Liquid Biofuels for Transportation in Tanzania

Potential and Implications for Sustainable Agriculture and Energy in the 21st Century

Study commissioned by the German Technical Cooperation (GTZ)
August 2005

Study funded by BMELV through FNR

The views and opinions of the author expressed in this study do not necessarily reflect those of the BMELV

Preface

The work was commissioned by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in Eschborn and makes a contribution to a more comprehensive project on international level that investigates the possible opportunities of biofuels especially in developing countries.

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Executive Summary

The successful growth of African economies hinges on their modern energy, of which liquid fuel plays an important role. Sharp fluctuations in oil prices have thwarted development plans in Africa and forced many countries to review their development and services project, their overall expenditure and their external trade relations.

Tanzania relies exclusively on imports for its oil needs. The value of Tanzania's imports increased from US $ 1,661.4 mio. in 2002 to US $ 2,145.3 mio. in 2003. This increase is largely attributed to an increase in importation of fuel. The fuel bill increased from 2002 to 2003 over 100 % (from US $ 195.6 mio. to US $402.0 mio.). The continuous high oil prices are a heavy burden for the country.

Just recently, the Tanzanian Government has started to think about alternatives to oil and during discussions with several high-level representatives of Government Ministries it became very clear that Tanzanian policy-makers are well aware of the large variety of benefits offered by displacing gasoline and diesel fuels with liquid biofuels for transport. The following benefits may act as the main drivers for future biofuels programmes in Tanzania:

- Agricultural/rural development – Creation of new jobs and income opportunities
- Reduction of oil imports – Foreign exchange savings
- Improved energy security
- Creation of new industries
- Reduction of GHG emissions – Opportunities for CDM and carbon trading
- Reduction of air pollution (Lead, SO_2, CO)
- Improved vehicle performance (ethanol as octane enhancer)

The GTZ has been commissioned to comprehensively survey the issue of "fluid bio-fuels for transportation" in a global environment guided by the principle of sustainable agriculture, energy and transport and to bring the results of the analysis in the international debate. The global survey will be carried out by the Worldwatch Institute, Washington. As a basis for the formulation of an international policy approach also country-specific considerations have to be analysed and to be taken into account. Therefore, regional studies will be undertaken in Brazil, China, India and Tanzania and experiences and knowledge from Germany, Europe and the US will be prepared. These regional studies act as a basis for the global survey.

This regional study report on the potential of biofuels for transportation in Tanzania is divided into the following four chapters.

Chapter 1 provides an overview of the current situation in the field of biofuels for transportation in Tanzania including the description of the transport sector and the (bio) fuel market in Tanzania as well as the identification of most relevant agricultural energy crops and forestry resources for biofuel production.

In **Chapter 2** the potential for production of biofuels in Tanzania is examined under a set of realistic scenarios. This chapter evaluates whether there is a practical potential to produce biomass for the production of biofuels at the scales necessary to have a real impact on the Tanzanian transport sector.

The assessment begins with estimates of the gross bioenergy potentials of the country based on analysis of soil, climate and terrain characteristics of different areas of the country and of the requirements of different crop types. This assessment of supply potential is then refined by considering the biofuel yields of current conversion technologies. Alternative levels of demand for biofuels based on the national demand for liquid fuels for petrol and diesel engines are analysed, and the supply requirements to meet these demands are assessed. Basic analyses of the economic viability of bioethanol and biodiesel production in Tanzania are carried out. Finally the future increases in potential for production of biofuels that may be expected to result from improvements in crop and conversion yields are described.

In **Chapter 3** the potential for biofuels production in Tanzania are investigated in relation to sustainability targets. Aspects taken into account for this analysis include food security and energy provision as well as environmental, socio-economic, and macro-economic aspects.

The drive to meet the Millennium Development Goals and the emerging underlying understanding that energy services underpin each of these goals has led to a sharp focus on the ability to provide those energy services at the local level. The parallel driving forces of energy security and climate change mitigation further re-enforce the need to find affordable, safe and sustainable renewable sources of energy. Modern bioenergy, an inherently rural, land-based activity has the potential to help provide those energy services. However, because modern bioenergy is a land and labour intensive form of renewable energy it also can have complex positive and negative implications for sustainability. Moreover, a carefully planned, established and monitored bioenergy provision chain can have overwhelmingly positive impacts on a range of sustainability indicators, but a poorly planned and established chain can have damaging environmental and social impacts in the short and long term. Finally, because of the biological basis to bioenergy production many of the factors necessary to develop a profitable and sustainable bioenergy chain are sensitive to the local environment.

As a result of the combination of complexity and site-specificity it is often not possible to establish generic standards and guidelines that ensure sustainable provision. Instead, a broad set of standards needs to be established underpinned by a detailed set of measurable criteria that can be monitored through an effective and transparent system, such as certification. This chapter summarises the main criteria that will affect the sustainable supply of biomass for energy and highlights the role assurance and certification could play in providing the mechanism for ensuring sustainability.

The recent increase in the price of oil and gas means that many forms of bioenergy are now directly commercial, particularly biofuels. However, the regulatory systems are not yet established to ensure that biomass is not effectively mined for short term profits to the detriment of the environment and local communities. Systems that are workable, transparent and reward best environmental and social practice are urgently required.

In **Chapter 4** recommendations for decision-makers in Government and industry are presented. This section provides an overview on the various motivations for the establishment of biofuels programmes in Tanzania as well as key lessons learnt from other biofuels programmes. Biofuel implementation opportunities and opportunities for German-Tanzanian collaboration are identified. Finally, concrete recommendations for the introduction of biofuels in Tanzania are presented including the establishment of a Tanzanian Biofuels Task Force and a Tanzanian Biofuels Producer Association.

The following list of concrete recommendations for action for the Tanzanian Government were elaborated as a follow-up of the expert workshop and policy discussion organised in the framework of the present study on 28 September 2005 in Dar es Salaam.

1. **Establish a high-level Biofuels Task Force**

   The aim of this Task Force is to provide advice and recommendations to the Government for the elaboration of biofuels policies and regulations suitable for the Tanzanian framework conditions (e.g. mandate, obligation, tax breaks, enabling fuel standards). This Task Force will ensure close co-operation between the different Government Ministries involved in the development of biofuels policies, as well as provide an information channel between Government and biofuels stakeholders from industry, farmers associations, NGOs and civil society.

2. **Establish a Tanzanian Biofuels Producer Association**

   The Biofuels Producer Association will give a strong voice to all actors which are or plan to get involved in the production, marketing and use of biofuels in Tanzania. This association shall also be acting as one of the important stakeholders of the Biofuels Task Force.

3. **Start immediate Government Action to promote increased use of biofuels**

   In order to quickly proceed with the introduction of biofuels in Tanzania, the Government should take immediate action to enter the learning-by-doing process – and not wait for results and policy advice from the Task Force.

   - Establish biofuels demonstration facilities; 1 large-scale ethanol and 1 large-scale biodiesel (or Pure Vegetable Oil) production facility with scales of more than 10.000 tons per year of biofuel output
   - Establish a production/user group for small-scale biodiesel (or PVO) production for transport fuel and bio-electricity production
   - Encourage the sales of flex-fuel vehicles and companies which modify diesel vehicles to run on Pure Vegetable Oils; investigations may be required on the relative benefits of esterified bio-oils and PVO for mineral diesel replacement
   - Investigate the option of using ethanol blends in gasoline as lead replacement in order to comply with Tanzania's obligation to phase-out leaded gasoline by 2005
   - Encourage financing options (e.g. capital allowances, tax breaks) and set-up incentives for (local and foreign) investors; consider revenue neutral options including additional taxes on fossil fuels to cover implementation costs of biofuels
   - Evaluate monitoring/ verification as a practical method for ensuring the sustainable development and use of biofuels and to quantify the national impact of their use

4. **Assess the role of Government in promoting biofuels**

   The Tanzanian Government needs to consider carefully its role in promoting biofuels, i.e. what should be internal Government activities and what should be carried out by the private sector, NGOs and local Governments.

5. **Pursue international facilitation options**

   The Tanzanian Government should pursue international facilitation options, such as the Partnership Dialogue Facility (PDF) of the European Union Energy Initiative, the International Bioenergy Programme of the Food and Agriculture Organisation of the United Nations (FAO). These international institutions have the mandate to assist with the development of biofuels through (for example) G8, Global Bioenergy Partnership.

6. **Establish co-operation with other African Governments**

   For example, the Tanzanian Ministry of Energy and Minerals should get in contact with their Zambian counterparts to ensure regional co-operation on the development of the Biofuels Task Force and relevant policy instruments.

7. **Integrate actions of the Biofuels Task Force with the Tanzanian Renewable Energy Agency and the Tanzanian Investment Centre**

   Effective cross-departmental actions on biofuels (and bioenergy) need to be ensured through careful considerations on how to integrate activities of the Biofuels Task Force with the Tanzanian Renewable Energy Agency and the Tanzanian Investment Centre.

8. **Promote applied research and development**

   Continued, applied research and development will be required and local and international academic institutions and private sector research organisations should be encouraged to collaborate on research and development in this critical emerging sector.

9. **Promote awareness raising activities**

   In order to provide solid grounds for the development of a biofuels sector in Tanzania, the population has to be informed about the significant benefits and opportunities offered by biofuels as alternative transport fuel.

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Abbreviations

AGENDA	AGENDA for Environment and Responsible Development
AGO	Automobile Gas Oil
ARI	Agricultural Research Institute
ATCL	Air Tanzania Company Ltd
AVGAS	Aviation Gasoline
BP	British Petroleum
CAL	Casement Africa Limited
CAMARTEC	Centre for Agricultural Mechanisation and Rural Technology
CEEST	Centre for Energy, Environment, Science and Technology
DIA	Dar es Salaam International Airport
DPK	Dual Purpose Kerosene
EWURA	Energy and Water Utilities Regulatory Authority
FO	Fuel Oil
GEF	Global Environmental Facility
GO	Gasoline
IDA	International Development Association
IDO	Industrial Diesel Oil
IK	Illuminating Kerosene
JET	Journalists on Environment in Tanzania
KAKUTE	Kampuni ya Kusambaza Teknolojia
KIA	Kilimanjaro International Airport
KIDC	Kilimanjaro Industrial Development Centre
KSC	Kilombero Sugar Company
LEAT	Lawyers' Environmental Action Team
LDCs	Less Developed Countries
LPG	Liquefied Petroleum Gas
MEM	Ministry of Energy and Minerals
MNRT	Ministry of Natural Resources and Tourism
MSE	Mtibwa Sugar Estate
MSP	Motor Spirit Premium
MSR	Motor Spirit Regular
NCI	National Chemical Industry
NGOs	Non Governmental Organizations
PM	Particulate Matter
SAA	South African Airways

SEECO	Sustainable Energy and Environment Company
SIDO	Small Industry Development Organization
TANESCO	Tanzania Electric Supply Company
TANGO	Tanzania Association of Non Governmental Organisations
TANROADS	Tanzania Road Agency
TAOMC	Tanzania Association of Oil Marketing Company
TATEDO	Tanzania Traditional Energy Development and Environment Organization
TAZARA	Tanzania Zambia Railway Authority
THA	Tanzania Harbours Authority
TIPER	Tanzania Italian Petroleum Refinery
TISCO	Tanzania Industrial Studies and Consulting Organisation
TPA	Tanzania Port Authority
TPC	Tanganyika Planting Company
TPDC	Tanzania Petroleum Development Corporation
TRC	Tanzania Railway Corporation
ULG	Unleaded Gasoline
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
URRP	Urgent Roads Rehabilitation Programme
USA	United States of America
VAT	Value Added Tax
VPO	Vice President Office
WTO	World Trade Organisation
ZIA	Zanzibar International Airport

Chapter 1 – Current Situation

1.1 Description of the Transportation Sector

In Tanzania, the Gross Domestic Product (GDP) in real terms grew by 6.7 percent in 2004, compared to a 5.7 percent increase in 2003. This growth rate was mainly attributed to the agriculture sector, trade, hotels and restaurants (including tourism), transport and communication.

The nation's population was estimated at 34.6 million in 2002 and the average per capita income was US$ 270. Over 67 percent of the population lives in rural areas with most relying on subsistence farming. The city of Dar es Salaam has an estimated population of 2.5 million in 2002 and Tanzania's next four largest urban centres together with their populations (in 2002) are: Mwanza (476,600), Mbeya (266,400), Arusha (282,700) and Tanga (243,600).

The transport sector has an effective role of contributing to social and economic development of Tanzania. The sector performance, though underdeveloped, has continued to grow due to both government efforts and private sector investment in road rehabilitation, modernization of port services and improvement in marine, railway and air transport services.

The transport sector grew by 6.2 percent in 2004 compared to 5.0 percent of 2003. The growth rate was attributed to an increase in investment in mobile telecommunications; construction and rehabilitation of airports and road; and an increase in transportation agencies. The sector's contribution to the GDP in 2004 remained the same as in 2003, at 5.4 percent. The transport sector is the main consumer of petroleum products accounting for 40 percent (approximately 580,000 MT) of all imports.

1.1.1 Means of Transport in Tanzania

The transport sector in Tanzania consists of roads, railways, marine and air transport sub-sectors. The details of each sub-sector are described below:

1.1.1.1 Railway Transport Sub-sector

Two railway systems operate in Tanzania, the Tanzania Railway Corporation (TRC) and the Tanzania Zambia Railway Authority (TAZARA).

i. **Tanzania Railway Corporation (TRC)**

   The Tanzania Railway Cooperation (TRC) has two lines, the central line that runs from Dar es Salaam to Tabora with two branches; one to Kigoma in the west along lake Tanganyika hence providing freight cargo transportation to the west of the country as well as the land- locked countries of Burundi, Rwanda, and eastern part of Peoples Democratic Republic of Congo. The second branch runs from Tabora to Mwanza port on Lake Victoria also providing transportation services to north and north-western part of the country including landlocked Uganda. Another line runs from Ruvu northward to Korogwe and then branches to Tanga port on the Indian ocean, another branch north-west to Moshi, Arusha and connecting to the Kenya railway system.

In 2004, TRC transported 1,333,249 tons of freight cargo compared to 1,450,000 tons in 2003, equivalent to a decrease of 8.1 percent. Similarly, TRC handled 464,000 passengers compared to 666,000 in 2003, equivalent to a decrease of 30.3 percent.

ii. Tanzania and Zambia Railways Authority (TAZARA)

The second railway system is the Tanzania – Zambia Railway Authority (TAZARA). It is a two country joint railway system linking the port of Dar es Salaam with Zambia and handling freight cargo for Malawi, Zambia and the Democratic Republic of Congo.

In 2004, a total of 929,000 passengers travelled through TAZARA compared to 1,021,384 in 2003, equivalent to a decrease of 9.0 percent. Likewise, a total of 610,286 tons of freight cargo were transported compared to 613,693 tons in 2003, equivalent to a decrease of 0.5 percent.

Both, the Tanzania Railway Corporation (TRC) and Tanzania Zambia Railway authority (TAZARA) are up for privatisation, most probably involving investors from outside the country.

1.1.1.2 Marine Transport Sector

i. Sea Transport

The Tanzania Harbours Authority (THA) operates the ports of Dar es Salaam, Tanga, Mtwara and the minor ports of Kilwa, Lindi and Mafia in the Indian Ocean. Dar es Salaam is the main port with a capacity of dry and liquid bulk cargo of 9.1 million tons.

During 2004, the Dar es Salaam port handled 5.761 million tons of cargo compared to 5.107 million tons in 2003, equivalent to an increase of 12.8 percent. A total of 2.286 million tons, equivalent to 39.7 percent of the total cargo were handled by the Container Terminal under a private operator, compared to 1.868 million tons in 2003, equivalent to a decrease of 3.4 percent. In 2004, 22.8 containers were handled per hour compared to 22.6 containers in 2003. The duration for container clearance increased from an average of 11.3 days in 2003 to 13.2 days in 2004. This situation was due to poor performance of TRC, TAZARA and road transportation. Specific figures for fuel consumption for this sub-sector are not accessible.

ii. Lake Transport

The new Tanzanian Port Act was enacted during 2004. Following this Act, all ports on the coast and lakes of Victoria, Tanganyika, and Nyasa shall be owned and operated under the Tanzania Port Authority (TPA). The Authority shall own those ports, while business and ports operations shall be leased to private firms. The Tanzania Marine Services Company started its operation in line with the new act. The Company carried 483,619 passengers in 2004, compared to 347,564 passengers in 2003, equivalent to an increase of 39.1 percent. Likewise, the company transported a total of 167,177 tons in 2004 compared to 143, 751 in 2003, an increase of 16.3 percent. The fuel used for lake transport is difficult to document due to the diversity of vessels in the lakes.

1.1.1.3 Air Transport Sub-sector

Tanzania has three international airports, Dar es Salaam International Airport (DIA), Kilimanjaro International Airport (KIA) and Zanzibar International Airport (ZIA), and more than 50 official airports and airstrips. The airports are equipped with modern facilities to provide excellent services both to passengers and cargo operators.

During 2004, local companies, which continued to provide air services, include Air Tanzania Company Limited (ATCL), Precision Air, Government Flight Agency, Coastal Travel, Regional Air Services, Air Excel, Flight Link, and Zan Air. A total of 1,950,383 local and international passengers were carried in 2004 compared to 1, 876,553 in 2003, equivalent to an increase of 3.9 percent.

i. **Air Tanzania Company Ltd (ATCL)**

During 2004, ATCL which is jointly owned by the Government and South African Airways (SAA) increased its aircrafts from 1 to 4 in 2003. A total number of 268,168 passengers travelled compared to 149,540 passengers in 2003, equivalent to an increase of 79.3 percent. The tremendous increase of passengers resulted from the Company's efforts towards improving its services. The Company's earnings increased to Tshs. 38.0 billion from Tshs 15 billion in 2003, equivalent to an increase of 153.3 percent.

ii. **Other Airlines**

Other private airlines transported 535,165 domestic passengers during 2004 compared to 429,567 in 2003, equivalent to an increase of 24.6 percent. Table 1.1 shows the number of domestic passengers carried in 2003 and 2004.

Table 1.1 Number of Domestic Air Passengers Carried in 2003 and 2004

Aircraft Company	**Number of Passengers**	
	2003	**2004**
Air Tanzania	149,540	268,168
Precision Air	248,375	314,720
Coastal Travel	76,856	90,277
Regional Air Services	23,179	29,353
Air Excel	-	17,773
Flight Link	413	173
Zan Air	35,372	45,641
Other Companies	45,372	37,228
TOTAL	**579,107**	**803,333**

Source: Tanzania Civil Aviation Authority, 2005

It is not possible to get specific figures for fuel consumption for the air transport sub-sector in Tanzania.

1.1.2 The Road Transport Sector

The vision of the road sector is embodied in Tanzania's Development Vision 2025 which gives high priority to investment in infrastructure. The aim of this vision is to have a modern, integrated and efficient road transport system that is safe, secure and environmentally friendly and meets the needs of the country.

The road transport sector has a network of about 85,000 km. The network consists of trunk (10,300 km), regional (24,700 km), district (20,000 km), urban (2,450 km) and community (27,550 km) roads. Only 5 percent of the road network is bituminised. Within Tanzania the transport sector contributes about 6 percent of the GDP and, in view of the importance of transit traffic, about 15 percent of foreign exchange earnings. The road transport accounts for over 70 percent of the freight movement in the country.

The geography of Tanzania, its size and diversity gives road transport a special position in the integration of the national economy. In particular, roads serve rural areas (where the majority of people live) more effectively than any other mode of transport.

National road networks (under the Ministry of Works) face lack of sufficient funds for rehabilitation upgrading and routine maintenance, lack of funds is due to the low capacity of the local construction industry and a low participation of the private sector. The proposed Urgent Roads Rehabilitation Programme (URRP) will be set up to address the issue of road network expansion in response to an increasing road transport in Tanzania.

The Government has rationalized and streamlined the institutional framework for the management of the road sector in order to enhance it, effectiveness and accountability. An autonomous executive agency, the Tanzania Roads Agency (TANROADS) has been established which is responsible for the management of trunk road construction, rehabilitation and maintenance. A National Road Board guides its activities with representation from the private sector (e.g. road users) and the Government. The Government has also established a road fund as the main source of finance for road maintenance. Additionally the local authorities under the Ministry of Regional Administration and Local Government are responsible for district and urban roads (the local roads network) in order to open up existing and potential rural productive areas for agriculture, small-scale mining enterprises and rural tourism.

Tanzania is currently in the second half of a ten year Integrated Roads Programme (1996-2006), which is designed to upgrade 70% of the country's 10,300 km of main roads and build some 3,000 km of new roads. The road network is currently 88,000 km and the programme is coming to the end. The limited performance is caused by lack of competent local road construction companies and resource constraints of the programme. Nevertheless, a continuation of the programme is possible using local funds.

Urban Commuter and Vehicle Fleet Services in Tanzania

During 2004, urban commuter services continued to improve due to the existence of competitive private sector participation and improved urban road networks. The prevailing competitive environment in this sector has led to an improvement of urban transport services. The number of commuter buses continued to increase in some urban areas. In the city of Dar es Salaam, the number of commuter buses increased to 6,600 in 2004 from 5,801 in 2003, equivalent to an increase of 8.0 percent. This significant increase was due to the demand for transport services in the city. Table 1.2 shows the number of commuter buses in urban areas and the vehicle fleet in Tanzania.

Table 1.2 Number of Commuter Buses (2003 and 2004) and Vehicle Fleet in Tanzania

Towns	**Number of Town Buses**		**Total of vehicles (ESMAP)**
	2003	**2004**	**2002**
Dodoma	153	170	4,973
Arusha	1118	1045	25,188
Moshi	225	720	9,789
Lindi	3	11	-
Tanga	120	169	34,776
Morogoro	312	300	8,513
Kibaha (Coast)	-	130	-
Dar es Salaam	5801	6,600	318,921
Sumbawanga	13	32	1,760
Mtwara	35	29	4,170
Songea	52	76	-
Iringa	97	113	8,192
Shinyanga	-	-	2,763
Mbeya	355	475	7,450
Singida	7	9	-
Tabora	17	37	5,212
Kigoma	70	472	2,867
Bukoba	25	21	9,998
Mwanza	660	776	18,545
Musoma	49	47	-
Manyara (Babati)	-	47	-
Total	**9,112**	**11,279**	**463,117**

Source: National Bureau of Statistics, 2005.

1.1.3 Problems of Road Transport Sector

The road transport sector in Tanzania is characterised by high cost, low quality services due to various reasons, including the lack of infrastructure investment and rehabilitation. The deteriorated state of the road transport sector is caused by:

- Shortage of adequate trained and experienced personnel in the transport planning and management,
- Inadequate infrastructure and facilities to cater for motorised equipment for rural areas,
- Low managerial capacity in public enterprises and absence of real competition,
- Lack of regulatory regimes that are adequately equipped to enhance competition, fair operation practices and complementarily of services,
- Insufficient dialogue between the public and private sector due to poorly developed service providers as well as the lack of users or consumers associations.

1.1.4 Road Transport and Fuels

Despite efforts to undertake exploration, Tanzania has not yet found oil and is, therefore, completely dependent on imported petroleum products. There are a number of companies exploring for oil, but so far no positive results have been achieved. However, natural gas, which is available, has started to be used as a substitute for oil in industries and power generation (stationary applications). Petroleum consumption increased from 1.24 million metric tons in 2003 to 1.45 million metric tons in 2004. This increase in fuel consumption results from policy changes, the expansion of private sector participation and foreign investments. The new policy allows oil companies to directly import petroleum fuels from oil producing countries. The following table shows the trend of petroleum products consumptions in Tanzania from 1995 to 2004.

Table 1.3 Petroleum Products Consumption in Tanzania in metric tones

TYPE OF PRODUCTS	YEARS									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LPG	7,004	8,937	2,800	3,490	3,719	3,720	20,009	22,150	4,964	5,588
AVGAS	4,193	3,942	1,579.7	4,762.18	4,820.14	0	0	0	2,287	2,461
PETROL	103,609.00	107,049	108,556.0	106,737.00	83,715.63	101,660.00	130,756	134,321	332,607	266,544
DIESEL	324,275.00	370,141	365,632.0	336,088.00	265,130.71	336,370.00	350,176	391411	626,577	652,548
INDUSTRIAL DIESEL	38,634.00	33,254	23,890.0	18,557.00	24,110.00	19,850.00	21,360	2300	19,479	19,715
FUEL OIL [1]	116,971.00	114,122	105,668.0	114,375.00	109,573.44	119,030.00	96,382	100,121	136,019	150,515
JETFUEL	56,146.00	55,060	55,515.0	50,954.00	4,201.24	51,190.00	49,598	48,171	120,758	143,922
PARAFFIN	154,378.00	202,795	177,621.0	122,626.00	76,065.30	83,370.00	104,252	108,124	-	-
TOTAL	805,210.00	895,300	841,261.7	757,589.18	571,335.46	640190	772533	806598	1,242,691	1,241,293

Source: Tanzania Petroleum Development Corporation, 2004

[1] the term fuel oil is used to indicate the heaviest commercial fuel that can be obtained from crude oil, heavier than gasoline and naphtha.

