitable for cultivation, predominantly for subsistence farming	**INDUSTRY** In nascent stages but there currently exist many initiatives mainly ethanol and biodiesel	**MARKET** Mainly transport industry and stationary applications. Some domestic uses for SVO (cooking & lighting)
Issues	• Limited land. • 98% of the farm holdings are small (<10 ha) hence cannot support sustainable feedstock production. • Problems with sugar farming • Maize, a potential ethanol feedstock is the staple food and is in short supply • 60% of farming systems is subsistence • Food insecurity	• Insufficient feedstock supply • Few processing facilities • No technical capacity • Economic feasibility still not assured • Poor infrastructure and inefficiency in production hampers growth • Ethanol produced from sugar molasses in stand-alone facilities rather than as an integrated process with sugar manufacture – more costly	• Competition for ethanol for beverage use. • Unsustainable pricing • Prices of potential feedstocks not based on their sale for biofuel manufacture, but for other more 'conventional' uses • Market for biofuels is still in its infancy
Policies	• Agriculture policy aims to increase productivity and income growth and enhanced food security and equity • Agriculture, Energy, Forest, Draft Environment propose sustainable biofuel feedstock production	• Establishment of Tax incentives – tax holidays and fiscal incentives for green energy investment • Build and strengthen research capacity • Promote CDM and carbon trade	• Establishing financing partnerships with the private investors • Diversify the sugar industry base and strengthen competitiveness of sugar factories • Achieve blending ratio of E-10 (bioethanol with petrol) by December 31st 2010 • Promoting the utilization of renewable energy sources for power generation or transportation
Emerging Patterns/ relationships	• ICRAF, other NGOs and companies working with farmers to promote jatropha • Focus on jatropha castor, croton and coconut as biodiesel feedstock • Kenya Forestry Research Institute conducting research on various species to evaluate biodiesel potential.	• Initiative for the Promotion of Biomass lead by the Institute for Research in Sustainable Energy and Development (IRSEAD) • Biodiesel strategy • Bioethanol strategy • National Task Force on Accelerated Development of Green Energy • Active participation in R & D and actual feedstock production	• National Biodiesel Committee with membership of petroleum industry, line ministries, NGOs and agricultural producers.
Impact/ future implications	• Opportunities to provide farm jobs • Environmental benefits of using biofuels • Expanded income through adoption of new cash crops. • Irrigated feedstock production to create more demand for water	• Growth in agro-industrialization • Huge investments needed in treatment plants to ensure compliance with water quality standards. • Private-sector-led development	• Straight Vegetable Oil for lighting and cooking to substitute kerosene, firewood and charcoal. • Integrated ethanol production to increase efficiency and lower costs • Diversify the sugar industry base and strengthen competitiveness of sugar factories

Conclusions

The case of Kenya is most relevant as has been producing bioethanol for nearly 20 years. The production has not been steady and tends to be exported for drinks to its neighbouring countries. It has been reported that land will not be sufficient to produce the amount of ethanol needed for the transport sector in Kenya. Nevertheless, alternative crops have been considered that do not compete with food or can produce both food and fuel (e.g. sweet sorghum, jatropha, castor oil). With the experience already in place and the different policy

mechanisms (e.g Task Force, Biofuels Programmes) it is possible that Kenya could produce biofuels in adequate areas that do not jeopardise food production in the country and do allow to rural development and a better income to the country.
Positive impacts can be expected at local level with job creation in some areas where conflict with other resources (such as water) is not an issue.

10. ZAMBIA CASE STUDY

Country characteristics

Location

Zambia occupies a near central location on the southern African sub-continent between 7^0 30' and 18^0 45' south latitude, and 22^0 00' and 33^0 30' east longitude. It is surrounded by the Democratic Republic of Congo in the north, Tanzania in the northeast, Malawi and Mozambique in the east, Zimbabwe, Botswana and Namibia in the south, and Angola in the west. It is divided into nine provinces. Lusaka is the capital and largest city

Geographical characteristics

Zambia covers an area of 752 614 km^2. Most of the western and central regions of the country are situated on the great plateau of central Africa. On the basis of the combined influence of rainfall, temperature, altitude, topography and soils, on the length of the growing season and hence crop options, Zambia is divided into three major agro-ecological zones ***Zone 1*** includes the major river valleys in the southwest, south, and southeastern parts of the country which experience very high summer temperatures and are prone to flooding ***Zone 2*** covers most of the central full extent of the country. It has a MAP of 800 to 1 000 mm, a growing season of 100 to 140 days and a medium to low risk of drought. ***Zone 3*** covers the full extent of the northern part of the country and is the largest zone.