While it is necessary to ensure smooth supply of petroleum products to all customers irrespective of their geographical locations, considerations should be made on how to facilitate cost-effectiveness and competition. Where appropriate, franchise areas should be established in order to enhance availability of petroleum products.

The petroleum sector in Tanzania was heavily regulated until 1997. The sole operating refinery was the outdated TIPER refinery, which refined imported crude oil into end products. It could only process around 50% of national requirements and the balance was imported by the Tanzania Petroleum Development Corporation (TPDC). In 1997, the government liberalized downstream marketing to promote competition in the petroleum sector (as a response to structural adjustment required by the World Bank). The government did this prior to establishing an effective oversight or regulatory function. The TIPER refinery was closed at the end of 1999. Within a short time, 70 companies registered as oil marketing companies. This figure included the major international oil marketing companies and many small local trading companies. Many had little experience and no own storage facilities. Several companies are believed to have engaged in tax evasion by avoiding tax on imported oil products.

The status of marketing and sales of petroleum products is shown in annex 1 on petroleum products statistics in Tanzania.

Annex 1.1 presents the projected total demand for petroleum products in Tanzania, which is estimated to increase to about 2.37 million metric tons by 2010.

Annex 1.2 presents the 2004 sales figures of TAOMC members (e.g. BP, Gapco, Gapoil, Shell, Total) for different petroleum products. Currently, BP is the largest market player with a market share of almost 19%.

Annex 1.3 presents the petroleum product sales in Tanzania for the years 2003, specifying domestic taxable sales as well as tax exempt sales.

Annex 1.4 presents the petroleum product sales figures for the first quarter of 2005. The data presented in these annexes was obtained from the Tanzania Association of Oil Marketing Companies (TAOMC).

The 2002 sales figures for petroleum products with respect to local markets and export markets are given in annexes 1.5 and 1.6.

1.2 Description of the (Bio) Fuel Market in Tanzania

1.2.1 Biofuel Activities in Tanzania

Tanzania's demand and price for petroleum products are growing rapidly at a rate of more than 30 percent per year. The country is currently one of the major consumers and importers of fossil fuels in East Africa. Since petroleum is a finite source, renewable fuels, such as ethanol and biodiesel, help to alleviate the dependence on petroleum imports.

Biofuels may show a good potential as transport fuels because they can be produced from locally grown oil and sugar/starch plants, thereby saving foreign currency for other imports. The following four primary drivers foster the increase in production and use of biofuels in Tanzania:

- Increase of Fuel Prices: Currently, the petroleum prices in Tanzania are increasing at fluctuating rates. Fuel prices of unleaded petrol range between Tshs 1,120 and 1,195 per litre and diesel costs between Tshs 1,075 and 1,095 per litre.
- Air quality: The number of cars in Tanzania has been increasing at a large rate, contributing to fuel shortage as well as air pollution.
- Availability of energy crops: Existing surplus grain and sugar by-products in the cities, non-edible oil crops and the need for economic development are important issues for development in Tanzania.
- Efforts of reducing fuel imports in view of rising world market oil prices (currently US$ 70 per barrel) which are hurting economies of poor countries such as Tanzania

1.2.1.1 Biofuels from Oil Plants

Transport biofuels have only recently entered in the debate in Tanzania. Although Tanzania has a large potential for biofuels production, this potential has remained to date unexploited. This is mostly due to inadequate technical know-how and the lack of policy support for biofuels development. In the field of biodiesel, research and development efforts are spearheaded by Kakute Ltd, FELISA, D1 Oils, the University of Dar es Salaam, TaTEDO and other stakeholders which are briefly presented in the following table.

Table 1.4 Stakeholders of Oil Plants in Tanzania

	KAKUTE	FELISA	TaTEDO	D1 OILS	UDSM
Location	Arusha (Monduli and Mto wa Mbu)	Kigoma Region	Seven Regions in Tanzania	Several Regions in Tanzania	(expected)
Objective	To disseminate knowledge of producing and processing Jatropha and assist smallholder farmers to produce Jatropha soap.	To ensure oil from palm trees will be produced in large quantities and used as alternative fuel in Tanzania	To facilitate promotion of biofuels production and marketing as substitute for imported fuels and as a means to support poverty reduction	To initiate the large-scale exploitation of oil plant products.	To conduct applied research, process development and provide expert professional services to industry, government and other organisations.
Activities	• Establish a test plantation on private ground • Plant Jatropha for erosion protection • Conduct research on Jatropha oil cookers • Disseminate knowledge of Jatropha soap production	• Management of oil seed plantations such as palm oil plantations • Production of vegetable oil • Future production of bio-diesel • Extraction and refinery of oils from other producers • Promote research on biofuels	• Facilitate the establishment of Jatropha tree nurseries in villages • Support production and distribution of Jatropha lamps for field test and demonstration purposes • Conduct combustion tests on Jatropha stoves • Create awareness on the benefits of using biofuels • Advocate appropriate biofuels policies	• Exploit fuel from Jatropha and Moringa plants • Install an oil purification station in several districts • Select suitable communities and identify land for planting energy crops • Investigate the biodiesel and by-products market • Develop a market infrastructure in communities.	Conduct research on biodiesel production from vegetable oil Conduct engine tests on pure bio-diesel and biodiesel/diesel blends
Type of Crop	Jatropha	Oil Palm	Jatropha	Jatropha and Moringa	Jatropha/Sugar cane
Area (ha)	25 ha (demo farm)	-	-	100,000 hectares (planned)	-
Product	Soap / fuel for lighting and cooking	Biodiesel for Transport	Biodiesel for Transport	Biodiesel for transport	Biodiesel and Bio-Ethanol for Transport
Expected Production	40 tonnes (accord. Workshop)	6,000 tons per year (planned)	No data available	No data available	Only for research purposes
Oil Plant Farming	Smallholder farmers	Smallholder farmers and company farms	Smallholder farmers and organisation farm	Company owned farms and smallholder farmers	-

In Tanzania NGOs (such as Kakute) working in rural areas are interested in the income generating possibilities by the utilization of Jatropha, mainly for oil and soap making. The economy of Jatropha soap production is positive in all the cases where data is available. In Tanzania, the economy of soap production shows the following impressing profit, which changes within the different steps of the process chain. The first step, the collection of seeds, shows the lowest income for 1 hour of work, (i.e. 0.29 USD per hour). The second step, oil extraction by hand operated ram press, shows an income of 0.73 USD per hour (i.e. almost 3-fold the income of seed collection). The third step, the production of soap from the Jatropha oil shows the highest profit, namely 2.82 USD per hour.

On the other hand, some government organizations and private companies are interested in the energetic aspect of using Jatropha oil for the large-scale production of biodiesel. The carbon sequestration effect of Jatropha plantations will play an important role for the financing of large projects. Today, the production of Jatropha oil in Tanzania takes place in small quantities only. Jatropha oil in northern Tanzania (Arusha, Engaruka, Mto wa Mbu) is traded for 2 USD per litre (3-times the price of diesel fuel at the filling station). Thus, it is currently not interesting to use Jatropha oil as diesel substitute. Jatropha oil is used for soap production or it is sold to soap makers. KAKUTE does offer lamps and cookers for the use of Jatropha oil, but there is not much interest in the population, as petrol for lighting and cooking is cheaper (if it is available).

Most of the organisations involved in the development of biofuels are dealing with biodiesel and not with bioethanol.

1.2.1.2 Biofuels from Starch/Sugar and Lignocellulose

Tanzania has a large potential for the production of bio-ethanol. A research project conducted by the Applied Microbiology Unit, University of Dar es Salaam 2003 identified the possibility of producing ethanol from lignocellulosic waste materials, primarily from the sugarcane industry in Tanzania. In addition to sugarcane waste, the project aimed at identifying other types of biomass waste that could be used for the production of bio-ethanol. The main target areas of this project are to evaluate the potential of bio-ethanol production from sugarcane waste and other types of lignocellulosic waste in Third World countries.

However, production of ethanol from primary agricultural products is often not cost-effective, because the value of the crops often exceeds the value of the ethanol produced. Bioconversion of lignocellulosic waste from agriculture - like sugarcane bagasse and sisal waste - for the production of bio-ethanol instead of on-field burning could be an effective method for reducing regional pollution. Bioethanol is considered as promising and useful product from agricultural waste, as it is a high performance fuel in internal combustion engines. Fuel ethanol, when produced from lignocellulosic materials, is also an important CO_2-neutral energy source that has a great potential of reducing the worldwide environmental impact caused by the transportation sectors. The production of bio-ethanol from agricultural surplus in Tanzania can furthermore contribute to the development of the country.

Today, the production of ethanol from lignocellulosic feedstock is still in the research and demonstration phase. The first commercial units are expected to be installed in North America and Europe in a few years. Thus, it will take at least about 10 years until this innovative biofuels technology is suited for applications in developing countries.

On the other hand, molasses, which are a by-product of sugar production, can already today be used for production of bio-ethanol (see section 2 of this study).

Nevertheless, several changes are required in the Tanzania transport system in order to promote ethanol blends as a transport fuel. Policy support for the introduction of bioethanol in Tanzania will be needed and the government will be required to enact special legislation to encourage blending of ethanol with gasoline. Enacting a complete supportive policy framework in Tanzania will take several years, but several policies and regulations may be formulated in short term in order to stimulate the use of biofuels in Tanzania.

1.2.2 Political Framework of the Fuel and Biofuels Sector

More than 40 percent of all petroleum imported to Tanzania is consumed in the transport sector. The development of this sector has both direct and indirect implications on total energy consumption and social economic growth.

The energy challenge within the transport sector is to ensure adequate supply, efficient and safe use of petroleum products. Regulatory measures improving, storage facilities, safety standards and adequate pricing needs to be implemented. Furthermore, it is necessary to improve the mass transport systems to reduce fuel consumption, traffic congestion and pollution in the cities. Finally, the investigation of options to replace the current transport fuels by alternatives such as electricity, biofuels and compressed natural gas should be encouraged.

In order to encourage an introduction of biofuels in Tanzania, biofuels crops should be introduced in the agriculture sector. Agriculture in Tanzania can produce several crops as feedstock for biofuels production. Thereby liquid fuels are of course interest, as their energy is highly concentrated, easy to store and transport and suitable for mobile applications. Biofuels like ethanol and biodiesel can be introduced into the fuel market through blends with gasoline and diesel.

1.2.3 Overview and analysis of existing policy instruments

The current Tanzanian transport policy has the objective to "*facilitate sustainable development by ensuring that all aspects of environment protection and management are given sufficient emphasis at the design and development stages of transport infrastructure and when providing services*"(Transport Policy 2003). It further emphasizes to select appropriate technologies by setting standards and enforcement mechanism through suitable regulations

Furthermore, the energy policy stresses on the promotion of "*petroleum exploration by using the best petroleum industry practice".* The cost of petroleum products to the Tanzanian customer is high, as few actors dominate the market. In addition, there is a problem with smuggling and dumping of petroleum products, with its implications on quality control, safety and revenue losses. The policy emphasises the need to supply petroleum products on a sustainable basis and cost effectively with due consideration of environment, health and safety aspects.

The petroleum sub-sector in Tanzania needs an efficient regulatory framework in order to safeguard the interests of stakeholders and to create a level playing in the field for the petroleum product suppliers and retailers. The restructuring of the petroleum sub-sector includes a review of relevant legislation in the Petroleum Act of 1980 and other relevant documents. Further, it will be important to review fiscal policies, which currently put a large burden on petroleum product prices. The fiscal review needs to be done with a long-term perspective, taking into account consequences on the petroleum sub-sector as well as implications on other sectors of the Tanzanian economy.

The Tanzania agricultural and livestock policy categorizes oil seeds as industrial or edible oilseeds. Industrial seeds are not used for human consumption while edible seeds produce vegetable oil for human consumption. Until today, research and extension services for oil seeds crops have been inadequate causing an insufficient performance of the oilseed sub-sector. Thus, there is an urgent need to improve these services in order to increase the production of oilseeds crops in Tanzania. Thereby, the private sector is important for growing and processing of oil seeds, whereas government attention must be directed to assisting the sector to accelerate the growth of the oilseed industry.

Up to date, none of these policies has given support for growing and exploiting potential biofuels crops such as Jatropha, and palm trees. Jatropha is grown by smallholder farmers and promoted by local NGOs for non-transport applications such as fuel for cooking and feedstock for soap making. Smallholder farming is the dominant mode of production in the current Jatropha growing areas. Other potential resources for biofuels production (e.g. bagasse, molasses) have not been exploited yet, and are utilized for electricity production (bagasse) and animal feed (molasses) by some sugar factories.

1.2.4 Structure and Main Actors of the Liquid Fuel Sector

The structure and main actors of the liquid fuel sector are based on the national policy of producing a transparent institutional framework with a clear division of roles and responsibilities in the energy sector and implemented in line with the liberalization of economy.

The role of government for the energy sector is to facilitate development, provide incentives for private investment initiatives and promote effective regulations, monitoring and coordination of the sector. The ministry responsible for energy including the liquid fuels sector (i.e. Ministry of Energy and Minerals) supervises the implementation of the energy policy, which is the main guidance for changes backed by legislation and regulations. The ministry facilitates mobilization of resources in areas where market forces fail to ensure adequate energy services. However, the current limitation of resource allocations poses a large barrier to the prevision of adequate services by the Tanzanian government.

The role and interdependence of different actors (the ministry, regulators and operators) are determined by different legislations. Through the regulatory functions of the sector, operators are licensed, markets and performance are monitored and necessary regulatory measures are applied. The following main actors play a crucial role in the Tanzanian liquid fuel sector:

1.2.4.1 Tanzania Petroleum Development Corporation (TPDC)

The Tanzania Petroleum Development Corporation (TPDC) is a national oil company responsible for exploration, promotion and development of oil and gas resources in the country.

The mandate of TPDC is to spearhead, facilitate and undertake oil exploration and development in Tanzania. In the year 2000, TPDC launched major exploration activities in the deep-sea area at the Tanzanian coast. Following the discovery of the Songo Songo Gas field, TPDC undertook the confirmation of the gas field as well as the appraisal and monitoring of the exploitation of the gas field. The role of oil marketing has been left to the private oil marketing companies.

Petroleum exploration and development in Tanzania is governed by the Petroleum Exploration and Production Act 1980. The act does not control prices, and the market of petroleum products and biofuels as potential substitute for petroleum products are not mentioned in the act. This act vests titles on petroleum deposits within Tanzania's mainland and it is designed to create a favourable legal environment for petroleum exploration by private oil companies. The act expressly permits the government to enter into petroleum agreements under which an oil company may be granted exclusive rights to explore for and produce petroleum. Under the Production Sharing Agreement (PSA), TPDC is granted the license (together with the government) into PSAs with oil companies. The terms of the PSA form the basis of these licences and are negotiable on a case-by-case basis.

After liberalisation of the petroleum sector in 1999, oil companies formed an association known as Tanzania Association of Oil Marketing Companies (TAOMC). TAOMC members include BP, Shell, Gapoil, Gapco, Caltex Oil, Oryx, Kobil Petroleum, Total, Engen Petroleum, OilCom and Natoil. Currently, the petroleum sector in Tanzania has no regulatory framework. There has been massive tax evasion and uncontrollable increase in fuel prices because the industry was liberalized without first establishing an effective regulator authority. Recently, the government has established the Energy and Water Utilities Regulatory Authority (EWURA) to regulate the energy and water sector in Tanzania including the technical aspects of downstream petroleum business.

1.2.4.2 Energy and Water Utilities Regulatory Act, 2001 (Act No. 11 of 2001)

This Act makes provision for the establishment of the Energy and Water Utilities Regulatory Authority (EWURA) and the EWURA Consumer Consultative Council. It lays down rules relative to powers and functioning of the Authority and the Council, and provides for the resolution of disputes in relation to regulated energy and water services and goods, including the supply of water and sewage services.

The Act consists of 40 sections divided into 7 Parts: Preliminary provisions (I); The Authority (II); Powers and proceedings of Authority (III); Review and appeals procedure (IV); The Council (V); Complaints and dispute resolution (VI); Enforcement and compliance (VII).

The Authority is established as a body corporate under section 4 (“Functions of the Authority defined”). The functions are performed in relation to “regulated goods and services” as defined in section 2. Functions include issue of licenses, establishment of standards for goods and services, monitoring of regulated sectors, etc. The Authority shall adopt an internal code of conduct pursuant to section 11. Powers of the Authority are outlined in sections 16 to 22 (part III). The Authority shall establish a Public Register under section 24. The Council shall be instrumental in protecting interests of users with regards to supply of regulated goods and services (Parliament Act, No 11-2001). Thus, EWURA will be an important player regulating the energy sector in Tanzania. Thereby, EWURA will also be responsible for the regulation and monitoring of a future biofuels sector in Tanzania.

1.2.4.3 Oil Marketing and Trading Companies

There are more than 70 oil marketing and trading companies in Tanzania including BP, TOTAL, ORYX, ENGEN, GAPCO, GAPOIL, OILCOM, NATOIL and KOBIL. For the distribution of petroleum product throughout Tanzania, these companies set-up create partnership with private individuals to operate petrol retail stations. The petroleum companies are organised under the Tanzania Association of Oil Marketing Companies (TAOMC).

In June 2003, BP introduced Unleaded Gasoline (ULG) (95RON) to enhance its brand image as an environmentally conscious company. It did this by introducing ULG side by side with leaded grade of gasoline. This in effect created two grades of gasoline for BP with increased costs caused by operating two distribution systems. Due to the deregulated nature of fuel prices in Tanzania, prices increased rapidly in response to rising world market oil prices. The main actors distributing petroleum products to the customers are petrol stations. Since some renewable energy innovations and technologies in Tanzania qualify for tax exemptions, a partial and a total tax exemption could also be implemented for biofuels in order to stimulate the development of biofuels in Tanzania.

1.2.4.4 Role of Civil society, media and other partners

The involvement of the following government ministries and stakeholders is essential to ensure the success of biofuels development in Tanzania:

- Ministry of Agriculture and Food Security (MAFS)
- Tanganyika Farmers Association (TFA)
- National Environmental Management Council (NEMC);
- Division of Environment, Vice President ’s Office;
- Tanzanian Ministry of Energy and Minerals;
- Tanzanian Bureau of Standards;
- Tanzanian Ministry of Communications and Transport;
- Tanzanian Ministry of Health/Local Government (health inspectors / community-based health care);

- Tanzanian Association of Oil Marketing Companies;
- Universities and colleges;
- Africa Clean Network, Tanzania.
- Health Board Associations;
- Tanzania Drivers Association;
- NGOs (TaTEDO, LEAT, AGENDA, JET);
- Tanzania Journalists Association; and
- Oil Marketing Companies (e.g. BP, GAPCO, TOTAL, MOBIL, ENGEN, ORYX);
- Development Partners (e.g. World Bank, UNEP, UNDP).

1.2.5 Importation, Refining and Distribution System

Petroleum development in Tanzania is governed by the Petroleum (Exploration and Production) Act 1980. This Act vests titles for petroleum deposits within Tanzania and is designed to create a favourable legal environment for exploration by oil companies. The import of petroleum products has been left to the private sector. Table 1.5 shows the import quantities of crude oil and petrol from 1995 to 2004. Other activities such as licensing, taxing and subsidies are implemented by related government departments such as the Tanzania Revenue Authority (TRA) and the Tanzania Petroleum Development Corporation TPDC.

Table 1.5 Crude Oil and Petroleum Product Import (Metric Tons)

TYPE OF PRODUCTS	**YEARS**									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CRUDE OIL	620,015.00	525,458.00	464,392.00	514,778.60	488,100.00	0	0	0	0	0
PETROL	25,380.06	30,199.34	56,554.28	21,378.00	22,123.30	105,462	130,756	134,321	332,607	266,544
DPK	141,793.49	167,126.23	174,242.76	109,055.00	73,273.60	83,370	104,252	108,124	-	-
DIESEL	239,770.28	236,601.95	223,112.55	126,613.00	151,220.93	351,988	336,370	350,176	391411	652,548

Source: TPDC, 2004

All equipment and materials imported for use in petroleum operations can be imported free of duties and import taxes and can be re-exported free of export duty or tax. Following the closure of the refinery plant TIPER in 1999, Tanzania stopped the import of crude oils for refining.

Analysis of Production, Supply and Use Chain

i. Fossil Fuels

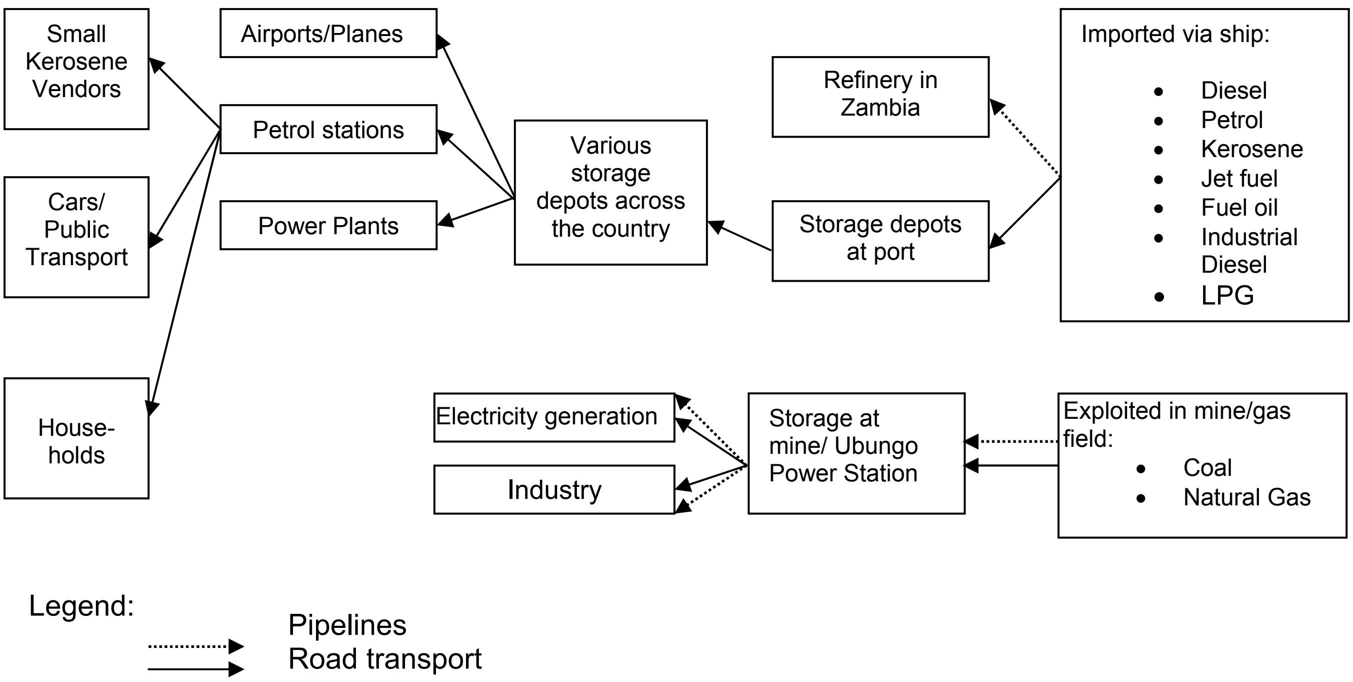
Tanzania does not produce its own petroleum oil and all requirements are met by imports. To reduce this dependence on imported oil, exploration activities are performed on in different parts of the country. The only existing refinery "Tanzanian Italian Petroleum Refinery (TIPER)" was shut down on 4th November 1999 and it was included in the list of factories required to be privatised. Thus, oil derived products like diesel, petrol and fuel oil are procured in bulk through International Competitive Bidding and the import of oil derived products cost a significant portion of the national foreign currency earnings

ii. Distribution

Distribution of petroleum products starts with the storage of the products in depots at the Dar es Salaam harbour (see figure 1.1). Dar es Salaam port has an oil jetty with the capacity of handling large tankers of up to 6,220,695 litres. Several oil marketing companies such as BP, Addax, Total or Mobil own depots for petroleum products. Blending of biofuels and petroleum products (diesel and gasoline) could be done in larger storage depots before distribution across the country. These practices would enable depots to maintain biofuels/petroleum levels to be specified by regulatory bodies. In a next stage of the distribution chain, the products are transported via road or railway to storage depots throughout the country. Altogether, Tanzania has 40 storage depots for imported petroleum products with a total capacity of 600 m^3 (Afrepren, 2004).

To finally reach the end consumer oil derived products are distributed to about 250 fillings stations across Tanzania. In addition to this distribution system, an 8-inch oil pipeline supplies petroleum crude oil to a Zambian refinery at Ndola. Tanzanian authorities are responsible for security and maintenance services for this pipeline.

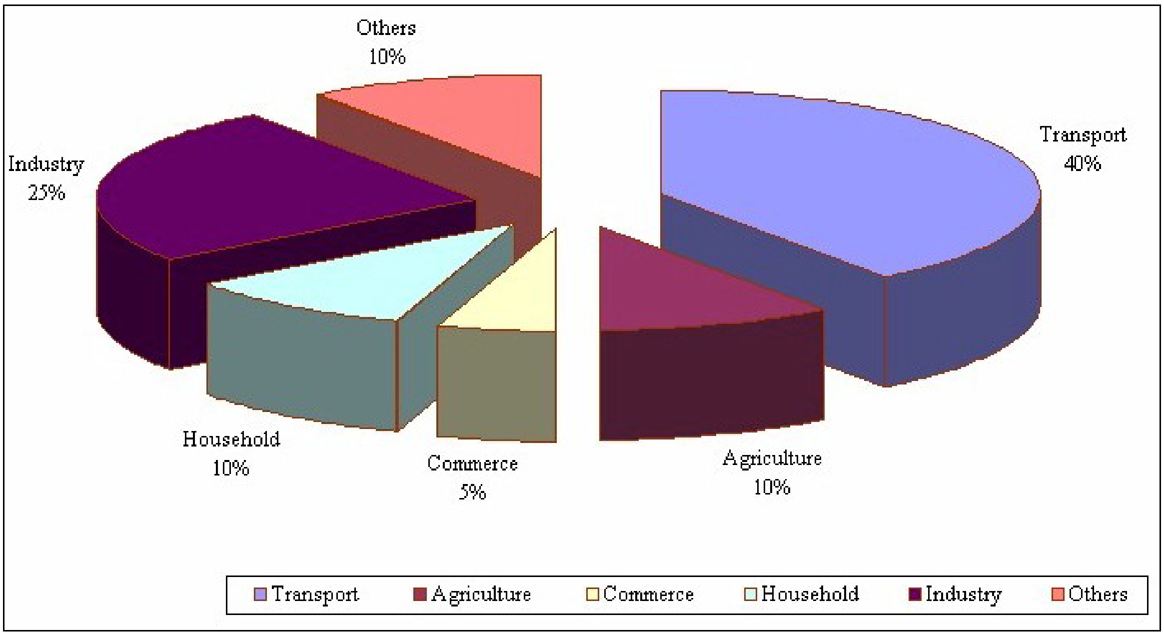
Figure 1.1 Distribution Chain for Petroleum Products



iii. End Users

The total annual demand for petroleum products in Tanzania is 1.2 million tones. The transport sector is the main user of petroleum products with a market alone 40%, followed by the industrial sector with a share of 25%. The agricultural, household and commercial sector account for the remaining 25% of total consumption. Figure 1.2 presents an overview of the share of petroleum products consumption in Tanzania.

Figure 1.2 Share of petroleum product consumption by economy sector



Source: The National Energy Policy, Feb. 2003

The transport sector includes cars and public transport railways, marine vehicles and planes, which have a high consumption of jet fuel. (Table 1.3)

The industrial sector is one of the major consumers of petroleum products, particularly due to poor energy management and inefficient energy use caused by old equipment and outdated technologies as well as capacity under-utilisation. The detailed consumption of different petroleum products is shown in Table 1.3.

Imported LPG is mainly used by oil marketing companies such as BP Ltd. and Oryx Oil, which are selling LPG cooking stoves as well as LPG. The household sector accounts for the majority of paraffin consumption as people use it for lighting and cooking.

1.2.6 Costs, Prices and Price Setting System

Fuel Prices in Tanzania

Prices of petroleum products in Tanzania are surging upwards unpredictably (see figure 1.3 and table 1.6) with consumers bearing the burden of rising international oil prices, a chaotic marketing system and a taxation regime that burdens the citizens with the highest petroleum taxes in East Africa (table 1.7).

Figure 1.3 Fuel Price Trend in Tanzania (US cents/litre)

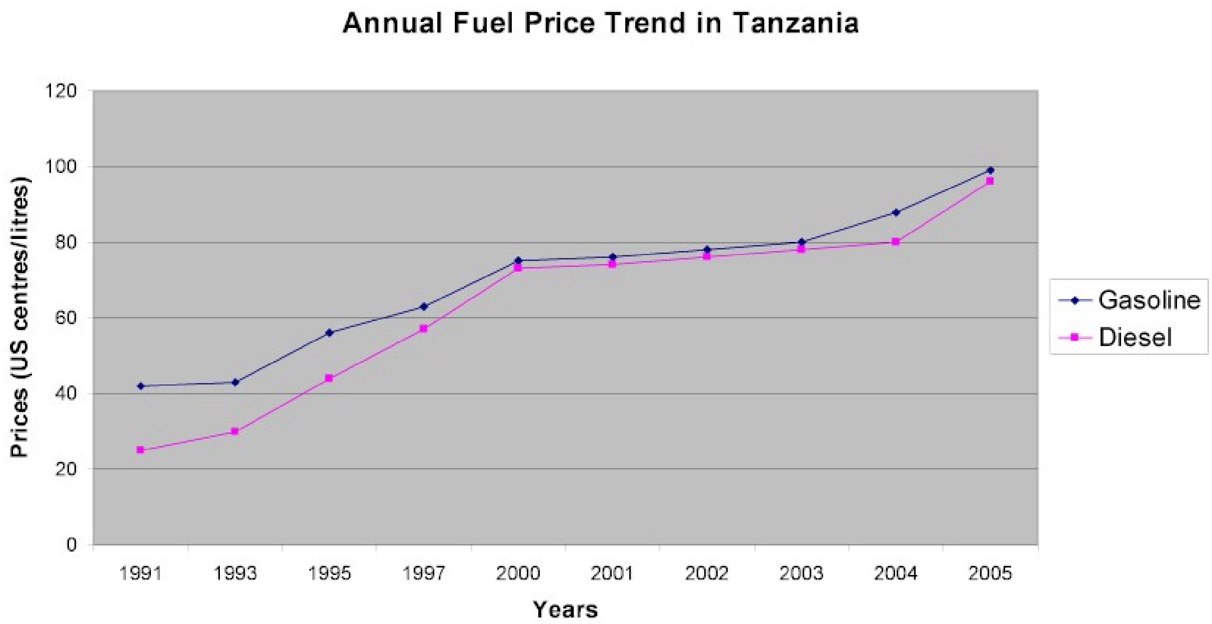


Table 1.6 Fuel Prices Trend in Tanzania (US cents/litre)

Type of Fuel	1991	1993	1995	1997	2000	2001	2002	2003	2004	2005
Gasoline	42	43	56	63	75	76	78	80	88	99
Diesel	25	30	44	57	73	74	76	78	80	96

Source: AFREPREN/author, 2005

If the regime of high prices persists, the effect will be higher prices for petroleum-dependent industries such as transport, agriculture and manufacturing, thus creating inflationary pressure to the economy and rendering impossible the economic programme spelt in this year's budget.

Oil consumers in Tanzania are particularly vulnerable to the impact of high international prices and in-built marketing inefficiencies due to the olgopolistic structure of the oil marketing industry.

In addition, Tanzania has a complex system of taxing petroleum products where VAT is paid on already paid taxes, consisting strong petroleum price increases whenever international prices go up. Currently, payable taxes include excise duty, VAT, customs duty and fuel levy. The Central Excise duty is an indirect tax levied on petroleum products, whereas VAT is payable on excise duty and fuel levy.

A simplified overview on the fuel taxes and the build-up of the market price for gasoline and diesel (i.e. Gasoil) is presented in Table 1.7, whereas a more detailed specification of the price build-up for diesel, heavy fuel oil, jet fuel and gasoline is given in annex 2.

Table 1.7 Fuel Taxes on Petroleum Products in Tanzania (2004)

Petroleum Products	REAL PRICES (SHS/LT)	EXCISE DUTY (SHS/LT)	ROAD TOLL (SHS/LT)	VAT (SHS/LT)	MARKET PRICES (SHS/LT)
Motor Super Premium (MSP)	720	146.0000	90.00	20%	1195
Motor Super Regular (MSR)	660	146.0000	90.00	20%	1120
Gasoil	659	127.0000	90.00	20%	1095
Industrial Diesel Oil (IDO)	659	201.0000	-	20%	1075

Source: TPDC, 2004

1.3 Most Relevant Agricultural Energy Crops and Forest Resources for Bio-fuel Production

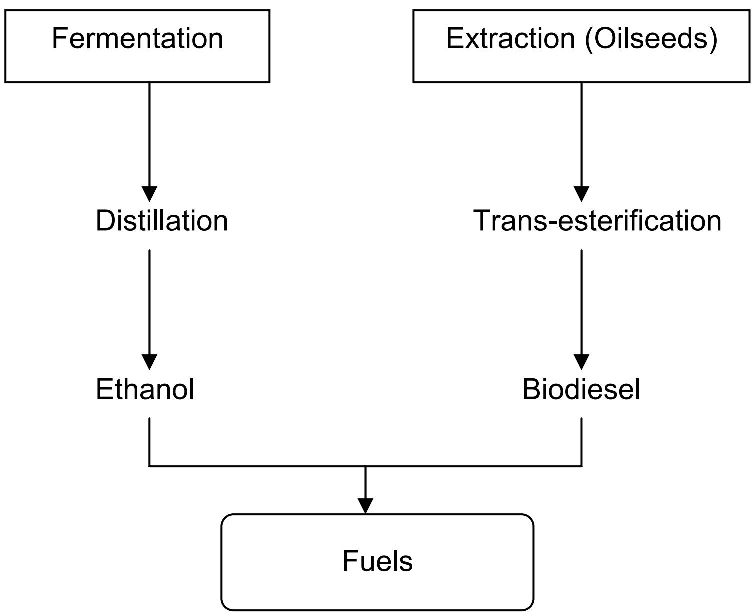
Agriculture is the largest sector in the Tanzanian economy and accounts for 40 to 50 percent of the national GNP, 75 percent of the exports and over 80 percent of the country's employment.

Agriculture is dominated by smallholder farmers (peasants) cultivating an average farm size of between 0.9 and 3.0 hectares. About 70 percent of Tanzania's crop area is cultivated by hand, 20 percent by ox plough and 10 percent by tractor. Tanzania has a rain fed agriculture and irrigation plays a major role. About 5.1 million hectares are cultivated annually (3.3 under annual crops and 1.8 million under perennial crops), of which 85 percent is under food crops which dominates the Tanzanian agricultural economy.

In general, there are different routes to use biomass as an energy source for transport applications (see figure 1.4). Plant oil can be extracted from oil seeds and converted to biodiesel in a trans-esterification process.

Alternatively, bioethanol can be produced from sugar and starch (and potentially in the future from lignocellulosic feedstock) by fermentation and distillation process.

Figure 1.4 Main Biofuels Conversion Routes



1.3.1 Agricultural and forestry feedstock

Tanzania's climatic growing conditions and its arable land can accommodate the production of a wide variety of agricultural products. Oilseeds crops include both industrial (castor seed) and edible oilseeds (sunflower, groundnut, cashew nut, sesame, copra, cottonseed, palm seed and soya). Major cash crops include coffee, cotton, tea, tobacco, sisal and cashew nut. Staples (maize, rice, and wheat), drought resistant crops (sorghum, millet and cassava) and other sub staples such as Irish potatoes, sweet potatoes, sugarcane, bananas and plantains are also produced in Tanzania. A summary of the marketed quantities of Tanzania’s principal cash crops sisal, cotton, cashew and sugarcane are presented in annex 3.1.

Four classes of vegetative sources (raw materials) can be used for biofuels production in Tanzania.

- Starch crops such as grains, maize and tubers like cassava,
- Sugar plants such as sugarcane,
- Cellulose plants (agriculture residues),
- Oil seed crops (like Jatropha, cotton, Moringa, Pongamia, etc.).

In Tanzania many tree species exist with seeds rich in oil. Promising tree species have been evaluated and it was found that *Jatropha curcas* and *Pongamia pinnata*, have a large potential. *Jatropha curcas* can be planted as protective hedges, on fallow lands and public lands along tracks and highways as well as in intercropping schemes with agricultural crops. Furthermore, Jatropha is suitable for poverty alleviation programmes that deal with land improvements.

In Tanzania, it will be possible to produce ethanol from sorghum, cassava, sisal, and sugarcane. Cassava and sorghum are drought resistant crops. They perform well in marginal lands and can be grown throughout the country.

1.3.1.1 Sugar Based Ethanol Production

Sugarcane

The potential major resource for ethanol production in Tanzania can be either processed through sugarcane–sugar route or through the sugarcane-sugar-molasses route. In Tanzania about 1,446 metric tons of sugarcane per hectare are produced and 70 litres of ethanol could be produced from one ton of sugarcane (Pant, 2003).

Table 1.8 presents the sugar and molasses production from the harvesting seasons 2000/2001 to 2004/2005 for the 4 main sugar factories (Mtibwa Sugar Estates (MSE), Kilombero Sugar Company (KSC), Tanganyika Planting Company (TPC) and Kagera Sugar Limited (KSL)). More detailed data for the Tanzanian sugar industry and future trends for the sugar industry are presented in annexes 3.2, 3.3 and discussed in detail in section 2.1.3.1 of this study. Molasses constitute one third of the weight of sugar produced in sugar industry. Large and small-scale sugar mills in Tanzania produce over 50,000 tons of molasses per year. Cane tops and leaves are burnt just before harvest and cane trash is left in the field as fertiliser.

Table 1.8 Sugar and Molasses Production

Year/ Company	MSE		KSC		TPC		KCL		Total	
	Molasses	Sugar	Molasses	Sugar	Molasses	Sugar	Molasses	Sugar	Molasses	Sugar
	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT
2000/01	13,407	31,829	23,091	61,688	16,489	42,018	0	0	52,987	135,535
2001/02	17,283	41,151	24,108	72,499	19,496	49,681	0	0	60,887	163,331
2002/03	15,477	36,850	30,683	98,420	22,682	54,850	0	0	68,842	190,120
2003/04	14,501	34,526	44,210	126,743	27,273	62,519	0	0	85,984	223,788
2004/05	14,734	35,081	42,944	126,516	24,354	52,755	6,883	15,511	88,915	229,863

Source: Tanzanian Sugar Board (TSB), 2005

In Tanzania several studies have been carried out to evaluate the viability of producing ethanol as a fuel for vehicles and for the use in the in chemical industry. In 1979, the National Chemical Industries (NCI) commissioned Tanzania Industrial Studies and Consulting Organization (TISCO) to carry out a detailed power alcohol feasibility study. It was found that the country has substantial potential for producing ethanol from a variety of agricultural crops and waste. Potential agricultural wastes for ethanol production include sugarcane molasses.

Sugarcane Bagasse

Currently in Tanzania, bagasse is used inefficiently for co-generation (see table 1.9) (Kishimbi, 2000). The power generated at sugar factories is mainly used for meeting their own power requirements, and the heat is used as process steam in the sugar production process.

Table 1.9: Bagasse co-generation in Tanzania

YEAR	TOTAL BAGASSE (50 % moisture, tons)	STEAM TURBINE OUTPUT (MW)	ELECTRICITY GENERATION (GWH)
1989/90	338422	4.8	22.3
1990/91	392403	5.7	25.8
1991/92	407389	5.8	26.8
1992/93	433218	6.1	28.5
1993/94	446075	6.4	29.4
1994/95	363694	5.2	23.9
1995/96	391213	5.6	25.8
1996/97	404040	5.7	26.6
1997/98	285132	4.1	18.8
1998/99	401652	5.7	26.4
1999/2000	429156	5.7	26.4

Source: Kishimbi 2000

Sugarcane Molasses

Only about 30% of molasses generated in Tanzanian sugar factories is exported or used as animal feed (Temu and Mbagga, 1993). The remaining molasse is a waste product (see table 1.10). Even after privatisation, in 2000 the Mtibwa Sugar Estate (MSE) that produces about 8,100 tons of molasses per year dumped several tons of molasses in the Wami River (Mwasanjo et al., 2000). Currently, sugarcane molasses are among the most promising feedstock for ethanol production in Tanzania as is discussed in detail in section 2 of this study.

Table 1.10 Waste generated in Tanzanian sugar industries 1989/90 to 1999/2000 (in tons)

YEAR	TOTAL SUGAR PRODUCTION	TOTAL CANE PROCESSED	TOTAL CANE WASTE (50% moisture)	TOTAL BAGASSE (50% moisture)
1989/90	92973	966919	821527	338422
1990/91	107803	1121151	751171	392403
1991/92	111920	1163968	779859	407389
1992/93	119016	1237766	829303	433218
1993/94	122548	12744992	853915	446075
1994/95	99916	1039126	696214	363694
1995/96	107476	1117750	748892	391213
1996/97	111000	1154400	773448	404040
1997/98	78333	814663	518210	285132
1998/99	110344	1147577	768877	401652
1999/2000	117900	1226160	821527	429156

Source: Kishimbi, 2000

Sisal

Since the 1950s, when the sisal plant was introduced to Tanzania, only its fibre has been used for productive purposes. The trend of sisal production in Tanzania is presented in table 1.11 and annex 6.3.

Table 1.11 Trend of Sisal Production in Tanzania

Season [1]	Area (Hectares)			Sisal production (Tons)
	Matured	Unmatured	Total	
1989/90	48826	33780	82606	33743
1990/91	49374	36240	85614	36001
1991/92	49374	36240	85614	24309
1992/93	49374	36240	85614	21221
1993/94	54485	24608	79093	29002
1994/95	52953	25757	78710	24716
1995/96	52018	27153	79171	28902
1996/97	50459	28507	78967	25022
1997/98	48745	29997	78742	22180
1998/99	151869	33997	185666	23229
1999/00	34645	7942	42587	41084
2000/01	34645	11473	46118	23542
2001/02	34645	11473	46118	23641
2002/03	39462	10611	50073	23280
2003/04	..	..	..	26758

The fibre only constitutes 2% of the plant. The rest, consisting of sisal waste and the bole, is dumped near the factory or left on the field to rot. Recent investigations revealed the polluting effect (MEM, 1999) of the sisal waste and showed that it is possible to produce biogas for cooking and heating (Electrowatt Engineering Services, 1986; CAMARTEC, 1992; UNDP, 1993; Capital Consultancy, 1993; UNIDO, 2003), which would reduce pollution and give the sisal estates another source of income.

The sisal leaf contains about 4% by weight of extractable hard fibre. The remains from the leaf still possess up to 20% by weight of extractable pulp and short fibres, the remainder being water and soluble sugars. The remainder of the plant consists of the stem (bole) and the pole, which are rich in solid pulp and liquid juice with a high concentration of soluble sugars. Utilisation of sisal waste for mushroom growing, animal feed and production of biogas has already been demonstrated at pilot scale in Tanzania. Production of ethanol from sisal juice is currently under pilot testing at the engineering college of the University of Dar es Salaam. The soluble sugar from the sisal waste, bole and polescan can be extracted and used for the production of ethanol, but more research on how sisal sugars can be fermented for ethanol production is required.

1.3.1.2 Starch Based Ethanol Production

Ethanol can be produced from a large number of different starch crops such as wheat, rice, maize, potatoes, and cassava. The conversion of starch into alcohol requires a conversion of starch into sugar in addition to fermentation and distillation processes. About 275 litres of ethanol could be produced from one metric ton of maize. With an estimated productivity of 2 metric tons per hectare in Tanzania, 550 litres of ethanol can be produced from one hectare of maize plantation.

1.3.1.3 Cellulose Residue Based Ethanol Production

Cellulose biomass including agricultural crops residues and wood has a large potential for bioethanol production in Tanzania. Crop residues such as rice straws and bagasse currently remain unused in some areas of Tanzania and could therefore be an important resource base for bio-ethanol production. According to literature (Pant, 2003), over 400 litres of ethanol can be produced from one metric ton of rice straw or bagasse.

In Tanzania, residues from the agricultural production of cash and food crops have the potential as feedstock for biofuels production. The main cash crops in the country include coffee, cotton, cashew nuts, tobacco, tea, sisal, sugar, cocoa, oil seeds and pyrethrum. The main food crops are maize, rice, wheat, millet/sorghum, cassava, pulses (mainly beans), potatoes, coconuts, groundnuts, sunflowers, bananas and plantains. Other sources of biowaste in the country include forestry and animal waste.

There are large regional variations for particular residues according to crop production patterns in the country. Large amounts of residues occur in the regions with private estates and intensive smallholder farming such as Manyara, Arusha, Kilimanjaro, Iringa, Tanga, and Kagera. In most farming systems, the annual production of crop residues is considerable. Table 1.12 presents an overview on the amount of residues, based on crop production data in the years 1990 and 2002.

Table 1.12: Residues from selected agricultural crops

Crop	Residue type	Quantity in tons (Year 1990)	Quantity in tons (Year 2002)
Maize	Stalks Cobs	4,483,623 700,569	6,116,250 954,135
Millet	Straw	577,993	361,375
Oil seeds	Shells	216,124	-
Rice	Straw Husks	917,526 140,118	1,851,878 281,418
Wheat	Straw Chaff	198,265 12,202	119,000 -
Cotton	Stalks Seed gin husks	605,776 142,552	667,500 -
Coconut	Husks Shells	462,140 136,480	321,373 92,040
Coffee	Husks	55,803	714
Sugar	Molasses Bagasse	76,000 776,000	441,670 -
Sisal	Sisal waste	900,000	
Sorghum	Straw	-	864,625

Source: Sawe, 1995; Swai. M, 2003

The current market in Tanzania for residues of agricultural production is still low and not well documented. Further studies to identify the actual uses of agricultural residues in the different regions of the country are urgently required. Currently, molasses from the sugar industry are used as animal feedstock with a low economic value of about 1.5 USD per 20 litres. On the other hand, in some sugar companies, molasses are dumped in rivers or used as road construction material. The use of molasses as animal feedstock may be replaced by other high value uses such as biofuels production. If the market for biofuels is developed and prices are profitable, more actors will make available molasses as feedstock for biofuels production. This will also contribute to the improvement of environment by avoiding detrimental waste disposal practices.

Crops

Tanzania's forest resources cover one third of Tanzania's total area i.e. some 33.6 million ha most of which is woodland of the miombo type. Forest plantations cover about 0.6% of the total forest cover. The total forest plantation cover area is estimated to be 160,000 to 200,000 ha. These comprise of about 83,000 ha (gross) of state managed industrial plantations, some 20,000-25,000 ha of private industrial plantation and up to 80,000 ha belonging to villages or local government of district Councils', NGOs, civil societies and religious organizations.

It is noted that about 25% of the standing volume of tree logs in Tanzania remains as residues after processing forest products. Saw mill is one of the largest forest industries, which generate considerable amounts of residues that can be used as energy source. Wood residues can be in the form of solid matter (e.g. off-cuts, barks, slabs, splints, trims) or in the form of dust from sawing and lumbering. There is processing capacity of 900,000 m^3 round wood in the country of which 33.3% is related to natural forest and 66.7% to plantations (Ngaga et al., 1998b). Among forest industries in the country, sawn wood production (saw milling and hand sawing combined) has the biggest share of the capacity standing at more than 71% followed by pulp and paper production having a share 21% and the rest is wood based products, Joinery and furniture (MNRT 2000). The major products produced in the country are sawn wood, pulp and paperboards, particleboards, plywood, fibreboards and furniture. The ply wood industries are currently down due to the lack of raw materials and worn out machines.