Environmental Characteristics

Zambia has four major vegetation categories. Closed forests covering 6% of the country are restricted to the higher rainfall regions. Savanna woodlands cover 64% of the country and are predominately classed as Miombo woodland. The tree component of the woodlands range from sparsely scattered in the drier south to tall dense tickets in the moister north and northwest. Although Termitaria (anthill vegetation) is distributed throughout the country, it only covers about 3 % of its area. Grasslands cover 27% of the country and range from those found in the drier south to those associated with wetlands, to open grassy plains the high eastern escarpments. Deforestation is proceeding at the rate of about 200,000 ha per year. Coupled with overgrazing, it has contributed to severe soil degradation (ECZ, 2001, Aregheore, 2003). Approximately 30% of the land surface has been altered for agriculture, forestry and settlements (Chapman and Walmsley, 2003).

Population characteristics

Total 12 million
Growth rate 2.1
Male 48 %
Female 52%
Urban population 35%
Rural Population 65%

Gross Domestic Product, Human Development Index

GDP 12.3 US bilion
GDP per capita 1544 USD
Agriculture 19 %
Industry 31 %
Services 50 %
HDI 0.48 (rank 164 out of 182)

Food products

Maize is the main staple product. Improved varieties of sorghum and millet have been widely and increasingly adopted by all categories of farmers since their initial release in 1989. Crop residues and agro industrial by-products such as molasses, brewer's grain, bone and fish meal, etc. play an important role in the nutrition of ruminant livestock (Aregheore, 2003, FAO, 2005).

Main crops

Type of crops	Zone 1	Zone 2	Zone 3
Staple crops	1. sorghum	1. maize	1. maize
	2. maize	2. sorghum	2. cassava
	3. Pearl millet	3. cassava	3. Finger millet
	4. cassava	4. Pearl millet	4. sorghum
Food legumes	1. groundnut	1. groundnut	1. bean
	2. cowpea	2. bean	2. groundnut
	3. Bambara nut	3. Bambara nut	3. Bambara nut
	4. cowpea	4. cowpea	
		5. Pigeon pea	
		6. Chick pea	
Cash crops	1. cotton	1. soybean	1. soybean
	2. soybean	2. wheat	2. wheat

	3. sunflower	3. cotton	3. exotic vegetables
	4. exotic vegetables	4. exotic vegetables.	4. rice
	5. wheat	5. sunflower	5. sunflower
	6. rice	6. rice	6. potato
	7. castor	7. tobacco	7. spices
		8. spices	
		9. flowers	

Land characteristics

Prior to independence 6% of Zambia was Crown Land and 94% Reserves and Trust Land. In 1964, the Crown Land became State Land and it was nationalized requiring State consent for all dealings. This requirement hampered development of unused land. In 1991, the MMD reintroduced the economic value of undeveloped land and the right of private land ownership. The Reserves and Trust Land became Customary Lands where the community owns all the land on behalf of its members, and the consent of the Chief is required to settle in the area (UN-HABITAT, 2005). Most small holders have customary land use rights Most land in opened-up areas is occupied but unexploited agricultural land, which is generally distant from where minimal infrastructure is developed, still remains unoccupied (FAO, 2005). The Commissioner of Lands attached to the Ministry of Lands is responsible for granting State Land.

Livelihoods

According to SIDA (2004) and FAO (2005) Zambia has four categories of farmers:-

small holders: 75% of the farmers are subsistence producers of staple foods on farms ranging from 0,5 to 9 ha. Although they only market an occasional surplus, they account for 51% of the agricultural GDP.

emergent farmers: 20% of the farmers produce food and cash crops on farms ranging from more than 9 to 20 ha,

medium scale: about 4% of the farmers produce food and cash crops on farms ranging from more than 20 to 60 ha. Together with the emergent farmers, they produce 25% of the agricultural GDP.

large scale: constituting less than 1% of the farmers and numbering less than 800 individuals or companies, these farmers grow cash crops on farms larger than 60 ha. Together with the medium scale farmers, they are commercial farmers characterized by high mechanization and have a well organized farmer network which facilitates the acquisition of inputs.