An overview of the estimated residue quantities (for the years 1994 until 2002) for sugarcane bagasse, sorghum straw, millet straw and wheat straw is given in annexes 4.1, 4.2, 4.3, and 4.4 respectively.

1.3.1.4 Oil seed crops

Recently, oil crops are gaining increasing interest in Tanzania. Table 1.13 presents a variety of oil plants which could potentially be used for biofuels production as well as their favourable climatic conditions and an identification of areas, where these oil crop plants could be grown in Tanzania. More information on oil plants is given in annex 5 of this study.

Table 1.13 Potential oil plants for biofuels production in Tanzania

Oil	Production (000 tons/year)	% Oil content	Favourable climatic conditions	Regions grown
Coconut	370	65		Tanga, Coast,
Cottonseeds	210	18	Tropics, Sub-tropics and Temperate climates.	Tabora, Mwanza, Shinyanga, Mara, Kagera, Tanga, Morogoro, Singida, Lake zone & Coast.
Groundnuts		45 - 55	Tropics, Sub-tropics and Temperate climates.	Dodoma,
Palm oil	60	43 - 51	Tropics & Sub-tropics.	Tanga, Dar es Salaam, coast.
Soybeans		18 - 48	Tropics, Sub-tropics &Temperate climates.	
Sunflower seeds		25 - >85	Tropics, Sub-tropics &Temperate climates.	
Copra		45 - 75	Costal hot temperature	Coastal areas.
Kapok		25	At the Coast and along coastal areas.	Korogwe, Mombo, Tanga, Coast, Morogoro & Shinyanga
Cashew nuts	123	46 - 47		Lindi, Mtwara, Ruvuma, Dar es salaam, Tanga & Coast
Jatropha	18-58	33 - 60	Tropical & Sub-tropical climates.	Arusha, Bukoba, Kilimanjaro.
Eucalyptus *(Globolus)*		10 - 85	Loam soils, (Moisture climates), Wet Montane climates, Over 2,000m.	Arusha, Mbeya & Iringa.
Macadamia Nuts (*Macadamia tetraphylla*)		60 - 78	Coffee-growing areas of the Tanzania highlands.	Kilimanjaro, Bukoba,
Pappea (*Pappea capensis*)			Drier forests, Savannah & Open woodlands.	Arusha, Dodoma, Morogoro, Babati.
Castor bean *(Ricinus communis)*		20 –50	Preferring Humus-rich& disturbed ground, (Its drought resistant)	Widely spread all over Tanzania.
S. Caffra		60	Low attitudes, woodlands& wooded grassland, 100-1,600m. 200-1,600mm rain/year. Salt tolerant.	Widely distributed all over the country.
Pigeon wood *(T. Guineensis)*			Higher rainfall areas, 0-200m.	Found in riverine forest or forest margins.
Cape mahogany *(T. Roka)*		55 - 65	Well-drained, rich soils & high ground water areas.	Bukoba, Mwanza, Mbeya & Kilimanjaro.
Margosa seeds *(Azadirachta indica)*		20 - 45	Pan-tropical in semi-arid & arid regions (withstanding drought). Very dry areas, & poor soils, 1-1,500m.	
Desert date *(Balanites aegyptiaca)*		40 - 46	Form arid and semi- arid regions to sub-humid savannah, 200-800 mm rainfall, and 0-2,000m.	Shinyanga, Nzega, Singida, Dodoma and Babati.
African fan palm *(Borassus aethiopum)*			Less dry areas of tropical Africa. In Tanzania-along the coast and along water courses.	Coastal Regions.
Peasic/Peach oil (*Persia vulgaris*)		40 - 50		Kilimanjaro, Arusha,
Moringa Ofeira			Tropical & Sub-tropical climates	Widely distributed all over the country.

Today, it is very difficult to report the prices for plant oils in Tanzania, as most oil crops have not yet been exploited. As a first step it is necessary to identify those oil plant species, which could be used for large-scale biofuels production without limitations through competing human consumption uses.

Furthermore Tanzania has the potential to grow large number of oil crops of which only a few are grown on a large scale. Today, the most important crops for oil based biofuels production in Tanzania are cashew nuts, palm oil, coconut, sunflower and Jatropha. However, sunflower, cashew, palm oil and coconut have competing consumption patterns, which can minimise their use as feedstock for biofuels production. The following table shows the oil yield per hectare for various crops in Tanzania as well as the currently planted area and the oil prices in Tshs.

Table 1.14 Oil Yield per Hectare for Different Crops in Tanzania

S. No.	Crop	Kg oil/Ha	Litres oil/ha	Area (ha)	Prices (Tshs/Kg)
1	Avocado	2217	2638	-	400
2	Cashew nut	148	176	81,300	300
3	Castor beans	1188	1413	-	-
4	Coconut	2260	2689	82,500	200
5	Coffee	386	459	394,000	450
6	Cotton	273	325	191,600	175
7	Euphorbia	440	524	-	-
8	Jatropha seeds	1590	1892	-	500
9	Jojoba	1528	1818	-	-
10	Macadamia nuts	1887	2246	-	-
11	Maize	145	172	2,852,300	237
12	Mustard seeds	481	572	-	-
13	Oil palm	5000	5950	-	350
14	Olives	1019	1212	-	-
15	Peanuts	890	1059	267,400	800
16	Pecan nuts	1505	1791	-	-
17	Pumpkin seeds	449	534	-	-
18	Rape seeds	1000	1190	-	-
19	Rice	696	828	688,500	600
20	Sesame	585	696	58,460	370
21	Soya bean	375	446	2,800	
22	Sunflowers	800	952	135,040	
23	Tung-oil tree	790	940	-	

Sources: MAFS, 2003 note: 1194.68 TShs = 1 US Dollar (7th Feb. 2006)

i. Jatropha curcas

One of the promising feedstock for bio-oil production in Tanzania is *Jatropha curcas.* Jatropha grows well on marginal lands of Tanzania with more than 600 mm of rainfall per year, and it withstands long drought periods. It also does well in areas where the rainfall is only 250 mm, but the humidity of the air is very high. The Jatropha plant is scattered and known by the majority of Tanzanians for a long time, but its utilization was limited to the use of the plant as protection hedge around homestead gardens and graves. Usually, the Jatropha seeds are not used. Recently, the KAKUTE project convinced a group of Maasai women as well as a women group in Mto wa Mbu, both near the Ngorongoro Crater, Arusha, Tanzania, about the interesting economic potential of this plant. Especially the medicinal property of the soap makes it interesting for the rural population. KAKUTE has been able to maintain the image of the soap being a "medicinal soap" and it has carried out demonstration projects for use of Jatropha for lighting and cooking.

Additionally, Jatropha oil can be used to run Lister-type engines driving grain mills and water pumps. These inexpensive pre-combustion chamber diesel engines of Indian origin require only the addition of a fuel filter to be able to run on pure Jatropha oil, thus eliminating the need for gasoil entirely. At maximal load conditions the Jatropha oil gives better results than gasoil because of its high oxygen content and the oil can also be used as a lubricant in these engines.

The energy needed to produce Jatropha oil in mechanical presses amounts to less than 10% of the energy content of the oil. Even more important than price is the possibility of local energy production, in order to overcome the periodic unavailability of gasoil in rural areas caused by lack of road access during rainy seasons.

Currently, the price of Jatropha oil is fairly high at 2 US$ per litre due to low production volumes. Nevertheless, with economies of scale, an increase of efficiency in the oil production process as well as “learning-by-doing” in Jatropha agriculture, oil extraction and conversion, the price of Jatropha oil may be able to compete with fossil fuels in the future.

ii. Palm Trees

Palm trees in Tanzania are grown by smallholder farmers and they are an important source of edible oil production. The palm oil industry is generally underdeveloped with an average production of only 6,000 tons of palm oil per year. Potentially, the smallholders could produce up to 20,000 tons of oil seeds, if they were better organised in outgrower schemes and associated to a biodiesel production plant. Currently, there is an urgent need for training of smallholder farmers and supporting palm oil production in order to fetch good prices in the market (FELISA, 2005).

iii. Cashew nut

Cashew, the third most important of Tanzania's export crops, is mainly a smallholder crop and contributes 10 % of the total value of Tanzania's foreign exchange earnings. Cashew nut yield large quantities of shells and husks, which area potential feedstock biofuels production. There are 11 factories processing raw nut in the country, and the 1998/99 production was about 93,000 tons of raw nuts.

iv. Coconut

Coconut palms are widely grown in Tanzania. In the 1960s the country produced enough coconuts to satisfy both its fresh nut and copra markets. By the late 1970s, the coconut industry was in very serious decline. It was generally agreed that the decline of the industry was due to a number of factors; such as an overage palm population, a lethal disease of palms (in some areas), lack of improved planting materials, poor crop husbandry, poor pricing, lack of research efforts, ineffective marketing channels and lack of a governmental support for development and suitable policies. The Tanzanian government decided to take steps to solve these problems. In 1979, the National Coconut Development Programme (NCDP) was created, based on cooperation between the Tanzanian Ministry of Agriculture and Livestock Development (MALD), the Coconut Extension Service (CES) and the International Development Agency of the World Bank (IDA) and the German Technical Development Cooperation (GTZ). The NCDP established a new linkage mechanism for research and extension services in the coconut sector.

There are about 140,000 hectares of coconut plantations along the coast of the Tanzania mainland and the islands Zanzibar, Pemba and Mafia, which produce more than 200 million coconuts annually. Like cotton, oil from coconut is edible and may be recycled for biofuels production after human consumption.

v. Cotton

Cotton, Tanzania’s second export crop is mainly a smallholder's crop and contributes 14% of the country’s foreign exchange earnings. Farmers use Cotton stalks as household fuel, while cottonseed husks from the ginneries are often disposed by burning (Sawe, 1995). Apart from fibres, cotton also produces oil seeds. The oil produced from cotton can be used for biofuels production. However, the cotton oil is an edible oil and has a competitive use for human consumption. One option would be to recycle the used cottonseed oil and use it as feedstock for biodiesel production. Currently, small amounts of vegetable oil are recycled for biodiesel production research at the Department of Chemical and Processing Engineering of the University of Dar es Salaam.

1.3.1.5 Estimated Production Costs

The costs of growing biomass are similar to those for any agricultural crop. Using the terminology of forestry, the basic cost categories are: (1) the “stumpage” cist (the capital cost of establishing the crop and the much smaller cost of maintaining it until harvest); (2) harvesting the haulage to the fuel preparation site; (3) fuel preparation (chipping and drying); (4) transportation to the market or contracted purchaser such as a bioenergy power plant; and (5) overheads or fixed costs. In addition, there must be a sufficient “net margin” or “net income” for the grower. This can be a very large element in the total cost structure (see below) but is often ignored in studies of bio-energy costs. Whether biomass production is an additional activity on “new” land, or a replacement of some part of the existing production pattern, growers normally want net returns that are at least as great as those from present land uses, bearing in mind the possibly production and market risk of relatively novel energy crops. The main cost items are discussed briefly in the table 1.15.

Table 1.15 Cost structure for primary bio-energy production (on per hectare basis)

Type of cost or revenue	Commentary
Establishment costs - Land purchase/lease - Land preparation (e.g. irrigation works) - Plants and planting - Fencing	These initial capital investments are of major importance: they often account for the largest part of the total investment and have to be carried until they begin to be offset by earning from harvest sales.
Maintenance costs - Fertilizer and application - Pesticides and application - Weeding, pruning - Irrigation charges - Thinning (for long rotations)	Sometimes called silvicultural costs, these vary widely according to location, species, and the management regime. Costs also differ because they can be adjusted by omitting or including various treatments in order to alter the returns and risks of the project.
Overhead costs - Insurance; rates and levies; management; financing costs	Overhead costs are generally stable and apply mainly to large-scale commercial enterprises.
Harvesting & Transport - Felling - Cutting up, trimming, stacking - Hauling to farm/ roadside - Drying and storage - Transport to conversion	These costs are incurred at the end of the production cycle. Although often high, they are not "carried" for a significant period. On difficult sites, hauling costs can be extremely high. Many of these costs may be met either b the wood producer or by the purchaser (energy conversion plant) drying and storage are not always necessary.
Revenues / Income - Intermediate harvests (grazing, grass, leaf fodder, tree seeds, pruning for firewood) - Thinning(for long rotations) - Final harvest	At the start of project, estimates of future revenue – based on volumes produced times price – are subject to considerable uncertainty. Intermediate products and thinning provide the earliest revenue stream, with the greatest certainly in product markets and may occur frequently through a rotation. The final harvest will normally provide the greatest volume but with large variation across agricultural and systems.

Source: FAO (2000)

The costs differ with places and crops depending on labour, transport and storage required for production of energy crops. The costs of Jatropha seeds collection, processing and soap making are presented in annex 6 of this study.

1.3.2 Agro-ecological Zones in Tanzania

Agricultural production is principally determined by moisture availability. In Tanzania, irrigation is minimal and agriculture mainly depends on rainfall. The rainy season varies along a North – South axis. The North has two growing seasons, i.e. during the short rainy season, which starts in October and run through January, and the long rainy season, which starts in March and continues through June. Moving South there is a gradual shift to a single growing season, which starts-in November/ December and runs through June. An assessment of growing periods in Tanzania (which includes rainfall distribution, moisture, retention, evapo-transpiration and other factors) indicates that about 46 million ha (about half of the land area) have a growing period over 120 days (sufficient for maize and beans) and a reliable onset of the rainy seasons. Within these regions with reliable moisture availability, the cropping potential (using the traditional low-input, low-output techniques is) determined by soil structure and nutrients status.

The simultaneous consideration of thermal, moisture, soil and topography characteristics permits the definition of broad agro-ecological zones. These classifications are useful for determining production and assessing the potential for crop cultivation. These agro-ecological zones are described below, and are linked to a description of farming systems. Additionally, rainfall patterns by regions for the year 2000 are presented in annex 7.

Table 1.16 Agro –ecological Zones in Tanzania

	Sub- Zone and Area	Soils and Topography	Altitude	Rainfall (mm/yr	Growing season
1.COAST	North Tanga (except Lushoto) Coast and Dar es Salaam South: Eastern Lindi and Mtwara, (except Malone Plateau)	Infertile sands on gently rolling uplands Alluvial soils in Rufiji Sands and infertile soils Fertile clays on uplands and river flood plains	Under 300m	North bimodal 750 – 1200mm South: unimodal, 800 – 1200mm	North: October – December and March - June South: Dec-April
II. ARID	North: Serengeti, Ngorongoro Parks, part of Maasai land Maasai Steppe Tarangire Park, Mkomazi Reserve, Pangani and Eastern Dodoma	North Volcanic ash and sediments, Soils variable in texture and very susceptible to water erosion. South: Rolling plains of reddish sand clays of low fertility. Susceptible to water erosion. Pangani River flood plain w/ saline, alkaline soil.	North 1300 – 1800 South: 500 – 1500m	North: Unimodal, unreliable, 500 – 600m m South: unimodal and unreliable, 400 –600mm	March - May
III. SEMI ARID LANDS	Central Dodoma, Singida, N. Iringa, some of Arusha, Shinyanga South-western: Morogoro (except Kilombero & Wami Basins and Uluguru Mts.) Also Lindi and Mtwara	Central : Undulating plains, w/rocky hills and low scarps. Well-drained soils w/low fertility. Alluvial hardpan and saline soils in Eastern Rift valley and Lake Eyasi. Black cracking soils in Shinyanga. Southern eastern: Flat, or undulating plains w/rocky hills. Moderately fertile loams and clays in South Morogoro). Infertile sands in centre.	Central: 1000 – 1500m Southern: 200 – 600m	Central: Unimodal and unreliable 500-800mm Southern: unimodal, 600 – 800mm	December - March
IV. PLATEUX	Western: Tabora , Rukwa (North and Centre), Mbeya North), Kigoma, part of Mara. Southern: Ruvuma and Southern Morogoro.	Western: Wide Sandy plains and Rift Valley scarps, Flooded swamps of Malagarasi & Ugalla rivers have clay soul with high fertility. Southern: uplands plains w/rock hills. Clay soil of low to moderate fertility in South, infertile sands in North.	800 – 1500m	Western: unimodal, 800-100 mm Southern: Unimodal, very reliable, 900 – 1300mm	November - April
V. SOUTHER N & WESTERN HIGHLAND S	**Southern**: Abroad ridge from N. Morogoro to N. Lake Nyasa, covering part of Iringa, Mbeya **South-western**: Ufipa plateau in Sumbawanga. **Western**: Along the shore of L. Tanganyika in Kigoma and Kagera	Southern: Undulating plains to dissected hills and mountains. Moderately fertile clay soils, with volcanic soil in Mbeya. South-western: Undulating plateau above Rift Valley (s) Sandy soils of low fertility Western: North- South ridges separated by swampy valleys. Loams and clay soils of low fertility in hills, with alluvium and pond clays in valleys.	Southern 1200 – 1500m South-western: 1400 – 2300m Western: 1000 – 1800m	Southern: unimodal, reliable, local rain shadows, 800 –1400mm South-western: Unimodal reliable 800 – 1000mm Western: Bimodal 1000 – 2000+mm	Northern: December – April South-western – November-April Western October – Dec and Feb - May
VI. NOTHERN HIGHLAND S	**Northern:** foot of Mt. Kilimanjaro and Mt. Meru, Eastern Rift to L. Eyasi. **Granitic Mts:** Uluguru Mts in Morogoro, Pare Mts in Kilimanjaro, and Usambara Mts. In Tanga, Tarime highlands in Mara.	Northern: Volcanic uplands. Volcanic soils from lavas and ash. Deep fertile and clays Soils in dry areas prone to water erosion. Granitic Mts. Steep mountains sides to highlands plateau Soils are deep, friable and moderately fertile on upper slopes, shallow and stony on steep slopes.	Northern: 1000 – 2500m Granitics 1000 – 2000	Northern: Bimodal, varies widely: 1000 – 2000 mm Granitic Mts. Bimodal and very reliable 1000 – 2000mm	Northern: November – January and March – June Granitic Mts. October – Dec and March - June
VII. ALLUVIAL PLAINS	K – Kilombero (Morogoro) R – Rufiji (Coast) U – Usangu (Mbeya) W – Wami (Morogoro).	K – Central clay plain, with alluvial fans East and west R – Wide Mangrove swamp delta. Alluvial soils, sandy upstream, loamy downstream in floodplain. U – Seasonally flooded clay soil in North, alluvial fans in South W. Moderate alkaline black soil in East and alluvial fans with well-drained black loam West.		K – Unimodal very reliable 900 - 1300 R – Unimodal, often inadequate 800 – 1200mm U- Unimodal, 500 –800 W – Unimodal 600 – 1800mm	K – Nov - April R- Dec – April U – Dec – March W – Dec – March.

Table 1.17 Areas of agro-ecological Zones in Tanzania

	Description	Agro-ecological Zone	Area
Coastal Zone	Low altitude plains (below 750m) on marine secondary and tertiary sediments	I	6 million ha
Eastern Plateaux and Mountain Blocks	Medium altitude plains (150 – 1,300m) on Precambrian metamorphic rocks	II & II	21.1 million ha
Southern Highlands	High altitude plateaux (1,500 – 2 000M) with volcanic and pre-Caribbean metamorphic rock	V	6.7 million ha
Northern Rift and Volcanic Highlands	Medium altitude plains (1,000 – 2,300m)	VI	5.8 million ha
Central Plateaux	Medium altitude plain (1,000 – 1,300m) on granite	IV	32.7 million ha
Rukwa – Rusha Rift	Medium altitude fit depression (800 – 1200m) with lake sediment	VII	3.5 million ha
Inland Sediments	Medium altitude plain (750 – 1,000m) on Karoo sediments	VII	6.7 million ha
Ufipa Plateau	High altitude (1,500 – 2,200m) on metamorphic, sedimentary and granitic rock	V	1.8 million ha
Western Highlands	Medium to high altitude plain (1200 – 1,900m) on volcanic or sedimentary rock	V	4.3 million ha

Source: Tanzania Bureau Statistics, 2004

Recent studies agree that the smallholder farming system can be grouped into the following six main categories. The classification is based on agro-ecological similarities, but also makes use of other factors such as cultivation intensity, levels of technology and linkage to the cash economy.

Coffee-Banana and Horticulture

Production in this system is based on perennials. Coffee and bananas are often intercropped. Tea is grown in appropriate season. Cereals and pulses are intercropped maintained with mulch from crop residues and manure from dairy cattle. Rainfall is high, and high-value vegetables and other crops are grown where linkages to markets are available. The systems is found in the densely populated highlands areas within the regions of Arusha, Kilimanjaro, Tanga, Mbeya, Ruvuma and Kagera (Zones V and VI)

Maize and Legumes

Of the six farming systems, the largest number of smallholders grows maize and legumes. Maize and legumes, sometimes intercropped, are the common denominator of this farming system, which also includes coffee, tobacco and pyrethrum as cash crops, and cassava as an additional food crop. Maize is grown as cash crop as well as for subsistence consumption. Most of the maize marketed in the country is produced under this system. While fertilizer is used in some areas, draught power use and mechanization are limited. Normally land is not scarce under this system, and fallowing and shifting cultivation are practiced. The system is found in zones with medium to good agriculture potential, and predominates in the Western Plateaux (Zone IV) and the South-western Highlands (Zone V).

Sorghum, millet, livestock (cotton and rice)

Under this system cropping is the farmer's main economic activity, contrary to the agro-pastoralists, who focus on livestock. Condition for crop production is marginally better than those under the agro-pastoralist system, and the need for constant migration and shifting cultivation is less. Land is not scarce, and fallowing is practiced. While food production is still based on the drought resistant cereals (sorghum and millet), farmers also produce cotton, oilseed and rice for market. Rice production from this system has increased marked in recent years. Livestock are important, not only for meat and milk production, but as a source of draught power for cultivation and transport. Draught power is banding (for rice, in valley bottoms), ploughing and riding. Animal manure helps to maintain soil fertility.

This system is prevalent in the Shinyanga and Mwanza regions at the north of the Plateaux and the Northern Highlands (Zones IV and V).

Wetland paddy and Sugarcane

The system is based on use of the permanent water sources to cultivate rice and sometimes sugarcane in river valleys and alluvial plains. Smallholders technology is simple, and furrow irrigation is the predominant technique. The potential for increasing yields through intensification is great. However, additional investment in water management infrastructure and grain milling capacity (by the private sector) will be needed to make expansion attractive to smallholders. Large-scale operations, public, and private, are also using irrigation to produce sugarcane and rice in these regions. The system is found in the alluvial river valleys in Zone VII.

Cassava, Cashew Nut, Coconut

The key subsistence crop in this system is cassava, grown in region where maize is too risky. Conditions are also suitable for cashew and coconut cultivation, the traditional cash crops. Land is not scarce, and fallowing and shifting cultivation are practiced, within limit imposed by continuous access to the cashew and coconut stands. Intensification is limited by climate and access to markets. Low prices for cashew and coconuts have caused smallholders to diversify into sesame and groundnuts. Where irrigation and markets are available, vegetables are also grown. Cashew nut production has been revitalized because of improved access to export markets and the availability of treatment for the powdery mildew disease. The system prevails in the Cost Region, Eastern Lindi and Mtwara (Zone I).

1.3.3 Size and Structure of Farms

The current ownership and use of land under large farms in Tanzanian regions are presented in Table 1.18. It is shown that only 22 percent of the total area is under private farms. On the other hand, the private sector is also much more likely to grow crops than Government. This could either signal a high degree of under-use of high- potential land on Government farms, or indicate that Governments farms are in areas with lower agricultural potential. A review of the distribution of large farms by regions shows that one third or more of the area under large farms is in private hands in Arusha, Tanga, Dar es Salaam, Lindi, Iringa, Singida, Shinyanga, and Mwanza. Only Arusha, Tanga and Iringa are in high-potential zones, and even these regions have low potential areas. In high-potential areas such as Kilimanjaro, Mbeya, Rukwa, Ruvuma and Kigoma, the Government owns over 80 percent of the area under large farms. Sale of these farms in high potential areas to private farmers should greatly increase use rates, and could have a major impact on production and export of traditional and non-traditional high value crops.

Table 1.18 Ownership and use of Area under Large Farms by Regions

Region	Private Area	Total Area	% Private	Share of Private Area Cropped	Share of Government Area Cropped
Dodoma		43,290		60%	0%
Arusha	57,231	110,400	52%	94%	81%
Kilimanjaro	1,141	11,378	10%	52%	56%
Tanga	123,119	306,539	40%	86%	46%
Morogoro	18,720	262,692	7%	93%	24%
Coast	27,263	105,333	26%		
Dar es Salaam	500	984	51%		
Lindi	8,981	28,442	32%	71%	6%
Mtwara	1,136	34,136	3%	100%	
Ruvuma	3,784	25,640	15%	17%	28%
Iringa	33,564	74,071	45%	23%	16%
Mbeya	2,528	69,739	4%	100%	17%
Singida	1,017	1,017	100%	94%	
Tabora		230			100%
Rukwa		100,648			
Kigoma		71,575			3%
Shinyanga	2,376	2,616	91%	26%	100%
Kagera	408	34,309	1%	100%	26%
Mwanza	6,321	7,435	85%	54%	100%
Mara	2,209	32,972	7%	0%	13%
Total	290,298	1,323,446	22%	57%	23%

Source: Tanzania Bureau of Statistics, 2004

1.3.4 Farm Enterprise Gross Margins, Financial Feasibility (cost and benefits)

The concept of energy crops is new in Tanzania. It is difficult to quantify costs and benefits involved in the production and marketing of fuel. As an example, the economic performance of Jatropha production under smallholder farmers is shown in annex 6. The realistic gross margins and financial feasibility of biofuels production can only be determined when biofuels activities are in place and developed for commercial purposes.

1.3.5 Area for energy crops

In Tanzania, the land policy aims to ensure a secure land tenure system, to encourage the optimal use of land resources, and to facilitate broad-based social and economic development without endangering the ecological balance of the environment. A major focus of this policy is the conversion of land into an economic asset to which all citizens should have equal access.

In Tanzania, currently a large part of the arable land remains unused. Hence, land for growing energy crops can be made available under special arrangements between the responsible ministry and the government. The reason for government involvement is initial arrangements required for registering land and costs of changing land use (e.g. from smallholder activities to private energy crop plantation). Energy crops can be grown at different levels in the Tanzanian community. Energy crops can be grown in a de-centralised manner by smallholder farmers which may sell their products to the vendors or nearby companies, alternatively energy crops can be cultivated by medium-scale farmers as additional income or by large-scale plantations and estates as dedicated crops (also for export).

The following table shows the land use for annual crops in small and large farms in Tanzania, also indicating the potential for expansion in certain regions where the area suitable for annuals exceeds the total planted area (e.g. Arusha, Morogoro, Coast, Ruvuma, Iringa, Tabora and Kigoma).

Table 1.19 Land use and potential for expansion for annual crops

Region	Small / Farms	Area Planted to Annuals per HH	Area planted to Annual by Small Holders	Ares planted to annuals by Large Farms	Total area planted to Annuals	Area suitable for Annuals	Share of Gross Suitable Area Currently Cropped	Share of suitable Area Currently Used, Adjusting for Fallow
	(No.)	(ha)	('000ha)	('000ha)	('000ha)	('000ha)	%	%
Dodoma	224,199	1.15	257.6	40.4	298.0	144.0	207%	351%
Arusha	221,112	0.83	183.7	46.4	230.0	287.0	80%	170%
Kilimanjaro	175,622	0.59	104.2	4.3	108.6	54.0	201%	517%
Tanga	210,276	0.70	146.3	1.3	147.5	158.0	93%	151%
Morogoro	185,894	0.60	111.1	16.2	127.3	996.0	13%	23%
Coast	117,849	0.95	112.2	54.8	167.0	319.0	52%	78%
Dar es Salaam	51,878	0.50	25.9	0.2	26.1	13.0	201%	290%
Lindi	124,397,	1.00	124.3	14.5	138.8	475.0	29%	48%
Mtwara	179,591	0.80	143.7	1.0	144.7	213.0	68%	138%
Ruvuma	130,303	1.63	212.2	2.0	214.2	1,139.0	19%	40%
Iringa	231,059	0.63	144.8	7.3	152.1	1,092.0	14%	34%
Mbeya	250,253	0.68	169.2	6.0	175.3	1,020.0	17%	34%
Singida	137,148	0.81	111.1	0.6	111.7	104.0	107%	125%
Tabora	155.177	0.92	142.3	0.0	142.3	678.0	21%	39%
Rukwa	111,334	1.25	139.2	0.2	139.4	981.0	14%	32%
Kigoma	129,865	1.03	133.9	0.7	134.5	544.0	25%	51%
Shinyanga	257,364	1.55	398.4	1.2	399.6	573.0	70%	90%
Kagera	254,229	0.52	131.8	4.1	135.9	339.0	40%	60%
Mwanza	246,737	0.73	179.1	1.1	180.2	535.0	34%	51%
Mara	129,080	0.87	112.7	15.9	128.6	189.0	68%	77%
Total	3,523,366	0.88	3,083.5	218.2	3,301.6	9,853.0	34%	62%

Source: Estimated from Pop. Census 1988 and Agricultural Survey 1989/90

1.3.6 Main actors

The main actors involved in the development of a biofuels sector in Tanzania are presented in the table below. These actors include a variety of government ministries, such as the Ministry of Agriculture and Food Secutiry and the Ministry of Energy and Minerals, as well as energy related parastatals such as the Tanzania Petroelum Development Corporation (TPDC) and the energy and Water Utilities Regulatory Authority (EWURA). Furthermore, the future development of biofuels in Tanzania will be prominently driven by potential biofuels producers. These include sugar factories, such as Kilombero Sugar Company (Illovo Ltd), Tanganyika Planting Company (TPC), Mtibwa Sugar Estates and Kagera Sugar Limited (KSC) as well as organisations involved in the promotion of small-scale oil seed plant production. Jatropha is grown by smallholder farmers in Monduli, Arusha.

Table 1.20 Potential actors of the biofuels sector in Tanzania

S. No.	Type of Actors	Specific Actors
1	**Central Government**	
	Ministry responsible for rural development	Ministry of Regional Administration and Local Governments
	Ministry responsible for agriculture	Ministry of Agriculture and Food Security, Ministry of Cooperatives and Marketing
	Ministry responsible for environment and forests	Ministry of Natural Resources and Tourism, Vice President Office
	Ministry responsible for energy or electricity	Ministry of Energy and Minerals
	Ministry responsible for transport	Ministry of Works and Ministry of Communication and Transport
	Ministry responsible for revenue and financing	Ministry of Finance
	Ministry responsible for international affairs (If the projects involve international financing or technical cooperation)	Ministry of Foreign Affairs
2	**Energy Related Parastatals**	
	Petroleum	TPDC, TIPER, Oil marketing companies, SIDO
	Regulatory bodies (e.g. public utilities commission)	EWURA, TAOMC, TBS
3	**Non-Governmental Organizations (NGOs)**	
	NGOs dealing with environment and development	TaTEDO, CEEST, SEECO, KAKUTE, SUDERETA
	Community development organizations	TANGO, and related NGOs
4	**Local, international, or joint local/ international private enterprises**	
	Enterprises that could produce or use biofuels	KSC, TPC, MSE, KSL, BETL, TAOMC, DILIGENT, KAKUTE, D1 Oils
	Enterprises that would supply, construct, and maintain bioenergy facilities	SEECO, SIDO, KAKUTE, FELISA
	Industries innovating in bio-energy technologies and energy – using goods.	SEECO, KAKUTE, FELISA
	Financing institutions (such as banks and micro credit institutions)	FINCA, PRIDE, ACB, CRDB, NBC, NMB
	Bilateral and Multilateral Donor organization	SIDA, WB, NORAD, GTZ
	Households, SMEs	

1.4 By-products of Biofuels Production

As currently there is no commercial production of biofuels, it is very difficult to assess the potential markets and prices for the by-products of biofuels production.

The well-known by-products of biodiesel production, in Tanzania most likely based on palm oil and Jatropha oil, are glycerine and oil seed cake. The latter could be used as animal feed and/or fertiliser and it is assumed that there would be a sufficient market for this product in the Tanzanian agriculture sector, certainly in the initial stages of a biofuels programme with its moderate production volumes.

Glycerine is a valuable chemical used for making many types of cosmetics, medicines and foods, and its co-production improves the economics of biodiesel production. However, markets for its use (in Tanzania most probably mainly for soap production) are limited and under high-volume production scenarios, glycerine could end up being largely used as an additional (low value) feedstock for biodiesel production.

In the process of ethanol production from sugarcane, the main by-products are bagasse and spent wash (molasses). Bagasse is the crushed stalk of the plant, consisting of cellulose and lignin, and can be used for process energy (electricity and heat) production in the manufacture of ethanol. Thereby, an efficient exploitation of bagasse will significantly contribute to a good economic and environmental performance of bioethanol production.

The spent wash, on the other hand, is a waste product that requires treatment for COD removal before discharge. It may also be used as feedstock for biogas and fertiliser production through anaerobic digestion.

As in the case of biodiesel, it is assumed that a sufficient market for fertilisers exist in Tanzania and the biogas could be used for electricity and heat generation.

Finally, it is acknowledged that a detailed assessment of the value, market and prices for the by-products of biofuels production in Tanzania will have to be performed prior to the development of a large-scale biofuels programme. In this current study only a brief overview on potential by-products of biofuels production is given.

1.5 Relevant Markets and Arrangements

1.5.1 The relevant fuel markets for fossil and biofuels

Oil Fuel Market

In Tanzania a free market exists for petroleum products. The petroleum consumption has reached 1.45 million metric tons. Tanzanian Petroleum Development Corporation (TPDC) is responsible for managing and the production and supply of fuel products in Tanzania. The regulatory body for petroleum products is the recently established Energy and Water Utilities Regulatory Authority (EWURA). The oil industry is an important sector of the country's economy and on average 55% of the country’s foreign exchange earnings are spent for the import of petroleum products. In order to reduce this burden, the current government policies are directed at the exploiting indigenous resources (e.g. national gas resources and potentially the use of biofuels).

Recently, Tanzania's fuel prices have rocketed to their highest levels in the country's history. Petrol is currently sold at between Tshs. 990 and Tshs. 1010 per litre and diesel has a recorded price of between Tshs. 990 and Tshs. 995. There are several factors influencing the price rise at national level, such as the Freight on Board (FoB) price of petroleum, the stability of the national currency (Tanzanian Shilling - Tshs) as well as several taxes on petroleum products. The increase in fuel prices is closely linked with the global market forces: which are currently driven by an increasing demand, especially in Asian countries. The oil companies have been fixing prices in accordance with the purchasing price including a profit margin since the full liberalisation of the oil sector in 2000.

The formation of a regulatory body, the Energy and Water Utilities Regulatory Authority (EWURA) aims at assisting the government to monitor fuel market trends in the country in order to ensure that no price cartels are formed. The increasing price of petroleum products leads to rising costs in the transport sector, which will have an harmful impact on the whole economy in Tanzania.

Biodiesel Market

Biodiesel can be blended in any proportion with conventional diesel and for its handling and storage no separate facilities are required. Therefore, blending of diesel, could be carried out at the storage depots of diesel marketing and distribution companies. But the role of marketing companies in distribution, pricing, and taxation of bio-diesel needs to be further studied prior to the development of a biofuels sector in Tanzania.

Ethanol Market

Ethanol can be blended with gasoline in different percentages. Thereby, the high oxygen content of ethanol facilitates its use as an octane enhancer in gasoline. In the initial stages of biofuels introduction in Tanzania low ethanol blends (e.g. E10) are recommended, as they do not require any engine modifications.

As in the case of biodiesel, blending should be done at the depots of the marketing and distribution companies. Depots are located at Dar es Salaam harbours. These companies will then be responsible for the distribution of the blended fuel throughout the country.

In order to reduce transport costs of ethanol from the production facilities to Dar es Salaam, it may also be an option to use smaller storage depots for blending in different regions of the country.

1.5.2 Policies and Targets

Up to date, no targets have been set for biofuels production and use in Tanzania. In order to promote the development of a biofuels sector in Tanzania and to gradually create a market for biofuels, policies, strategies and targets need to be formulated and implemented by the government. Clear targets will attract more actors and entrepreneurs to the production and marketing of biofuels

On the other hand, for Tanzania the use of ethanol as octane enhancer and lead replacement in gasoline may be of particular importance. The country has signed an agreement reached in June 2001 at the Dakar Conference, Senegal, which obliges the countries of sub-Saharan Africa to launch national programmes to phase-out leaded gasoline by 2005. In order to reach this goal, an action plan demonstrating the benefits of leaded gasoline phase-out has been developed by the World Bank's Energy Sector Management Assistance Program (ESMAP) (ESMAP, 2003).

During this present study no clear outlines for a coherent strategy for the phase-out of leaded gasoline in Tanzania was brought to the attention of the authors by the involved Government departments and the Tanzania Association of Oil Marketing Companies (TAOMC). Therefore, the implementation of an ethanol programme in Tanzania seems to be an attractive option for addressing Tanzania's international obligation to eliminate lead in gasoline. Certainly, co-ordination of international leaded gasoline phase-out programmes with fuel ethanol programmes could provide large synergistic benefits.

1.5.3 Current situation of WTO agreements

The effective implementation of WTO commitments on international trade by Tanzania continues to be hampered by lack of adequate financial, institutional, technological, and technical capacities, a situation that is exacerbating Tanzanian participation in new and future negotiations. Tanzania therefore calls for renewed commitment to technical cooperation through adequate provision of resources in the regular budget of the WTO and other core agencies according to their mandates. Additionally, the need for improved coordination in the delivery of this assistance is emphasised as a necessary requirement to facilitate effective participation.

The primary purpose of the ITC/UNCTAD/WTO Joint Integrated Technical Assistance Programme to Tanzania is to help the country in building national capacity for the understanding and thus servicing her obligation arising from being a Member of WTO. The Integrated Framework (IF) for Trade Related Technical Assistance to Tanzania which was endorsed by the High Level Meeting on Integrated Initiatives for LDC's Trade Development is progressing well and will eventually increase the benefits that Tanzania derive from the trade-related assistance provided by the core agencies and other development partners. An Inter-Institutional Technical Committee on WTO has been established but needs to be strengthened.

Biofuels for transport, including ethanol, biodiesel, and several other liquid and gaseous fuels, have the potential to displace a substantial amount of petroleum around the world over the next few decades, and a clear trend in that direction has begun. The world trade relies more on ethanol than biodiesel. The world market of ethanol is growing between 2-3% a year with global consumption expected to rise to 41.5 billion litres by 2006. The main exporters of ethanol are USA, Brazil, France, South Africa and the United Kingdom. Brazil is the largest producer of ethanol, manufacturing over 12.5 billion litres a year.

One of the issues surrounding the future of biofuels comes from the prospect of international trade. While one of the major justifications for bio-fuels seems to be a desire to maintain a secure domestic supply, importation of biofuels could provide the fuel to many countries at a greatly reduced cost. However, most countries have high importation tariffs on biofuels to make imported fuel uncompetitive with the domestic supply.

Developments in biofuel technologies are also likely to reduce costs and make biofuel an increasingly attractive option to consumers and governments. Research into production of ethanol from cellulose-based feedstock could allow producers to extract ethanol from maize stalks, sugarcane leaves, and other forms of organic waste. These technologies are likely to reduce feedstock costs, which could make ethanol fuels considerably more affordable, especially in developing countries.

In general, Tanzania has a significant potential to produce biofuels from sugarcane and oil seed crops such as Jatropha and palm trees. Thus, Tanzania could become a cost competitive supplier of biofuel to the world market, due to the relatively high sugarcane yields and large currently under-utilized areas. It has to be emphasized that this is a future scenario and supportive policies and strategies will be required to establish a biofuels sector in Tanzania. However, if all the ambitious goals are reached, which have been formulated in the various biofuels programs around the world, there is tremendous scope for growth, not only in domestic markets but also for biofuels exports.

One recent study on “Biofuel for Transport” focuses on the near-term potential for economically competitive cane ethanol production worldwide until 2020. The study estimates that enough low-cost cane-derived ethanol could be produced over this time frame to displace about 10% of gasoline worldwide. However, this ethanol would mostly be produced in developing countries, while demand would be mainly in developed countries (where transport fuel consumption is much higher). Thus, a substantial international trade in ethanol would need to arise. While this is just one study, focusing on one type of feedstock, it suggests that much more attention should be paid to the global picture, and to the potential role of biofuels trade. Currently, many IEA countries have import tariffs on liquid biofuels, and recent WTO initiatives affecting biofuels, such as the inclusion in a WTO list of environmental products for which dismantling of trade barriers is sought, need to be pursued further.

1.6 References

Barwell I. etl (1985): Rural Transport in Developing Countries, Intermediate Technology Publication

BBI (2005): Fuel Ethanol (A technological Evolution), Novozymes and BBI International

D. Cornland et al (2001): Sugarcane Resources of Sustainable Development (A case study in Luena, Zambia), SEI

DEVPLAN (2005.): Economic Review 2004/05

ESMAP Report (2003): Phase-out of Leaded Gasoline in Oil Importing Countries of Sub-Saharan Africa

FAO (1988): Liquid Fuels from Biomass, FAO, Rome Italy

FELISA (2005): FELISA Biofuel Project , Kigoma, Tanzania

Focus on biodiesel; SA to make biodiesel in African Energy Journal vol. No 1; 2005

HABITAT (1991): Comparative Modal Efficiencies in Urban Transport with Reference to Development Countries, HABITAT, Nairobi Kenya

http://www.afrepren.org/draftrpts/hbf/geo_tz.pdf#search='Importation%20of%20Petroleum%20fuels%20in%20Tanzania

In search of a new approach for a sustainable transportation in Africa's urban areas: benefits of interdisciplinary cooperation and sectoral coordination in Dar-es-Salaam, Tanzania. *Paper presented in an International Conference for Integrating Urban Knowledge & Practice Gothenburg, Sweden. May 29 – June 3, 2005*

J. Bhagavan and M. Teferra (1996): Transport Energy in Africa, AFREPREN, Nairobi Kenya

J. Dawson I. Barwell (1993): Roads are Not Enough, Intermediate Technology Publication

K.T. Shaine (2004): Biodiesel Handling and Use Guidelines, US Dept of Energy

Karekezi et al (2004): Africa Energy Data and Terminology Handbook, Year 2003–2004 AFREPREN

MCT (2003): National Transport Policy

MEM (2003): National Energy Policy

MNRT (1998): National Forest Policy

MOA (1997): Agricultural and livestock Policy; MOA (2001): Agriculture sector development strategy, October 2001

MOA (2002): Basic Data for Agricultural Sector 1994/95-2002/03

OECD (2003): Biofuel for Transport (an International Perspective), International Energy Agency

Oscar Kibazohi, Mitigation Option –Use of Biodiesel UDSM Dar es Salaam, Tanzania

PC (2004): Report for the Committee on Development of Bio-Fuel, Planning Commission, Government of India, New Delhi, India

Private sector participation in development and management of roads network in Tanzania. http://www.worldbank.org/transport/training/ppp_workshop/rd_policy_tanzania.pdf

Production of bioethanol and methane from lignocellulosic waste with emphasis on Tanzania http://www.dtu.dk/Centre/EMAB/English/Research/Research7.aspx

Regulation of Petroleum Product Pricing in Africa: A Proposed System Based on Studies of Four Sub-Saharan Countries 1996, Patrick A. Wright http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/09/10/000009265_3980624164452/Rendered/PDF/multi_page.pdf

Reinhard K. Henning (2004:) The Jatropha System "at the international Conference, Renewables" in Bonn, Germany, Rothkreuz 11, D-88138 Weissensberg, Germany www.jatropha.org

Surging Petroleum Prices 'Suffocating' Growth in Tanzania http://allafrica.com/stories/200507220763.html

Tanzania Revenue Authority (TRA):http://www.tanzania.go.tz/government/tra.html

TaTEDO (2003): Alternative Resources for Income Generating for Women in Monduli. June 2000 - June 2004. http://www.jatropha.de/tanzania/ari-monduli-description.htm

TaTEDO (2003): Developing Sustainable Rural Energy Strategies at District Level, TaTEDO/UNDP

TaTEDO (2004): Energy potentials of sugarcane and sisal wastes in Tanzania, TaTEDO Dar es Salaam

TSB (2004): Documents from the Tanzania Sugar Board, Dar es Salaam Tanzania

United Republic of Tanzania (1980): Petroleum (Exploration and Production) Act, Government Printers

Wne J L (TW), J H Ebden and P Swan (Mott Macdonald), A Comparison Of Freight Transport Operations In Tanzania And Indonesia, Copyright Transport Research Laboratory 1997

www.jatropha.de; 1998. The potential of *Jatropha curcas* in Rural Development and Environment Protection - An Exploration

Chapter 2 – Potentials

Currently, there is no commercial production of biofuels for transportation in Tanzania. However, there is growing interest in producing both bioethanol and biodiesel in the country. Three separate schemes for growing oilseed crops for use as feedstock for biodiesel have recently been announced in the country, and the sugar industry is actively investigating the potential for production of fuel ethanol from sugarcane (Msimbira, 2005; Daily News, 2005). Given Tanzania's burdensome fuel import bill, lack of indigenous petroleum production and apparently plentiful availability of land suitable for growing energy crops, the prospect of local biofuels production has clear attractions. In this chapter, the potential for production of biofuels in Tanzania under a set of realistic scenarios is examined.

This chapter evaluates whether there is a practical potential to produce biomass for the production of biofuels at the scales necessary to have a real impact on the TZ transport sector. In order to understand what this potential might be, it first evaluates the land areas available and capable of supporting biomass productivities in relation to the potential scale of the conversion plant and its associated economics and location.

The assessment begins with estimates of the gross bioenergy potentials of the country, based on analysis of soil, climate and terrain characteristics of different areas of the country and of the requirements of different crop types. This assessment of supply potential is then refined by considering the biofuels yields of current conversion technologies. Alternative levels of demand for biofuels based on the national demand for liquid fuels for petrol and diesel engines are analysed, and the supply requirements to meet these demands are assessed. Basic analyses of the economic viability of bioethanol and biodiesel production in Tanzania are carried out. Finally the future increases in potential for production of biofuels that may be expected to result from improvements in crop and conversion yields are described.

2.1 Biofuels Supply and Demand Scenarios

2.1.1 Bioenergy Potential Based on Agro-ecological Conditions

The total potential for bioenergy production in Tanzania depends on the potential for crop production in the country. For a viable biofuels industry, the land must also be capable of supporting sufficiently high crop yields for production to be economic. A recent assessment by the Food and Agriculture Organisation of the United Nations (FAO) found that Tanzania had 55.2 Mha potential area for rain-fed crop production from the total land area of 93.8 Mha. 10.8 Mha of this area were in use for crop production, leaving 44.4 Mha of land potentially available for (food and non-food) crop production (Table 2.1, Table 2.2). While these figures present only a broad picture of land use in what is a very large and diverse country, they do suggest that land availability is not likely to be a barrier to bioenergy production in Tanzania.

Table 2.1 Land with rain fed crop production potential by land class (Mha)

AT1 Dry semi-arid	AT2 Moist semi-arid	AT3 Sub-humid	AT4 Humid	AT5 Marginal In AT2-AT4	AT6 Fluvisols/ gleysols	AT7 Marginal fluvisols/ gleysols	Total rain fed potential	Irrigated arid and hyper arid land	Total with crop prod. potential
MS, S, VS[a]	S, VS	S, VS	S, VS	MS	S, VS	MS			
5.73	12.7	21.5	0.35	10.3	2.81	1.88	55.2	0	55.2

Source: World Agriculture: Towards 2010 An FAO Study, edited by Nikos Alexandratos, Wiley 1995

Notes:
a MS: marginally suitable; S: suitable; VS: very suitable;. Class AT5 contains areas considered marginally suitable in classes AT2, AT3 and AT4.