Policies Linked to Bioenergy Sector

Energy Regulation Act of 2008. The Ministry of Energy and Water Development is developing a long-term strategy (2009 – 2030) which includes biofuels as a priority sub-sector, and which foresees close cooperation between the DE and the Environmental Council because Environmental and Social Impact Assessments (ESIA) will be required for bioenergy projects.

Biofuel Progammes

Department of Energy (DE)

Crops Used for Biofuels

Crop	Area cultivated ha
Sunflower	26 000
Soyabean	15 000
Maize	750 000
Sorghum	22 000
Sugarcane	17 000
Cassava	165 000
Jatropha	
Oil Palm	

Ministries Involved in Bioenergy

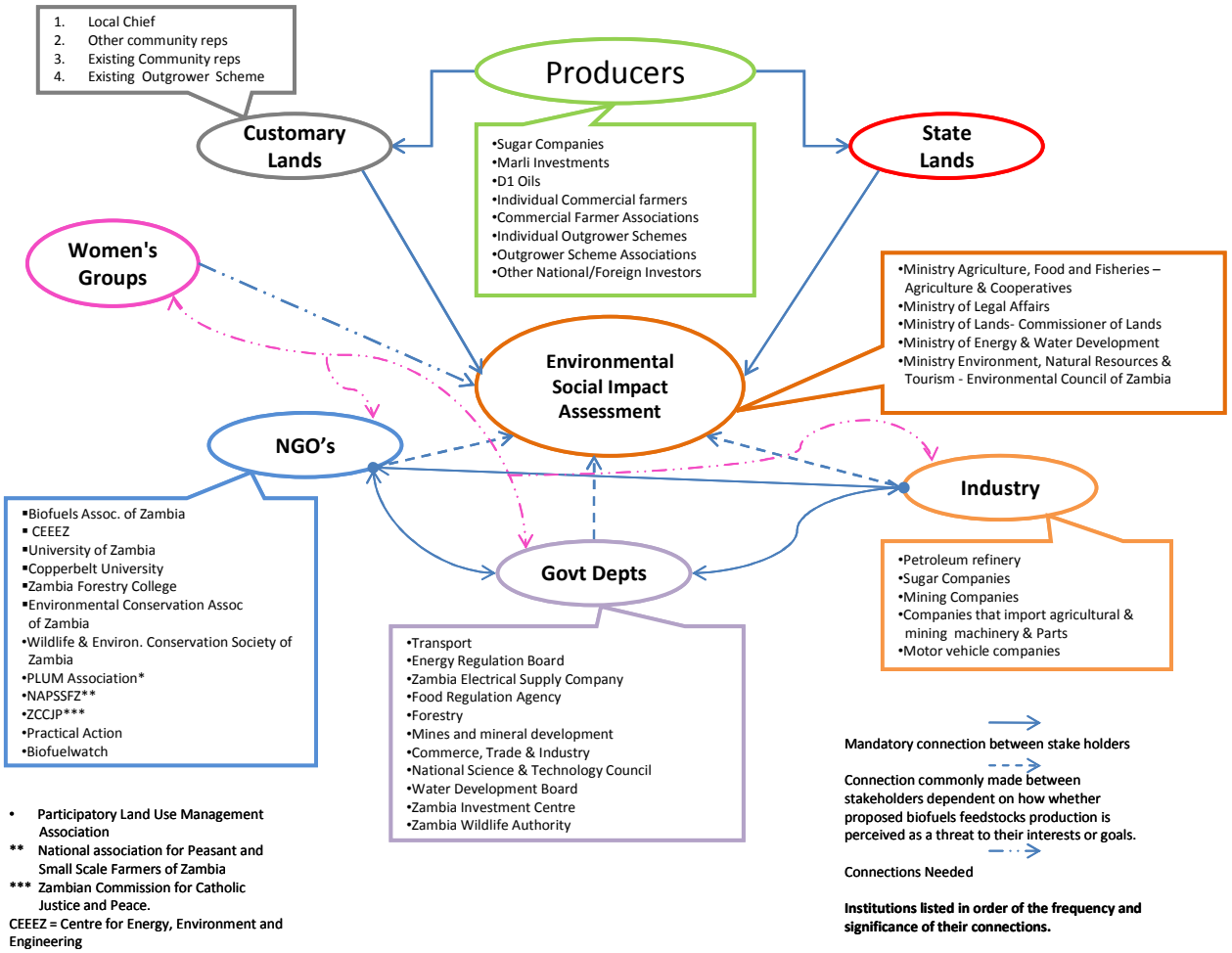
Screening of different policies were looked at and apart from the Energy Ministry no linked to others was found.

Implications of Biofuels Production on Water and Employment.

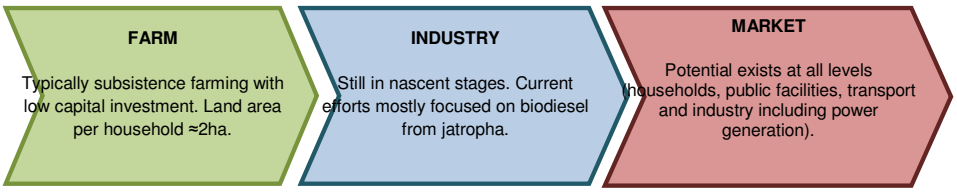
In areas where the MAP is greater than 800 mm rainfed sugar cane production is economically viable. The same applies to sweet sorghum where the MAP is greater than 600mm. However, irrigation substantially improves the yields of both crops (Watson et al., 2007). The survival rate of Jatropha seeds, seedlings and cuttings is substantially improved if they are watered for the first three years (Mudede, 2010). Given that Aregheore (2003) and BOZ (2003) estimated that less than 9% of the land with irrigation potential was irrigated (as noted in section 4), it would appear that Zambia can withstand a substantial production of biofuel feedstocks even under irrigated conditions, without detrimentally affecting national water availability.

Biofuels production is likely to generate employment in both the informal and formal sectors. Von Maltitz and Brent (2009) estimated that Zambia would create 27 046 jobs in meeting its biofuel targets. However, they cautioned that "fuel production must provide jobs of sufficient quality to ensure that workers are able to achieve security through their remuneration from biofuel endeavours".

Mapping of Policies and Institutions



Summary of biofuels activities implications in Zambia



Issues	• Low crop yields due to non-existent/low investment in crop production. • The best crop producing areas have less available land for cultivation.	• Insufficient feedstock supply • Few processing facilities • No technical capacity • Economic feasibility still not assured • No commercial facilities established yet	• Market information lacking • Dramatic increase in demand for biofuels but no commercial supply
Policies	• Liberalization of agricultural sector • Focus on food security • Policy promotes cash crops and production of industrial raw material sustainably • Promote integrated and sustainable use of natural resources.	• Limited interface between energy policy and plans relating to national economic planning. • Energy Policy encourages commercialization and private sector participation.	• Biofuels Association, and the Department of Energy (DE) has already taken the decision to initially focus on transport rather than electricity • Plans to introduce biodiesel to be used straight or blended with diesel, and ethanol to blend with petrol
Emerging Patterns/ relationships	• Several actors (e.g. multinationals, NGOs, institutions and small holders farmers) are implementing biofuel projects. • Significant potential for irrigated land and several areas apt for oil palm and jatropha.	• Investors have started biofuel production at on the experimental stage	• A statement on blending biofuels with mineral petrol has been slotted in the New Petroleum Supply Act.
Impact/ future implications	• Improved standard of living and linkages with others sectors in the economy • Employment opportunities will be created through agro-industrializations • Opportunities for income generation and diversification by producing and selling biofuel feedstocks • Energy supply in rural areas will stimulate rural development and	• Growth in agro-industrialization • Private-sector-led development	• Initiatives started will create market opportunities • Zambia is a net fuel importer hence high potential to become a significant biofuel producer. • Biofuel development could represent a paradigm shift in agricultural development. • The Ministry of Energy and Water Development is developing a long-term strategy (2009 – 2030) which

Conclusions

Zambia's initial steps into biofuel production still seem to be controversial. This is one of the countries that provides an example of the need for energy alternatives as it is a landlocked country with no indigenous oil reserves. The country has had a food security crisis for a number of years despite around 12% of the arable land being dedicated to agriculture. It seems that the dependency of the country on food imports is due to the lack of infrastructure and investment in the agricultural sector. The Energy Ministry considers that bioenergy could be an excellent opportunity to significantly enhance the production potential of feedstock for both food and biomass production.