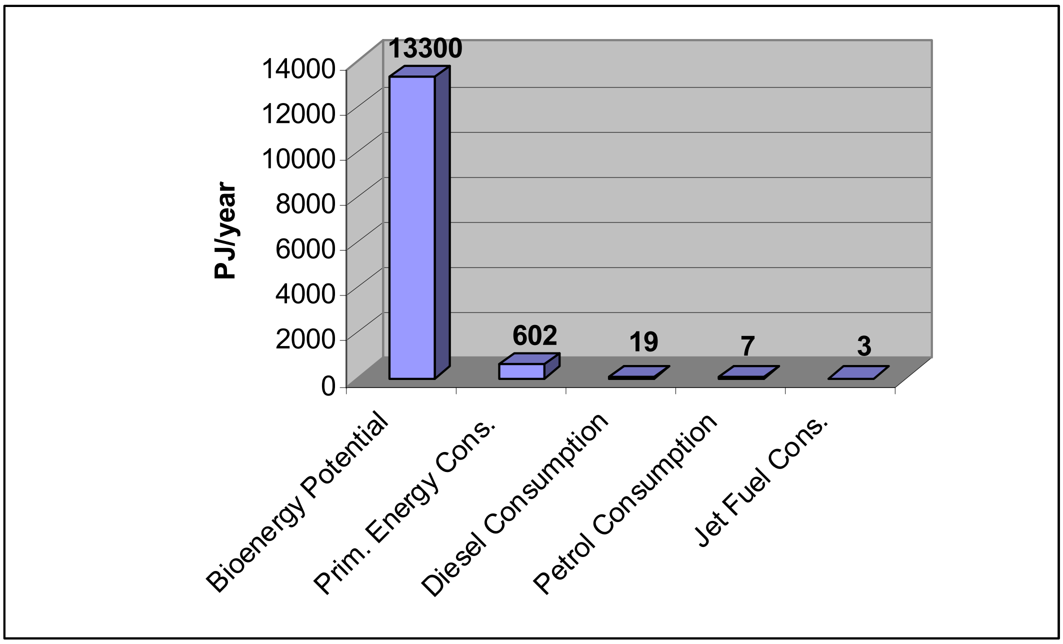
Table 2.2 Land with rain fed crop production potential, land in use and land potentially available (Mha)

Total with crop prod. potential	Currently in use for crop production			
	Rain fed	Irrigated	Total	Balance
55.2	10.7	0.15	10.8	44.39

Source: World Agriculture: Towards 2010 An FAO Study, edited by Nikos Alexandratos, Wiley 1995
Notes:
a Including irrigated arid and hyperarid land

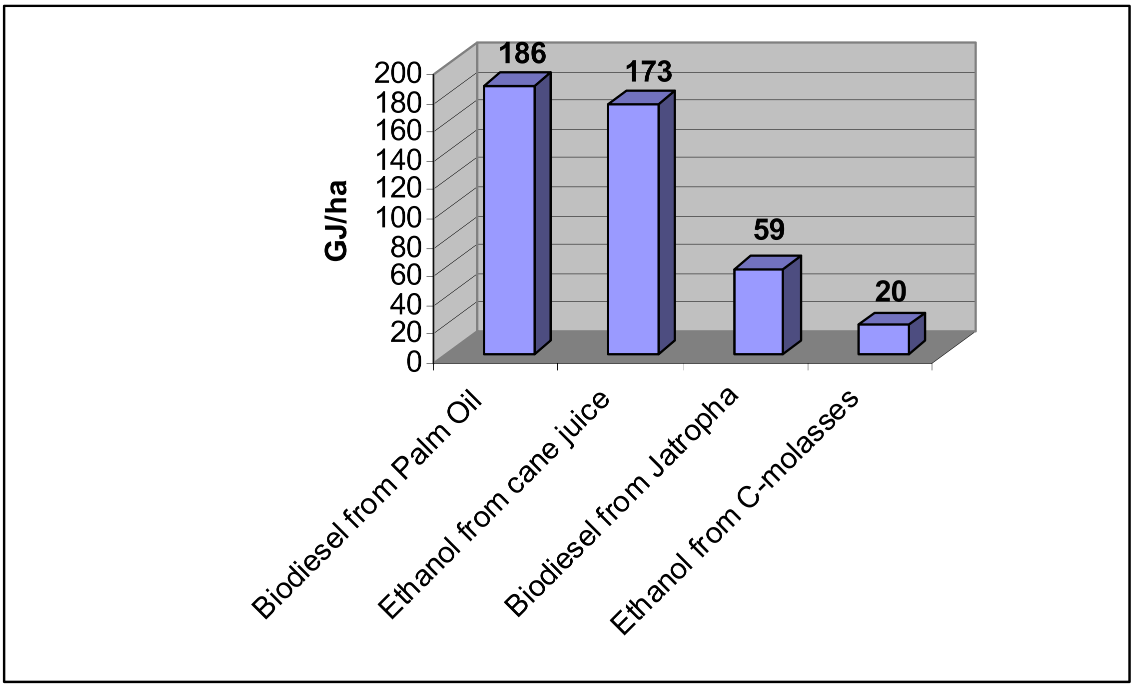
It is useful to estimate the potential for bioenergy production from the “potentially available land” (44.4 Mha) in order to gauge the limits of any real production. Using a range of biomass production of 75-300 GJ per hectare per annum, the limits of bioenergy production in Tanzania would be in the range 3.3 to 13.3 exajoules per annum. This compares with total annual primary energy consumption in Tanzania of 0.602 exajoules (IEA, 2002). Figure 2.1 illustrates this vast difference between current energy consumption in Tanzania and the potential bioenergy production.

Figure 2.1 Bioenergy Potential vs. Primary Energy Consumption in Tanzania (2002)



In considering the introduction of a biofuels industry in Tanzania, it is also useful to compare the expected energy yields per hectare for production of different transport fuels (Figure 2.2).

Figure 2.2 Potential Biofuel Yields per Hectare of Land Harvested in Tanzania



Production of biofuels with conventional technologies uses feedstock from sugar crops and starch crops (cereals and root crops) in the case of bioethanol and oilseed crops for biodiesel. The FAO has made assessments of the total land areas suitable for cultivation of these crop types in different countries based on soil, climate and landform data. The FAO methodology classifies land as very suitable (VS), suitable (S), moderately suitable (MS), marginally suitable (mS) or not suitable (NS) for cultivation of a crop under conditions of high, intermediate or low agricultural inputs. Table 2.3 shows the total land areas suitable for rain-fed cultivation of sugar crops, cereals, root crops and oil crops with different input levels in Tanzania (FAO, 2002).

Table 2.3 Gross cultivation potential for rain-fed production in Tanzania (000 ha)

CROP TYPE	INPUT LEVEL	VS	S	MS	mS	NS	(VS+S) as % of Total Land Area	(VS MS) as % of Total Land Area	(VS mS) as % of Total Land Area
Cereals	Low	5417	17656	21274	11361	38111	24.6%	47.3%	59.4%
	Intermediate	6789	17522	22266	10078	37164	25.9%	49.6%	60.4%
	High	12616	18474	11216	3432	48081	33.1%	45.1%	48.8%
Root Crops	Low	2284	11078	15272	13230	51955	14.2%	30.5%	44.6%
	Intermediate	2816	11461	14952	12555	52036	15.2%	31.2%	44.5%
	High	6891	13325	10816	5856	56932	21.5%	33.1%	39.3%
Sugar Crops	Low	11	444	3054	8159	82152	0.5%	3.7%	12.4%
	Intermediate	30	541	3150	8238	81860	0.6%	4.0%	12.7%
	High	210	596	6175	10704	76134	0.9%	7.4%	18.9%
Oil Crops	Low	3266	20734	17256	10779	41784	25.6%	44.0%	55.5%
	Intermediate	5574	25720	15716	7682	39127	33.4%	50.1%	58.3%
	High	14558	19416	8121	2283	49442	36.2%	44.9%	47.3%

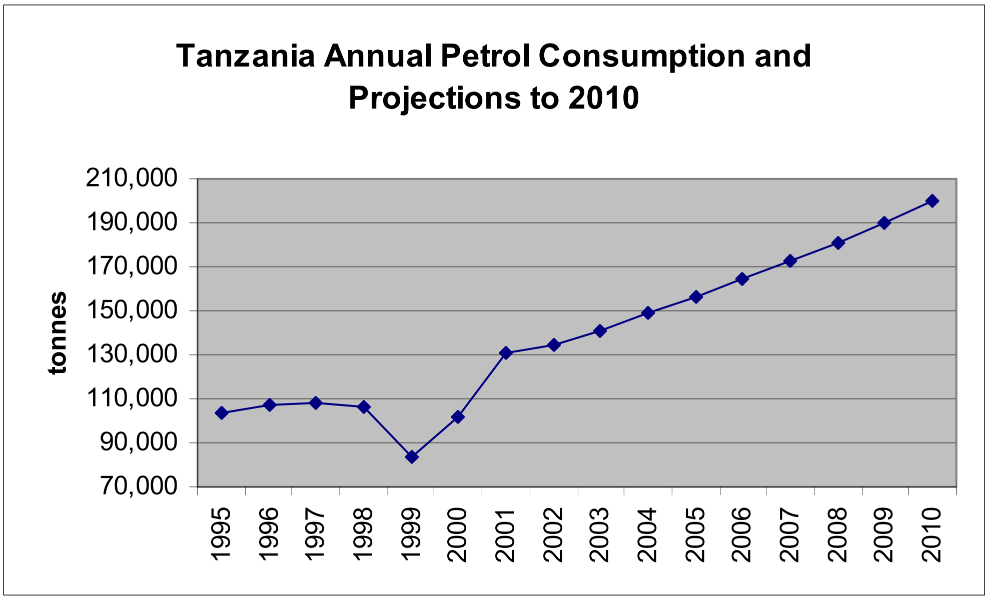
Total land area = 93819000 ha
Source: Global Agro-ecological Assessment for Agriculture in the 21st Century, http://www.iiasa.ac.at, accessed September 2005

The gross areas indicated in table 2.3 include land currently in use for food and non-food crop production, as well as land required for infrastructure and settlements, and legally protected areas. The FAO estimates that typically, 10-30% of potentially suitable land may not be available for agriculture because of other competing uses (ibid.). Nevertheless, these figures point to a significant potential for energy crop production.

2.1.2 Future Demand for Transport Fuels

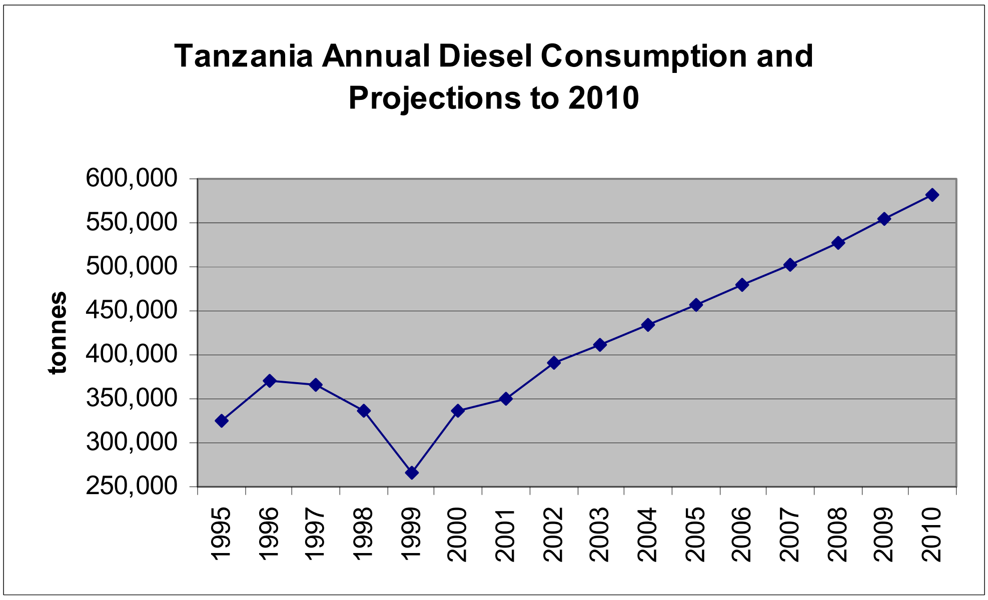
Since the closure of the TIPER refinery at the end of 1999, Tanzania has been entirely dependent on imports of refined petroleum products to supply the fuel needs of its transport sector. Over the period 1995-2003, petrol and diesel fuel consumption increased on average 4.5% and 3.3% per annum respectively, though there were significant dips in consumption coinciding with the price increases after deregulation in 1997 and closure of TIPER. For projections of fuel demand to 2010, the TPDC forecast projection of 5% annual growth in total petroleum consumption is used for both petrol and diesel. (Note that real GDP growth in Tanzania in 2004 is estimated at 6.2% and the medium term forecast is for this to increase to almost 7% [AfDB/OECD, 2005]).

Figure 2.3 Tanzania Annual Petrol Consumption and Projections to 2010



Figures for 1995-2002 are for actual consumption, from Tatedo 2005. Figures for 2003-2010 are projections based on assumption of 5% annual growth in consumption.

Figure 2.4 Tanzania Annual Diesel Consumption and Projections



Figures for 1995-2002 are for actual consumption, from Tatedo 2005. Figures for 2003-2010 are projections based on assumption of 5% annual growth in consumption.

2.1.3 Potentials for Biofuels Blends and Straight Substitution

In the near term, the level of demand for biofuels is most likely to be set by requirements for blending with petroleum fuels at levels that do not require modifications to vehicles. This may limit blend levels to E10 (10% ethanol by volume) for petrol-fuelled vehicles and B20 (20% biodiesel by volume) for older diesel-fuelled vehicles, though biodiesel can be used straight or in any blend ratio in newer vehicles. Figure 2.5 and Figure 2.6 give the projected requirements for ethanol and biodiesel respectively through to 2010 if E10 and B20 blending were to be instituted nationally.

Figure 2.5 Ethanol Requirements for E10 Blending

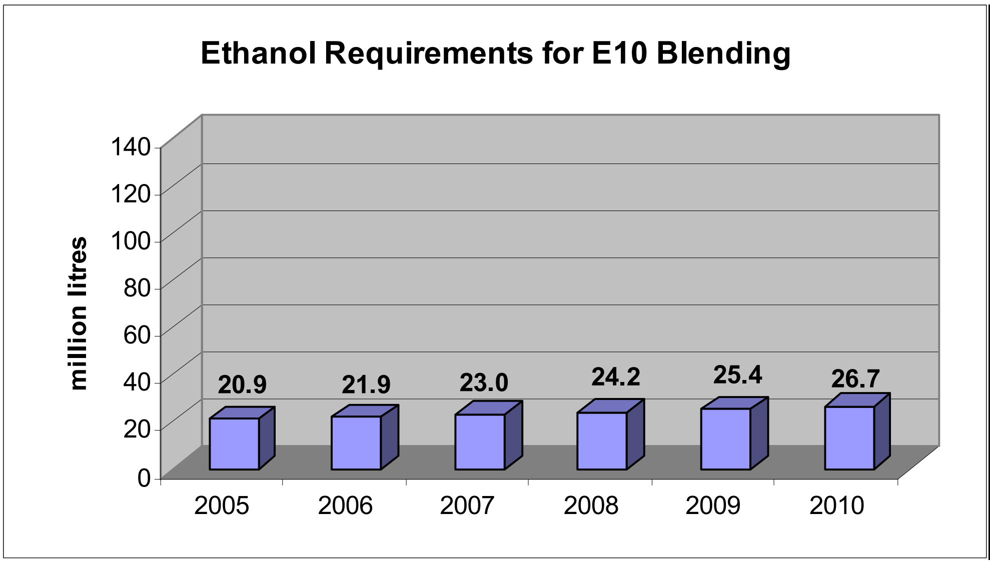
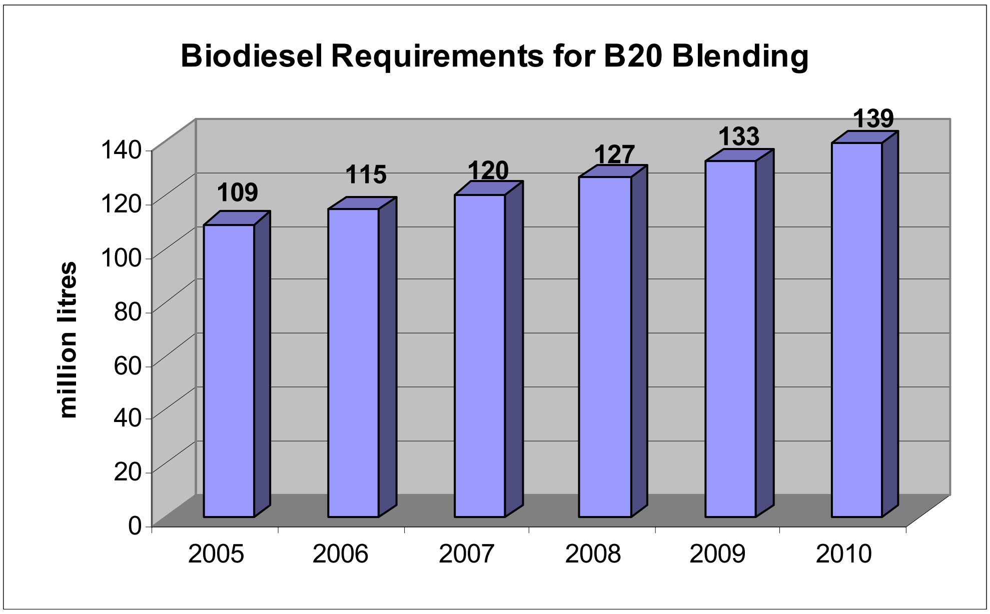


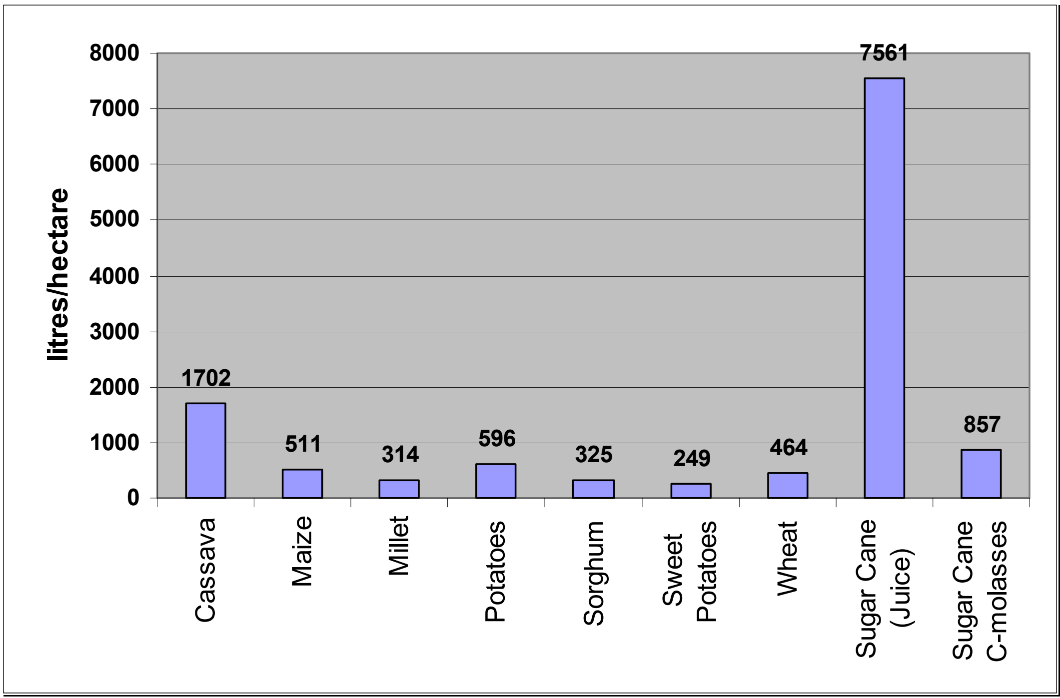
Figure 2.6 Biodiesel Requirements for B20 Blending



2.1.3.1 Potential for Ethanol Production to Meet Blending Requirements

A number of sugar and starch crops suitable for commercial production of bioethanol by conventional fermentation are grown in Tanzania. These crops are grown mainly for food. Sugarcane is one of the most favourable feedstock for large-scale ethanol production. Compared to the other feedstock options currently available in Tanzania, sugarcane provides the highest potential yield of ethanol per hectare of land harvested, as illustrated in Figure 2.7

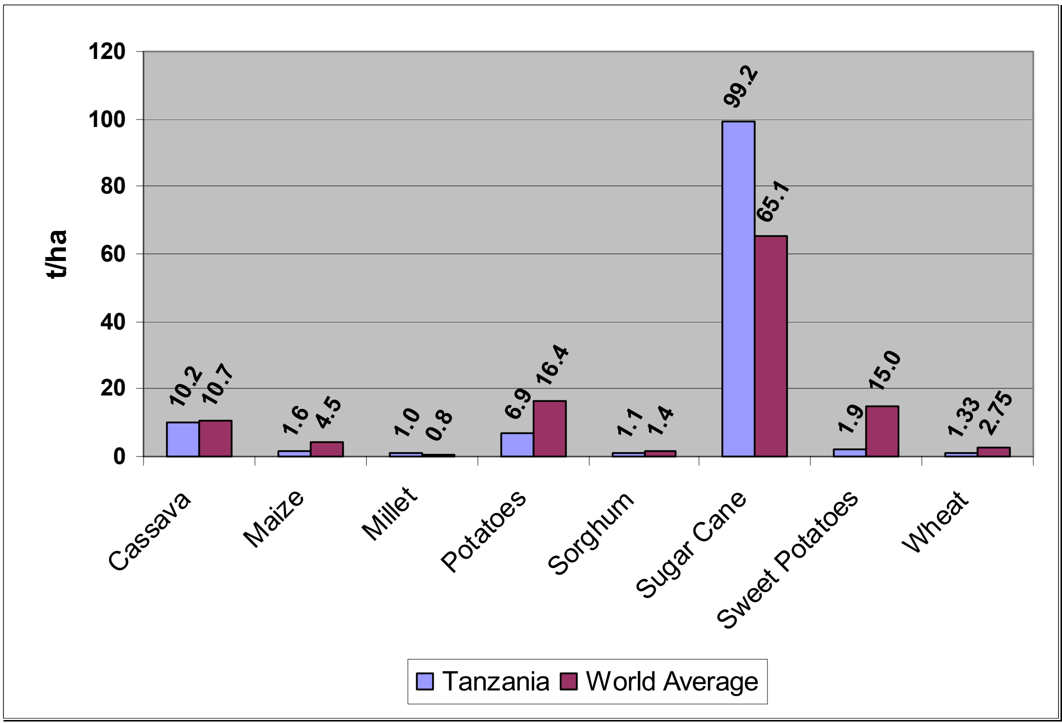
Figure 2.7 Expected Ethanol Yields per Area Harvested for Sugar and Starch Crops in Tanzania



Crop yields used in ethanol yield calculations are averages of annual yields reported by the FAO (http://faostat.fao.org) for the period 1999-2004

There is a long history of growing sugarcane as a cash crop in Tanzania and there appears to be great potential for expansion in sugarcane production in the country. Growing conditions in parts of Tanzania are very well suited to production of sugarcane, and average cane yields in the country are significantly higher than the world average (Figure 2.7).

Figure 2.8 Tanzania and World Average Yields for Sugar and Starch Crops, 1999-2004

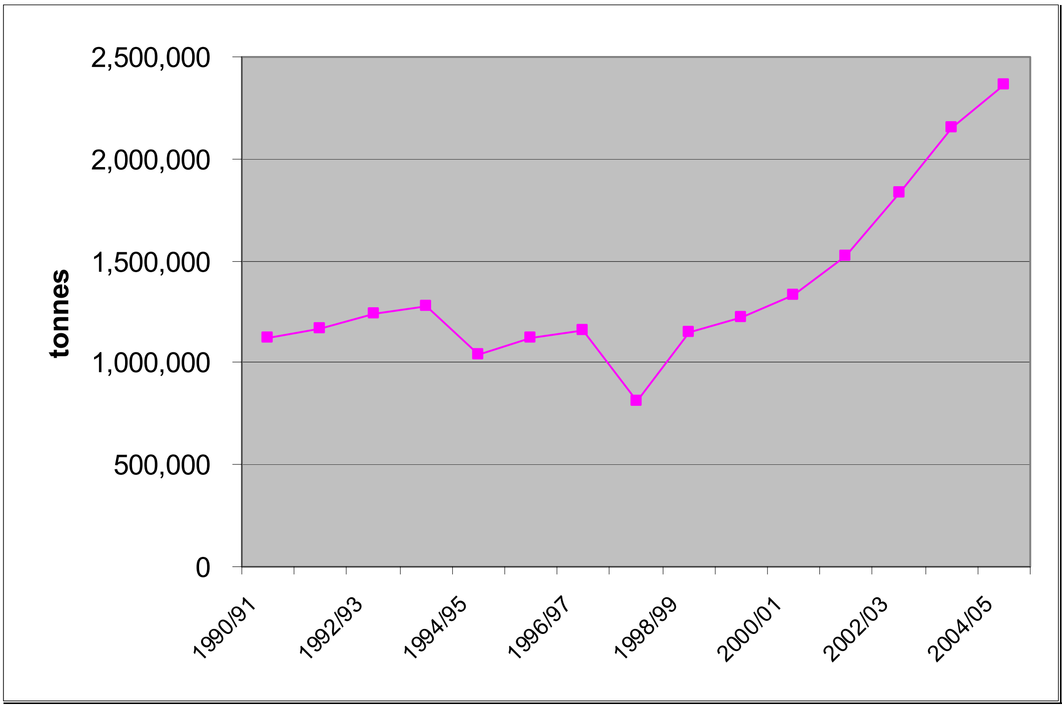


Based on data from FAOSTAT (http://faostat.fao.org)

The potential for ethanol production from sugarcane to meet possible demand for blending with petrol is considered below.