Zambia is an agricultural country with nearly 70% of the active population dedicated to this sector and has been looking at different crops for biofuel production such as sweet sorghum and cassava. The biofuels Association in Zambia is a strong organization and could play an important role in the promotion of biofuels and food production.

The opposing perspectives of different stakeholders continue to be an issue that hinders the future development of biofuels and bioenergy in the country.

11. MOZAMBIQUE CASE STUDY

Country characteristics

Location

Mozambique is located on coordinates 18° 15' S, 35° 00' E in south-east Africa and borders the United Republic of Tanzania to the north, Malawi, Zambia, Zimbabwe, South Africa, Swaziland, and the Indian Ocean. It has a coastline of nearly 2,750km. The country is divided into eleven provinces (from south to north): Maputo, Maputo city, Gaza, Inhambane, Manica, Sofala, Zambézia, Tete, Nampula, Niassa, and Cabo Delgado. It has a total area of 801,590 sq km of which 784,090 sq km is land and 17,500 sq km is water.

Geographical Characteristics

Mozambique occupies the eastern fringe of the great southern African escarpment. The mountains of the interior fall to a broad plateau which descends to coastal hills and plain. Rivers generally run west to east. The coastal beaches are fringed by lagoons coral reefs and strings of islands. The extensive low plateau covers nearly half the land area. The Zambezi is the largest of 25 main rivers. Mozambique is divided into 10 provinces: Cabo Delgado, Gaza, Inhambane, Manica, Maputo, Nampula, Niassa, Sofala, Tete, Zambezia. Maputo is the administrative capital.

Environmental Characteristics

The most significant environmental issues are desertification, pollution of surface and coastal waters, and persistent migration of people from the hinterland to urban and coastal areas caused mainly by a long civil war and recurrent drought in the hinterlands.

The plateau is savannah – dry and open bushveld and wide stretches of grassland. There are patches of forest in the western and northern highlands. Dense subtropical bush characterizes the coastal plain. Forest covers approximately 25% of the land area, having declined at 0.3% p.a. between in the period 1990 - 2005. Arable land comprises 5.6% and permanent cropland 0.3% of the total land area.

Population Size and Characteristics

Total 21,669,278
Population growth rate is 1.791%
Population density 28 people per km2
Male 42%
Female 58 %
Urban 37%
Rural 63%

Gross domestic product and Human Development Index

GDP 9,735 million US dollars
GDP per capita $456 US dollars
Agriculture 24%
Industry 31%
Services 45%
HDI 0.402 rank 172 out of 182

Main food crops

- Maize: 0.4-1.3 tonnes/hectare
- Cassava: 4-5 tonnes/hectare
- Beans: 0.3-0.6 tonnes/hectare
- Sorghum: 0.3-0.6 tonnes/hectare
- Rice: 0.5-1.8 tonnes/hectare

Main Agricultural food products imports and exports

The main agricultural products include cotton, cashew nuts, sugarcane, tea, cassava, corn, coconuts, sisal, citrus and tropical fruits, potatoes, and sunflowers. Industrial crops include tobacco, cotton, cashew, coconuts, tea, paprika, soybeans, sesame, sunflower and citrus. Mozambique is a net importer of food commodities, especially rice, wheat and, to a lesser extent, maize[6]. Mozambique relies on imports for all its domestic wheat requirements. Imports of rice account for about 75 per cent of total domestic consumption, and those of maize (mostly from South Africa) account for about 13 per cent of total domestic consumption.

Main agricultural exports include cotton, cashew nuts, sugarcane, tea, cassava (tapioca), corn, coconuts, sisal, citrus and tropical fruits, potatoes, sunflowers.

Land characteristics

About 4 million hectares of land equal to about 10% of arable land is under cultivation, out of which 97% is cultivated by smallholder farmers.

Agricultural land - % of land area:	61.96 % of land area
Arable and permanent cropland:	4,135 thousand hectares
Arable land - % of land area:	5.55 % of land area

Livelihoods

About 3.2 million smallholder farmers are responsible for 95% of all agricultural production. Each household cultivates an average of 2 hectares. Approximately 91% of the land is tilled by small and medium scale farmers and is used for annual crops which include maize, cassava, rice, sorghum, millet, cowpeas and groundnuts. Maize, cassava and cowpeas were the most common food crops, cultivated by 79%, 73% and 50% of the farmers respectively The majority, i.e. 80%, of the population is active in agriculture. Of these, about 90% work in the family farm sector. The family

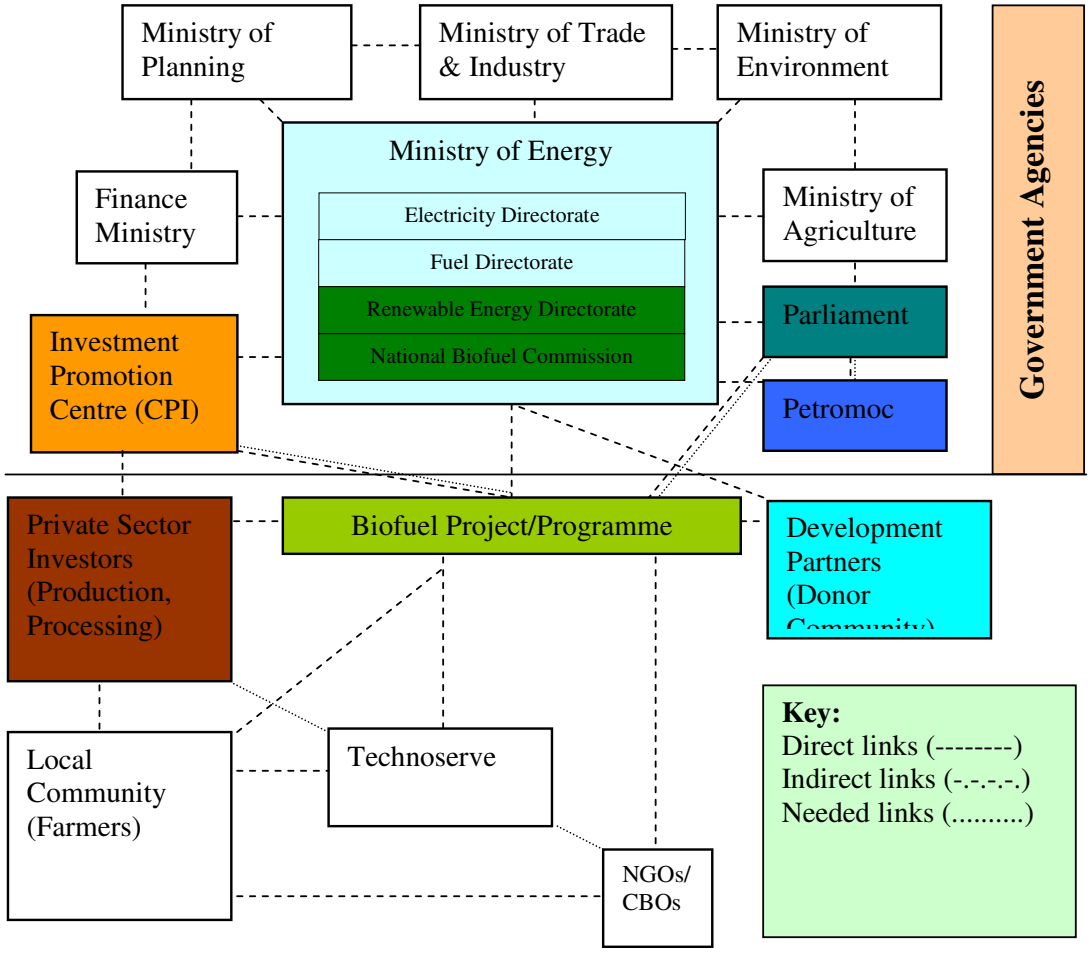
[6] *International Institute for Sustainable Development, 2009. Agriculture: Future Scenarios for Southern Africa - Food Production in Mozambique and Rising Global Food Prices*