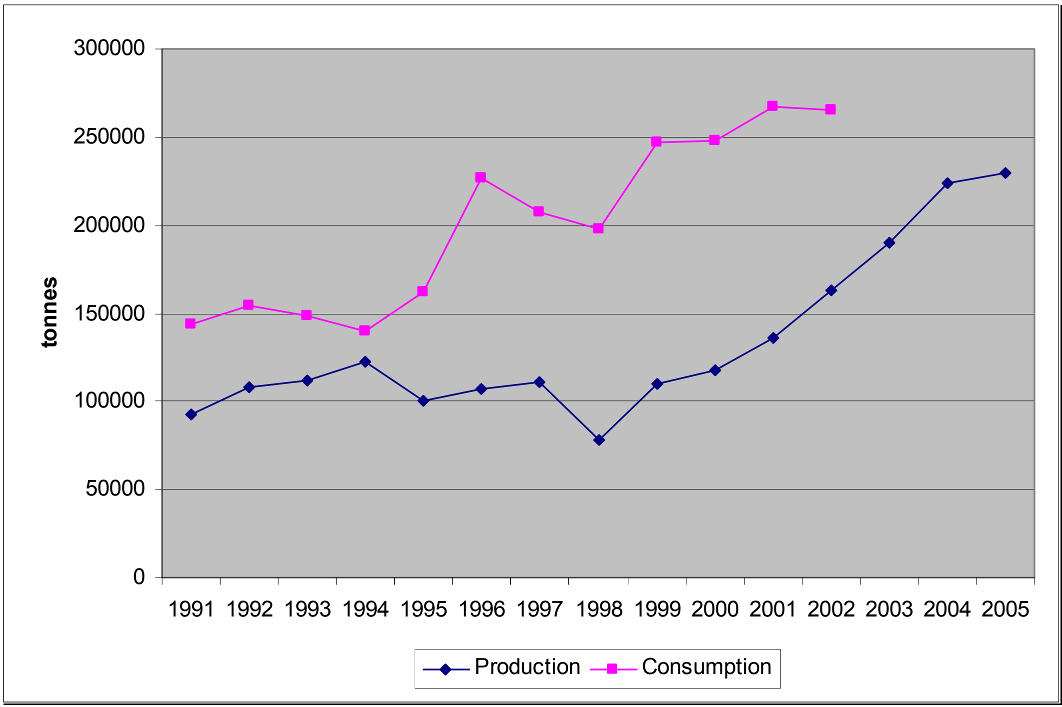
Starting with the privatisation of the sugar industry which began in 1998, sugar cane and sugar production in Tanzania has increased significantly in recent years (Figure 2.9). However, the country still does not produce enough sugar to meet local demand (Figure 2.10) and has to import sugar. Until Tanzania becomes self-sufficient in sugar, it will be difficult to justify diverting sucrose from crystalline sugar to ethanol production, and the C-molasses by-product of sugar production is likely to be the only sugarcane feedstock used for ethanol production.

Figure 2.9 Total Sugarcane Production in Tanzania, 1990/91 – 2004/05



Data for 1990/91-1999/00 from Tatedo, this study, quoting Kishimbi 2000; data for 2000/01-2004/05 from Sugar Board of Tanzania (Msimbira, 2005)

Figure 2.10 Sugar Production and Consumption in Tanzania, 1991 - 2005



Production data from Tatedo, 2005; consumption data from FAOSTAT (http://faostat.fao.org), accessed September 2005

The sugar industry in Tanzania has ambitious plans for continued development of the industry, with projections for a doubling of sugarcane production between 2005 and 2010 (Table 2.4). Correspondingly, sugar production capacity is projected to double over this period, with a new sugar mill planned to begin production during the 2006/07 crushing season (Table 2.5). Although Tanzania does not produce as much sugar as it consumes, the country does export small amounts of sugar each year. Annual per capita sugar consumption over the period is projected to increase from 9.9 kg to 11.9 kg.

Table 2.4 Projections for sugarcane production (tonnes)

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Kilombero Sugar Company	1,000,000	1,100,000	1,200,000	1,400,000	1,400,000	1,600,000
Tanganyika Planting Company	660,000	700,000	729,000	758,000	777,700	777,700
Mtibwa Sugar Estates	725,000	775,000	820,000	920,000	1,020,000	1,020,000
Kagera Sugar Limited	163,000	394,000	512,000	539,000	698,700	798,500
Ruipa I	-	-	100,000	400,000	600,000	800,000
TOTAL	**2,548,000**	**2,969,000**	**3,361,000**	**4,017,000**	**4,496,000**	**4,996,000**

Source: Sugar Board of Tanzania

Table 2.5 Projections for sugar production, consumption and exports (tonnes)

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Kilombero Sugar Company	111,000	120,000	130,000	150,000	170,000	200,000
Tanganyika Planting Company	68,000	72,000	75,000	78,000	80,000	80,000
Mtibwa Sugar Estates	70,000	75,000	80,000	90,000	100,000	100,000
Kagera Sugar Limited	12,000	34,000	46,000	54,000	70,000	80,000
Ruipa I	-	-	10,000	43,000	66,400	87,000
Small scale	10,000	15,000	16,000	16,000	18,000	24,000
TOTAL	**271,000**	**316,000**	**357,000**	**431,000**	**504,000**	**567,000**
Consumption	**380,411**	**401,063**	**422,908**	**446,485**	**471,224**	**497,546**
Surplus (Deficit)	**(109,411)**	**(85,063)**	**(65,908)**	**(15,485)**	**32,776**	**69,454**
Exports	**22,234**	**23,613**	**24,560**	**26,684**	**29,120**	**32,000**
Surplus (Deficit)	**(131,645)**	**(108,676)**	**(90,468)**	**(42,169)**	**3,656**	**37,454**

Source: Sugar Board of Tanzania

If all the C-molasses resulting from the Tanzanian sugar industry's projected production were used for ethanol production, total ethanol produced in 2006/07 would be over 28 million litres (Figure 2.11). This would be enough for a nationwide 12.2% blend by volume, or equivalent to 7.9% of national petrol consumption on an energy basis. The potential national blend percentage would grow to 13.6% in 2008/09, after which sugarcane production would be surplus to national crystalline sugar requirements and a choice between producing more sugar for export and producing more ethanol would exist. If all the "surplus" cane is used for ethanol production, the potential blend would rise to 28.5% (equivalent to 18.4% on energy basis) by 2010. If the "surplus" is used for producing sugar, the potential would still reach 22.1% (equivalent to 14.3% on energy basis) by 2010 (Figure 2.12).

Figure 2.11 Ethanol Potential from C-molasses Production, 2004/05-2009/10

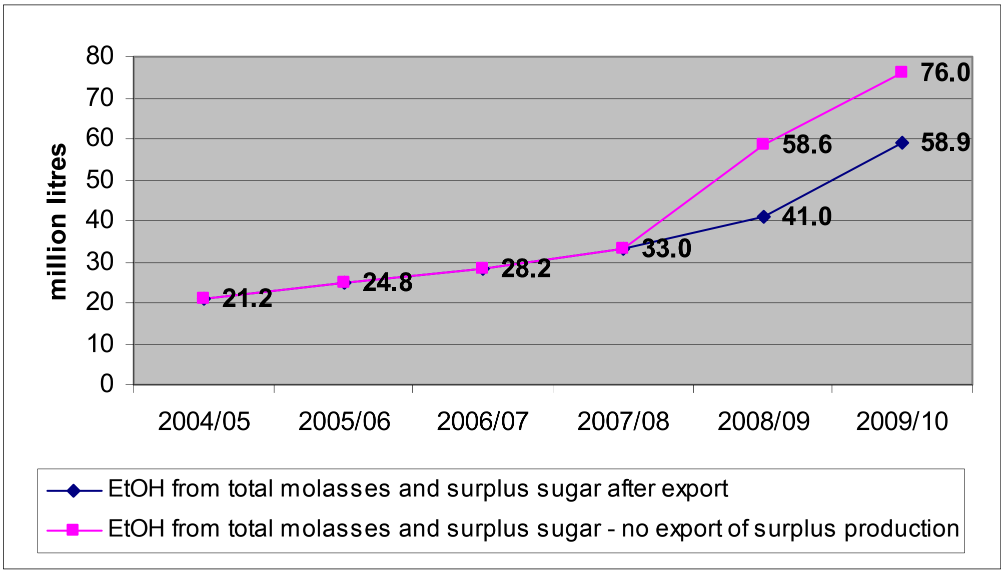
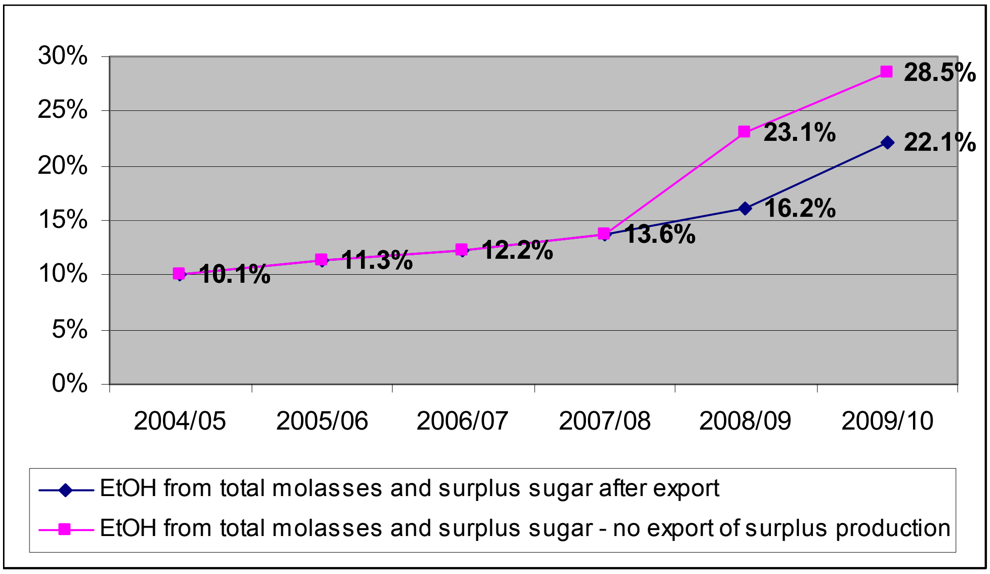


Figure 2.12 Nationwide blend percentages (volume basis) possible if all C-molasses is used for ethanol production, 2004/05-2009/10



In recent years, C-molasses produced by the sugar industry in Tanzania has been disposed of as a low value product or as a waste. Even if some molasses continue to be sold to downstream markets, there is clearly potential for substitution of a significant fraction of Tanzania's petrol demand with ethanol derived primarily from C-molasses.

The Tanzanian sugar industry has identified a number of sites as being most favourable for the next phase of expansion in sugar cane and sugar production in the country. Based on the Sugar Board of Tanzania's estimates of the potential for sugar production at a number of these sites, Table 2.6 provides estimates of the potential for ethanol production from the C-molasses by-product of sugar production and from the total sugarcane production (i.e., all cane juice used for ethanol production).

Table 2.6 Ethanol potential from sites identified as suitable for future sugar production

	Sugar Potential (t/a)	Ethanol Potential from C-molasses(Ml/a)	Ethanol Potential from Sugarcane Juice (Ml/a)
Ruipa	224,000	18.1	161.3
Ikongo	82,000	6.6	59.0
Mahurunga - Mtwara	10,000	0.8	7.2
Usangu Plains	70,000	5.7	50.4
Kilosa	60,000	4.9	43.2
Masaki Plains	200,000	16.2	144
TOTAL	**646,000**	**52.3**	**465.1**

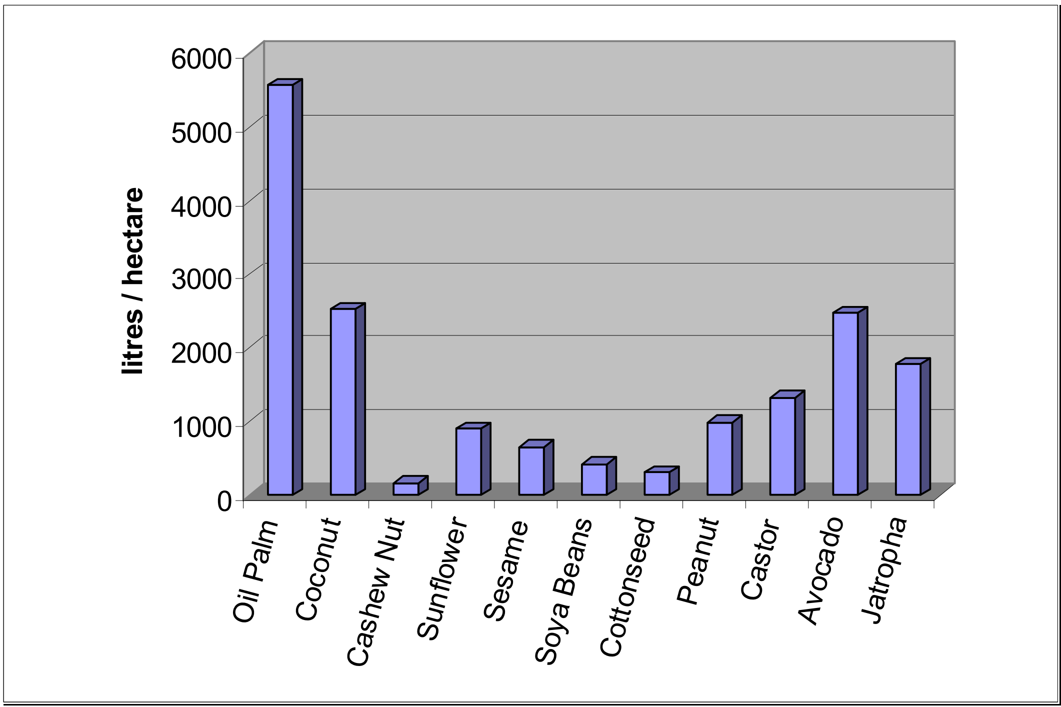
Table 2.7 Potential ethanol production at different mills in 2010, based on different feedstock

	Projected cane harvest in 2009/10 (t)	Ethanol Potential (million litres)			
		C-molasses feedstock	B-molasses feedstock	A-molasses feedstock	Cane juice feedstock
Kilombero Sugar Company	1,600,000	14	28	65	122
Tanganyika Planting Company	777,700	7	14	32	59
Mtibwa Sugar Estates	1,020,000	9	18	41	78
Kagera Sugar Limited	798,500	7	14	32	61
Ruipa I	800,000	7	14	33	61
TOTAL	4,996,200	43	88	203	381

2.1.3.2 Potential for Biodiesel Production to Meet Blending Requirements

A range of oilseed crops grown in Tanzania may be used as feedstock for biodiesel production. The two most promising crops are oil palm and jatropha. Oil palm is favoured because of its very high yield of oil per hectare compared with other oilseed crops. However, oil palm is also valued as a food, and there may be objections to its use as a fuel competing with its food use. Jatropha, on the other hand, is not a food crop, and its use for biodiesel production avoids problems related to competition between food and fuel. Figure 2.13 provides a comparison of the yields of biodiesel per hectare of different oil crops harvested.

Figure 2.13 Potential Biodiesel Yield per Hectare for Oilseed Crops

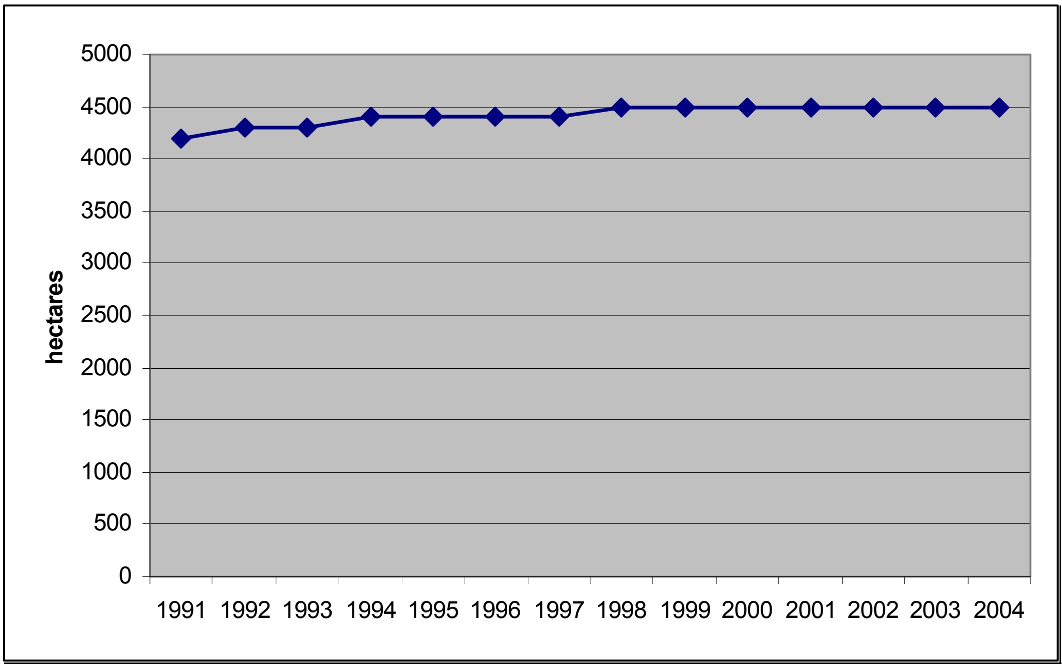


Oil yields per hectare from Tatedo, 2005 (chapter 1, this report); biodiesel yields based on conversion efficiency of 0.98kg biodiesel per kg plant oil and biodiesel density of 0.88kg/l

Note that while the calculation for biodiesel yield from oil palm as presented in Fig. 2.13 above is based on an oil palm yield of 5000 litres/hectare, actual average palm oil yield in Tanzania for 2002 (the latest year for which data was available from the FAO) was 1500 litres per hectare. Oil palm is only grown on a small scale in Tanzania, and yields of fruit and oil per hectare could be improved considerably with improvements in inputs and management for the crop, improved technology for oil pressing and larger scale production.

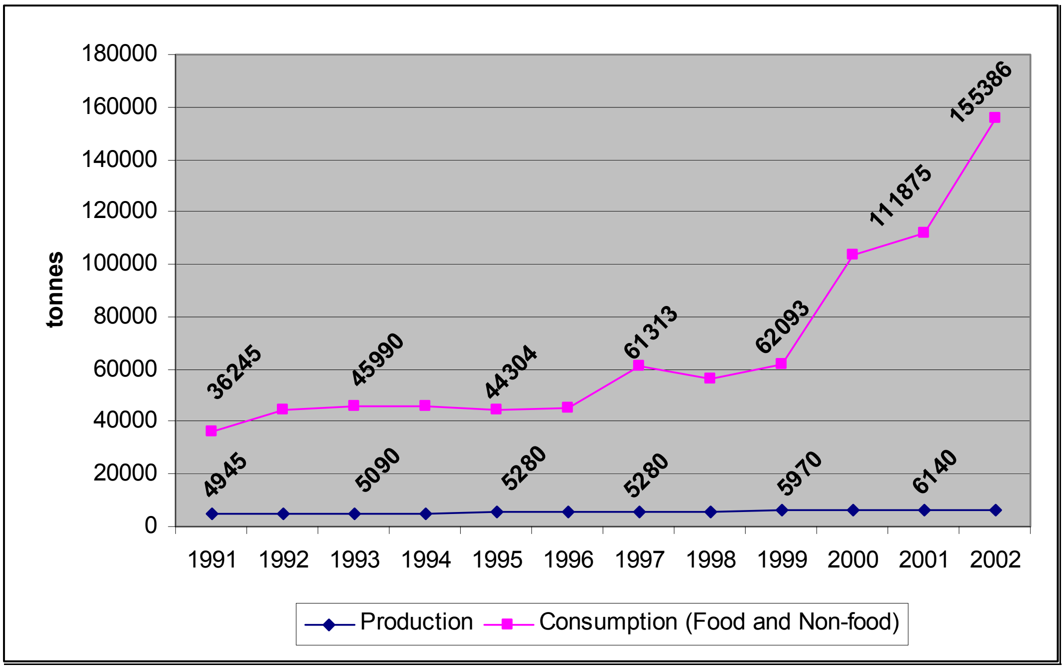
The land area planted with oil palm in Tanzania is relatively small, and has increased only very slightly in recent years (Figure 2.14). In 2004, about 4500 hectares of oil palm were harvested. By comparison, the area estimated by the FAO to be very suitable to moderately suitable for oil palm cultivation ranges from 1.2 million hectares for rain fed cultivation with low inputs to 5.8 million hectares for irrigated land with high inputs.

Figure 2.14 Area of Oil Palm Harvested Annually in Tanzania



Production of palm oil in Tanzania is only sufficient to meet a small fraction of national demand (Figure 2.15). The ready availability of cheap imported palm oil from Malaysia and Indonesia (Comesa, 2005) has been an important factor behind the level of local production remaining relatively static over a period when demand has increased considerably. A competitive local palm oil industry would be in a position to take advantage of a large existing market for palm oil in addition to a large potential market for biodiesel feedstock.

Figure 2.15 Palm Oil Production and Consumption in Tanzania

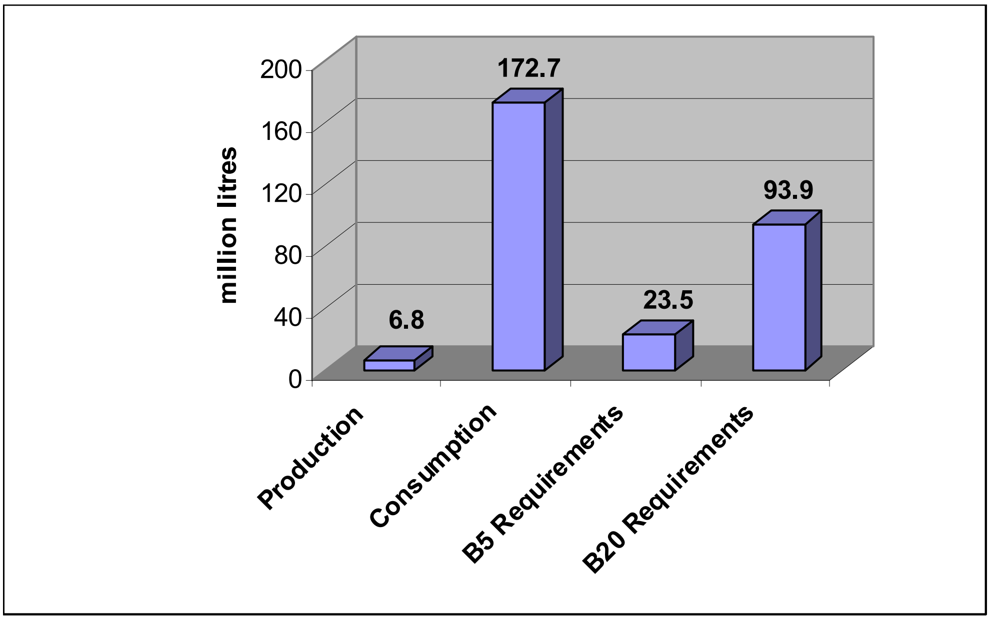


Source: FAOSTAT (http://faostat.fao.org), accessed October 2005

There is a current proposal for a palm oil biodiesel project in the Kigoma region. The proposed project would involve cultivation of 8,000 hectares of oil palm, firstly to produce palm oil to meet local food and soap production demands, and then eventually to produce biodiesel (Hongo, 2005). If the project achieves the target oil yield of 5000 litres per hectare, palm oil production could approach 40 million litres per year. This production would itself not be enough to displace current imports (about 172 million litres of palm oil were imported into Tanzania in 2002 [FAOSTAT, 2005]). Alternatively, forty million litres of palm oil could be converted into about 39 million litres of biodiesel. Diesel fuel consumption in Tanzania is projected to be about 700 million litres in 2010; if all the projected palm oil production in the Kigoma project were to be converted to biodiesel, a 5.7% national blend would be possible (This is equivalent to 5.2% on an energy basis).