Land may not be sold; access is free of charge, but once occupied the land can be inherited to the occupant's direct descendants. land in Mozambique is still owned by the state, and cannot be bought or sold. Long-term use rights can be obtained through occupation by communities, through occupation in good faith for at least 10 years	agriculture system is characterized by family labor force and low mechanization.
Policies in place The energy Policy (1998) The Energy Sector Strategy (2000) The Poverty Reduction Strategy Rural Energy Development Land Policy (1997)	**Biofuels Programmes** Biofuels Policy and Strategy National Biofuels Council National Biofuels Strategy and Action Plan
Biofuel Crops Potential feedstocks include sugarcane, Sweet sorghum, cassava, maize (for ethanol), *Jatropha curcas*, coconut, sunflower, soy, groundnuts (for biodiesel). However based on sustainability of feedstock as well as evaluating their potential for income generation, cost of production, socioeconomic and environmental impacts the chosen crops for biofuel production in Mozambique are the following: sugarcane and sweet sorghum for ethanol, *Jatropha curcas* and coconut for biodiesel.	**Ministries involved** The Ministry of Agriculture Ministry of Energy. Three directorates (Electricity Directorate, Fuels Directorate and Renewable Energy Directorate) The Environment Ministry

Implications of biofuels production

Final use of biofuels in Mozambique will be for cars and industry, agricultural and home electrical equipment. Ethanol will be used as direct blend with fossil fuels. Ethanol can also be used to produce gel fuel as a domestic energy source to reduce over - dependence on Charcoal and wood. Biodiesel can be used in generators. Straight vegetable oil can be used in Stationary diesel equipments. For the use of cars, a blending of up to 20% biofuels can be implemented with out modifications to the engines.
Mozambique. also reports that they are many enquiries from around companies interested in acquiring land to establish biofuel plantations.
Other stakeholders involve NGOs such as Technoserve, Petromoc, and the Investment Promotion Centre (CPI)

Mapping of Policies and Institutions



Summary of biofuels activities implications in Mozambique

	FARM 97% of cultivated land tilled by smallholder farmers. Each household cultivates an average of 2 hectares.	**INDUSTRY** Large-scale projects still in nascent stage, comprising bioethanol & biodiesel	**MARKET** **Mainly** transport and industry, agricultural and home electrical equipment.
Issues	•Family agriculture system characterized by family labor force and low mechanization •Fertilizer use is very low, used only for cash crops •Agricultural inputs such as tractors, ploughs, fertilizers, pesticides and others are low, or almost zero •Production constrained by pests, seed shortages and labor shortage •Concerns over food security issues in relation to growing food crops for biofuels	•Unavailability of feedstock and infrastructure	• Market for biofuels is still in its infancy
Policies	• Poverty Reduction Strategy has energy as one of the six pillars. • Biofuels Policy and Strategy establishes guidelines for the public and private sector to better participate in the biofuels industry.	•National Biofuels Strategy has outlined an Action Plan that envisions commercialization of biofuels in the period 2009 – 2015 which will involve feedstock production and establishing processing industries	•National Biofuels Strategy Action Plan also envisions establishment of distribution networks.
Emerging Patterns/ relationships	•Mozambique has engaged governments and businesses in other countries with successful biofuel programmes, e.g. Brazil. •Agreements on trade cooperation, investment, and technology transfer concluded between Mozambique and European countries.		•At least 5 serious players have been investigating the potential of biofuel in Mozambique.
Impact/ future implications	•Opportunities to provide farm jobs •Environmental benefits of using biofuels •Expanded income through adoption of new cash crops. •Irrigated feedstock production to create more demand for water	•Growth in agro-industrialization •	•Ethanol can be used to produce gel fuel as a domestic energy source to replace firewood and charcoal •Country's dependence on imported fossil fuels will reduce.

Conclusions

Mozambique has been the recipient of numerous investors in the last years for bioenergy crops production. The National Government has followed a conscious path into the development of their policies and the mapping of the country to better identify the areas where this production is possible without generating negative impacts in local resources and food production.

At farmer level the infrastructure and investment for agriculture is very limited or nearly null affecting the yields. Mozambique is a net importer of food commodities, especially rice, wheat and, to a lesser extent, maize. At the same time the country relies on imports for all its domestic wheat requirements. Imports of rice account for about 75 per cent of total domestic consumption, and those of maize (mostly from South Africa) account for about 13 per cent of total domestic consumption. Nevertheless, there are reports about the land availability for food and bioenergy crop production.

Since most of the bioenergy initiatives have recently started it is difficult to assess how the local communities are engaging with the production.

12. GENERAL CONCLUSIONS

The production and possibilities for investment on biofuels in Africa need to consider the differences and collection of factors at regional and local level including geographical location, land use patterns, preferences, income distribution patterns, cultural and social aspects. With these assumptions it is possible to consider that in Africa, there is much scope for improving agricultural productivity. Furthermore, many countries already have policies in place or are on the way to produce their own policies regarding biofuels production. Nevertheless, as some of the case study countries showed, these policies are sophisticated, although the capacity to implement and monitor them may be limited. This is an issue that needs to be considered for the standards and certification issues and for the efforts that the Global Bioenergy Partnership (GBEP) is trying to pursue.

Although we acknowledge that Africa is a continent with 61 territories and that the number of case studies in this report is limited, the literature review and the regional experiences point out to the issue that Africa has the potential to meet both its food and fuel needs from biomass. The food vs / and fuel debate and the reality in the continent is more acute and nuanced than in any other region, and African leaders struggle with a combination of urgent drivers and obstacles that require unique and carefully thought through policies.

Another important issue to be considered is the need for directed investment (both internal and external) for the development of this industry and the careful stimulation that local markets need. This will require further studies specially for the consideration of the diversification of products related to bioenergy crops in the local markets

Exporting some biomass and biofuels may be necessary to encourage the investment required to expand food and fuel production but great care needs to be taken to add value locally and protect local land and labour rights.

Biofuels can be grown on significant scales without indirect effects on food production or natural habitats though some considerations on production, sustainability and policy should be taken into account as follows:

- The stakeholder mapping in all the case studies showed the lack of interaction between all of them (government, private, NGOs, farmers) despite that the bioenergy production activities show clear cross cuttings in different areas such as Agriculture, Energy, Industry, Transport, Social, Environment agencies and Ministries.
- The case studies reviewed in this document do not represent the total activities and situation of the rest of the countries in the continent but are some of the most relevant examples in different regions in the continent.
- On land currently under cultivation, in the less developed countries it can be possible to triple yields by using improved management practices, potentially freeing up more land for biofuel production.
- It is estimated that the area under sugar cane in the region could be doubled without reducing food production or destroying valuable habitats. Sweet sorghum shows promise for integration with sugar cane and extending production into drier areas.
- Jatropha is being planted in southern Africa with plans for expansion, but is relatively unproven and has yet to reach commercial-scale oil production. Oil palm is mostly grown in West Africa but cold-tolerant varieties have been successfully demonstrated in southern Africa.
- If biofuel production brings investment in land, infrastructure and human resources, it could help to unlock southern Africa's latent potential and positively increase food production.

- Investors and Governments in the EU should look not just at local Policies but also at Regional Policies in Africa which create an umbrella for countries who do not have a dedicated policy on biofuels. Enacting a legal and regulatory framework that allows for the development of modern biomass is also necessary in African countries and EU countries can contribute to promote this and enforce regulations where available.
- In South Africa, expansion of agriculture may be limited, but in Mozambique, only 10% of arable land is currently under cultivation.
- It is necessary to look for subsidy policies, equitable power prices and consistent trade and taxation policies.
- Private investors should comply with international agreements, local policies and regulatory frameworks on trade, agriculture and sustainability issues.
- International agreements on land use and resources considerations (conservation areas, definition of idle land, suitable land for biofuels, water) will help to strength the sustainability considerations at local level.
- Secondary effects should be avoided strengthening the use of traditional environmental management methodologies (EIA, SEA, SIA) with local research groups and professional bodies.

Recommendations:

- The involvement of stakeholders should be not only for the decision-making process but also for the enforcement and monitoring of the bioenergy activities.
- Food security involves many aspects that are not strictly related to land availability, crop selection and production. These other aspects such as trends in national and international markets, speculation, activities of middleman and others should also be considered as causes and not just the development of bioenergy industry.
- It cannot be denied that negative impacts have occurred in some areas (not whole countries), such as displacement, and these should not only be avoided but legally penalised.
- National Governments should also look at case by case for the decision making of investments not only for bioenergy crops but also for other agricultural and industrial developments, specially where these activities are increasing.
- Adequate investment for these activities should favour not just the National Economies but also the small producers.
- Further research is still needed including the local capacities (Universities and Research Institutes) in order to assess the possibilities of the extension of local markets and the forms of investment to contribute to the expansion and further development of the agriculture, industry and economy sectors in Africa with a positive contribution to the population and the environment.