Figure 2.16 compares the production and consumption of palm oil in Tanzania in 2002 with the quantities of palm oil that would have been required in that year to produce enough biodiesel for B5 and B20 blends.

Figure 2.16 Production and Consumption of Palm Oil in Tanzania and Requirements for 5% and 20% Blends with Petroleum Diesel (2002)



The other crop most favoured as a feedstock for biodiesel production is *Jatropha curcas* or physic nut. There is experience in Tanzania of cultivation of jatropha for small-scale oil production, and this has been particularly promising in its demonstration of the potential for aiding rural poverty alleviation and empowerment of women (Tatedo, 2004). Cultivation of jatropha around the world has tended to be on a small scale, and production and yield data for plantation-scale cultivation is limited. The oil yield from jatropha plantations is reported to be about 1600 kg oil per hectare from the fifth year onwards (Grimm, 1996), although some local experience in Tanzania suggests that actual yields in Tanzania may be significantly less than this (Burland, 2005). On the basis of a yield of 1600 kg oil per hectare, 19,700 hectares of jatropha would have to be harvested each to produce enough biodiesel for a 5% national blend with petroleum diesel in 2010. For a B20 blend, 78,800 hectares would be required.

Table 2.8 Land Requirements for Substituting 20% (by volume) of National Diesel Consumption with Biodiesel (ha)

Oilseed Crop	2005	2006	2007	2008	2009	2010
Oil Palm	19,625	20,606	21,637	22,719	23,851	25,053
Jatropha	61,715	64,800	68,040	71,442	75,004	78,782

2.1.4 Impact on international trade

As discussed in section 2.1.3.1 and illustrated in Figure 2.12, by 2010 Tanzania could be producing more than enough ethanol to supply a national 20% blending programme. This would not only result in a corresponding decrease in imports of petrol into Tanzania, but could also present Tanzania with the option of exporting fuel ethanol to countries with a needing to import ethanol. An analysis of the potential of regional or international trade in ethanol is beyond the scope of this study, but a previous study (Carensa, 2005) has pointed out that the sugar industry South Africa, for example, would not be able to produce enough bioethanol for a nationwide 10% blend. Depending on how much crystalline sugar South Africa continues to produce for export, by 2010 the country might need to import up to 850 million litres of ethanol in order to blend to 10% with petrol nationally.

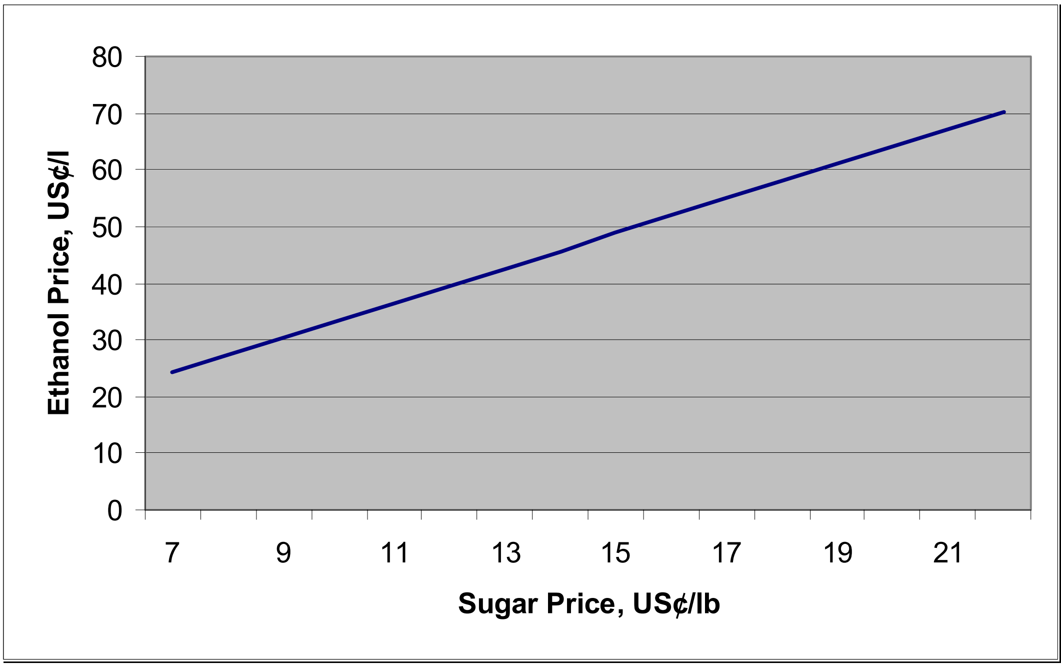
2.2. Economics- Biofuels and Fossil Fuels

Biofuels programmes have generally required government subsidies or other incentives in order to compete with fossil fuels. However, with the generally accepted forecast for petroleum prices to remain high (greater than $40/bbl) in the long term, and a gradually decreasing cost of production for biofuels in many countries, the economic prospects for biofuels production are more favourable than ever. For both bioethanol and biodiesel, feedstock costs represent the single greatest component of the production cost, and those producers using low-cost feedstock tend to be the lowest cost producers of biofuels in the world.

Around 60% of the ethanol produced globally is made from sugarcane feedstock (Berg, 2002). Production costs for ethanol from sugarcane are generally lower than for ethanol from other feedstock. Production of ethanol from sugarcane is usually closely associated with production of crystalline sugar from sugarcane, the latter process being a mature and very important industry in many countries. The economics of production of ethanol from sugarcane therefore normally involves consideration of the relative prices of sugar, ethanol and petrol.

For a producer with the option of producing either ethanol or sugar from a given quantity of sugarcane, the choice may be described in part by the graph in Figure 2.17. Each point on the line indicates a sugar price and a corresponding ethanol price for which the revenue derived from processing a given quantity of sugarcane is the same whether the cane is processed into sugar or ethanol. For all combinations of ethanol and sugar prices represented by points above the line, processing of cane into ethanol would provide more revenue than producing sugar. For ethanol and sugar price combinations represented by points below the line, the reverse is true. Note that the choice here is between producing only ethanol on the one hand and producing only sugar (and C-molasses by-product) on the other. Note also that the line in Figure 2.17 represents equal revenue, not equal profitability. For determination of profitability, additional information relating to costs and any additional by-product revenues associated with from the processing of sugarcane into sugar and ethanol would be required.

Figure 2.17 Plot of Ethanol and Sugar Prices Providing Equal Revenue per Tonne Cane



Assumes C-molasses can be sold on world market for US$60/t

Table 2.9 illustrates the variation of the price of petrol in Dar es Salaam, with the world market price of petrol, as well as the ethanol threshold price, the ethanol price below which ethanol is competitive with petrol in Dar es Salaam. Figure 2.18 shows how the ethanol threshold price varies with the world market price for petrol. In August 2005, the retail price of petrol in Dar es Salaam was TZS 1120/litre. At that price, ethanol would be competitive at a retail price of TZS 729/litre, or about US$ 0.64/l. Ethanol production costs in Brazil have been reported at US$ 0.23 per litre (IEA, 2004), and a recent study by the Dutch Sustainable Development Group reported an ethanol production cost for least developed countries at between US$ 0.36 and US$ 0.60 per litre (DSD 2005). Therefore, at current petroleum prices, production of ethanol in Tanzania is likely to be competitive with petrol. A more detailed feasibility study would be required to confirm this.

Table 2.9 Cost of Petrol in Dar es Salaam and Ethanol Price

World Market Price-FOB Mediterranean or Arab Gulf (US$/barrel)	Landed Cost at Dar (US¢/litre)[1]	Dar Cost incl. Excise Duty, Road Toll and VAT (TZS/litre)[2]	Ethanol Threshold Price (TZS/litre)
20	16.3	502	326
50	35.5	760	494
100	67.6	1191	774

[1]Includesfreight to Dar es Salaam at US$20/tonne, seller's premium at US$10/tonne, transit insurance at 1% cost and freight, wharfage at Dar port at US$3,tonne + VAT and factor of 1% of CIF to cover for ocean and transit losses.

[2] Includes excise duty at TZS146/litre, road toll at TZS 90/litre and VAT at 20%; Exchange rate: US$ 1 = TZS 1120.
Source: Tatedo, 2005

Figure 2.18 Ethanol Threshold price in Dar es Salaam vs. World Market Price of Petrol

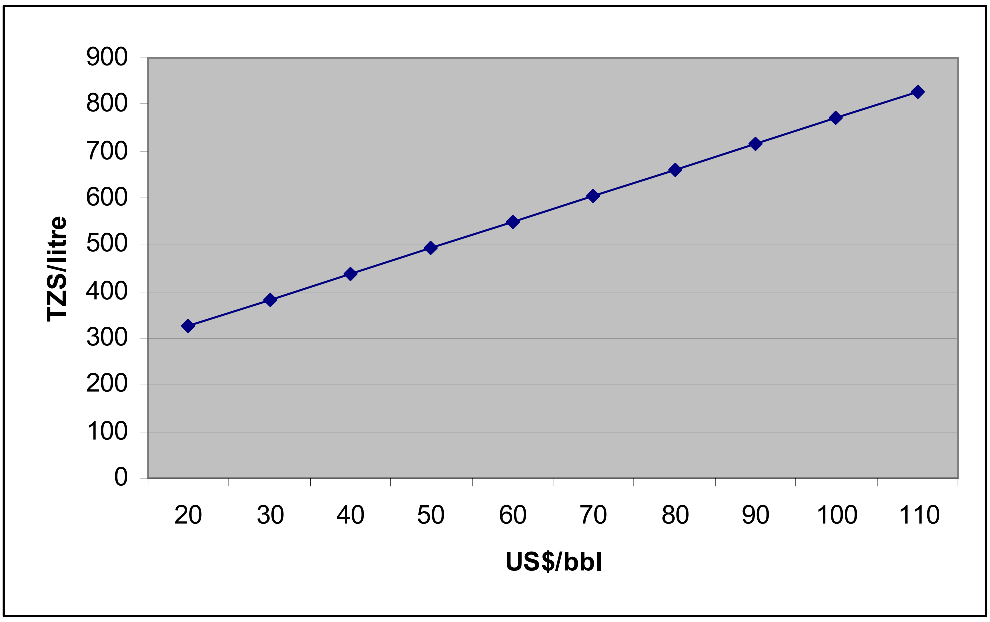


Table 2.10 illustrates the variation of the price of diesel fuel in Dar es Salaam with the world market price of diesel, as well as the biodiesel threshold price. Figure 2.19 shows how the biodiesel threshold price varies with the world market price for diesel fuel.

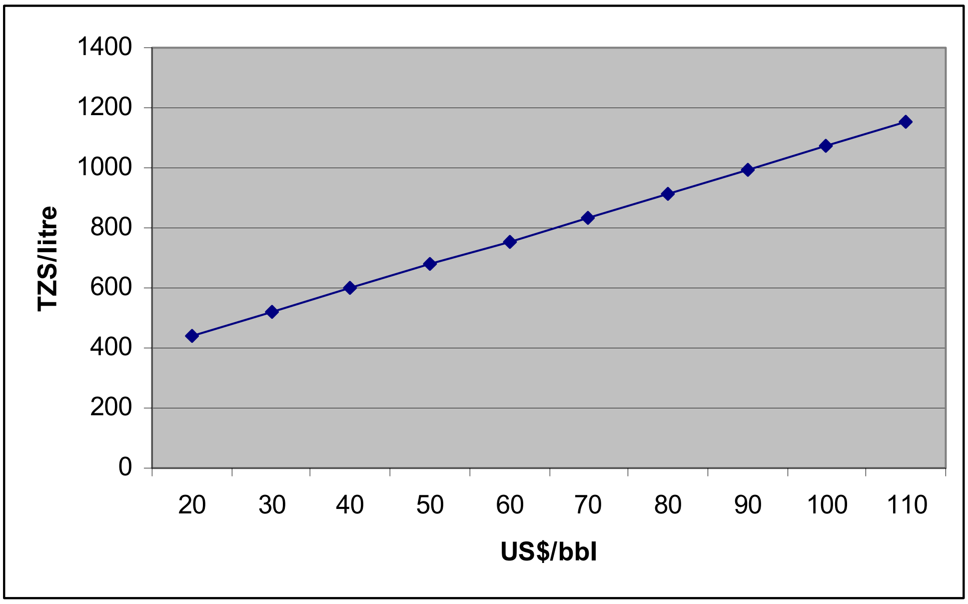
Table 2.10 Cost of diesel fuel in Tanzania

World Market Price-FOB Mediterranean or Arab Gulf (US$/barrel)	Landed Cost at Dar (US¢/litre)[1]	Dar Cost incl. Excise Duty, Road Toll and VAT (TZS/litre)[2]	Biodiesel Threshold Price (TZS/litre)
20	16.3	479	431
50	35.5	738	664
100	67.6	1169	1052

[1]Includesfreight to Dar es Salaam at US$20/tonne, seller's premium at US$10/tonne, transit insurance at 1% cost and freight, wharfage at Dar port at US$3,tonne + VAT and factor of 1% of CIF to cover for ocean and transit losses.

[2] Includes excise duty at TZS127/litre, road toll at TZS90/litre and VAT at 20%; Exchange rate: US$1 = TZS1120.
Source: Tatedo, 2005

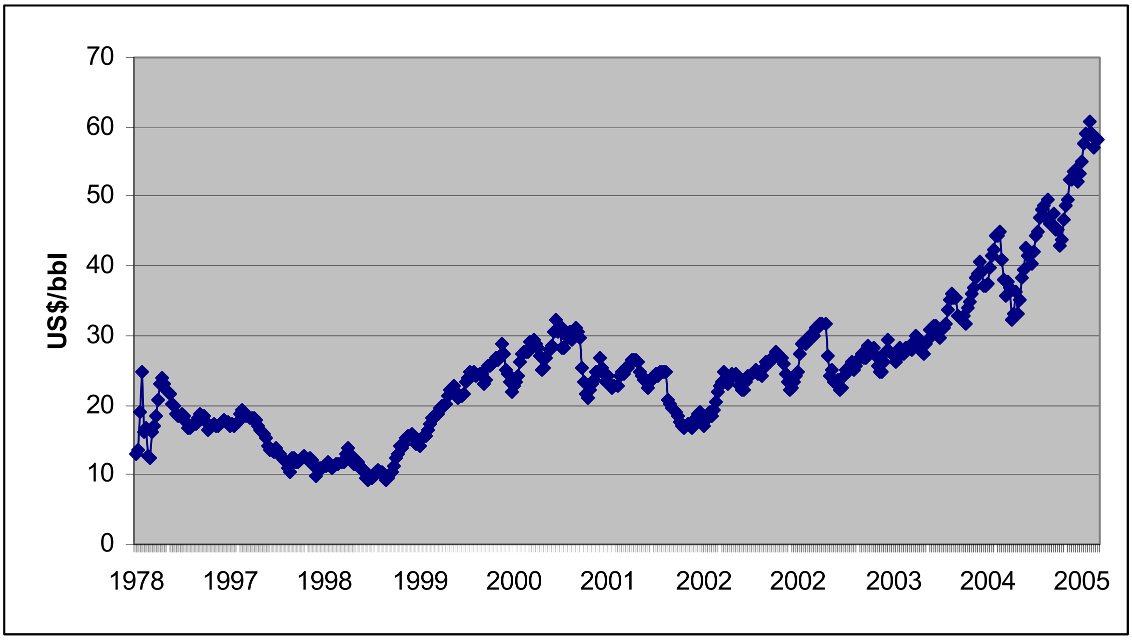
Figure 2.19 Biodiesel Threshold price in Dar es Salaam vs. World Market Price of Diesel Fuel



Volatility in world oil prices

With petroleum at current high levels, production of biofuels in Tanzania appears economically attractive. However, the economic viability of biofuels production will depend on the long-term petroleum price. Most forecasts seem to suggest that the real long term petroleum price is likely to be greater than US$40 per barrel. The long-term trend in world average crude oil price over the last two and a half decades can be seen in Figure 2.20.

Figure 2.20 Long-term World Average Oil Prices



Source: US Energy Information Administration, http://www.eia.doe.gov/emeu/international/petroleu.html#IntlPrices

2.3. Possibilities for Future Improvements in Biofuel Potential

In the previous sections, the analyses of potential for biofuels production in Tanzania were based on traditional varieties of sugar, starch and oilseed crops and conventional, commercial conversion technologies. Looking into the future, it should be possible to improve on the potential for biofuel production in various ways. Strategies for improving biofuels production range from optimising conventional production processes to utilizing completely new feedstock and conversion technologies. Most of these approaches to biofuels production have yet to be proven commercially, but it seems likely that a number of improvements – increased energy crop yields, improved energy efficiencies of conversion processes, a wider range of suitable feedstock for biofuels production and reduced costs of production - will be realized in coming years.

2.3.1 Improved potential via processing

The Brazilian model: The Ethanol-Sugar Complex

This approach to ethanol production is actually an optimisation of current ethanol production processes, rather than a future technology. It is based on the experience of the Brazilian ethanol industry which has evolved over the past three decades into a flexible, integrated ethanol-sugar production complex. The result is an efficient, multi-product facility which seeks to optimise production and minimize waste and costs through a flexible response to market signals and maximum utilization of by-products.

Sugar mills traditionally try to extract as much crystallisable sugar (sucrose) from the cane as is economically possible. This normally involves three stages of boiling and crystallisation known as strikes. The molasses remaining after extraction of crystalline sugar from the boiled sugarcane syrup during the first strike is termed A-molasses, and this becomes feed for the second strike, which extracts more crystalline sugar and leaves B-molasses. B-molasses is in turn fed to a third strike, after which further sucrose crystallisation is no longer economically feasible. The resulting C-molasses typically still contains about 7-10% of the sucrose that entered the factory in the cane, as well as other fermentable sugars (mainly glucose and fructose, typically constituting ½% of the mass of cane and about 15% of the mass of C-molasses). This C-molasses by-product of sugar production is a good feedstock for ethanol production using standard yeast-based fermentation. In this way significant quantities of ethanol may be produced from sugar cane while production of crystalline sugar is maximised. Depending on the relative prices of sugar and ethanol, however, it may be preferable to divert some of the sucrose in the cane to ethanol production, reducing the yield of crystalline sugar. This may be done by using B-molasses, A-molasses or cane juice as feedstock for ethanol production.

In Brazil, ethanol is produced from combinations of cane juice and molasses depending on the relative prices of sugar and ethanol. In Africa, both Zimbabwe and Malawi have experiences of producing significant quantities of ethanol from sugarcane for blending with petrol. The Zimbabwean plant at Triangle in the south-east of the country began operations in 1980 and has over the years used combinations juice, A, B and C-molasses (Scurlock, et. al., 1991; Pereira, et. al., 2000) The Malawian plant at Dwangwa started operations in 1982 and uses C-molasses. It is currently in a phase of expansion to meet increased demand (Presscane, 2005).
Energy is required in various stages during processing / conversion and highly integrated plants that recover and re-use heat and water have made substantial savings to the energy requirements of producing both sugar and ethanol from sugarcane. The distillation process itself is a major energy consumer and recent developments in membrane distillation, particularly molecular sieve techniques, may result in future energy and emissions savings.

2.3.2 Improved potential via future technologies

A range of technological options for biofuels production, currently at different stages of research and development, promise improved potential through increasing biofuels yields from available feedstock, increasing the range of suitable feedstock for biofuels production and improving the economics of biofuels production. These technologies may be divided into bio-chemical and thermo-chemical processes.

2.3.2.1 Bio-chemical

Improvements to traditional C6 yeast based fermentation

Conventional ethanol production from biological sources is based on the fermentation of C6 sugars which can be efficiently carried out by yeast in simple batch and continuous fermentation processes. Fermentation and then distillation of simple C6 sugars obtained from crops such as sugarcane is a mature technology. In previous decades, R&D focused on the isolation and development of efficient strains of yeast, but now, the theoretical efficiency of this type of biochemical conversion system is nearing its limit. Therefore, recent R&D has concentrated on starch and cellulosic hydrolysis to produce simple sugars and then fermentation using existing technologies. The commercial success of ethanol produced from starch is based on the cheap production of α-amylase enzymes isolated from bacteria and fungi. These enzymes hydrolyse the starch into 2-glucose units (Maltose) and longer glucose polymers. The products of the hydrolysis, all C6 sugars, are good substrates for yeast-based fermentation.

Lignocellulosic Ethanol:

Since most biomass consists not of sugar or starch but of lignocellulosic material, the range of suitable feedstock for ethanol production would be greatly increased if affordable means of producing ethanol from lignocellulosic material were available.

The viability of lignocellulosic ethanol production requires the production of ethanol from both C6 and C5 sugars which is not yet demonstrated at commercial scales. R&D is concentrating on the isolation and production of cheap enzymes from bacterial and fungal sources and the development of recombinant organisms. Currently, approximately, 300 l of ethanol can be produced per tonne of fibre (e.g. straw). Improvements in the conversion technologies are expected as the technology matures and cost reductions in significant cost reductions in enzyme production are predicted over the next decade.

Zeachem process

This multi-step process uses a combination of fermentation and chemical conversion to produce ethanol from carbohydrate feedstock without production of carbon dioxide, leading to improved carbon yield (>90% potential claimed) compared with direct fermentation (maximum 67%).
In the first step, carbohydrate feedstock is fermented to produce acetic acid. Homoacetogenic micro-organisms are available which can ferment both five and six carbon sugars. In the second step, the acetic acid is esterified with an alcohol to produce an ester. In the third step, the ester undergoes hydrogenoloysis to produce the desired ethanol product and the recycle alcohol for the esterification step.

2.3.2.2 Thermo-chemical Processes

Biodiesel via Gasification – the Fischer Tropsch (FT) route

In this process, lignocellulosic feedstock (e.g. woodchips or straw) are supplied to a gasifier equipped with a down-stream FT catalytic reactor. The gasifier feeds an FT reactor, which produces a mixture of kerosene, diesel and naphtha. Lighter gaseous hydrocarbons are also produced by FT reactors, which can be used to power a combined cycle gas turbine in order to co-produce electricity.

Dimethyl Ether (DME) production as a diesel substitute

The process of producing DME is similar to FT-biodiesel, being based on the gasification of lignocellulosic feedstock, downstream cleaning, detoxification and finally catalytic reforming. DME can act as a non-toxic, non-corrosive, methanol replacement with similar physical properties to LPG. It has good ignition properties and may therefore be a useful diesel extender / modifier. Despite being at an early R&D stage, DME is being advocated by Volvo as a major potential renewable diesel replacement of the future.
The conversion technologies for the production of DME are similar to FT but very much in the experimental phase. The main advantage of DME compared to FT-biodiesel or mineral diesel is its prospective extremely low emissions.

Pyrolysis

This technology is based around the ancient technology of charcoal production and has been modified to create more stable, controllable and rapid reaction conditions. The process produces an unstable bio-oil which can be stabilised and upgraded for diesel and petrol replacement. This technology is currently at R&D and pilot demonstration phase at relatively small scales, and may be an important future source of high-value biochemicals.

2.3.3 Improved potential by plant breeding

The extensive nature of large scale biomass production for energy and the underlying shift in economic emphasis towards the bioenergy component of cropping means that plant breeders need to focus on a range of relatively novel crop quality and productivity parameters. These parameters may include:

- increasing total above ground biomass rather than focus on harvest index and product quality parameters;
- tolerance to drought and diseases, visual damage may be less important;
- improvements in water use efficiency (WUE);
- improvements in nitrogen use efficiency (NUE);
- improved crop structures and photosynthetic efficiency (radiation use efficiency – RUE);
- search for and optimisation of indigenous species / varieties with better adaptability / productivity than exotics, and;
- mixed cropping systems to enhance biodiversity.

Over the next 5 to 15 years, plant breeders are likely to have to focus on two broad categories of crop types, each aimed at yielding products to substitute for petrol or diesel. The options for using plant breeding to improve these categories are evaluated below.

2.3.3.1 Petrol

For Petrol-substitution, sugar and starch-rich plant species are needed to supply conventional fermentation facilities. In Tanzania, the most likely immediate prospect for ethanol production on a large scale is the sugarcane industry which may focus on the use of its by-product C-molasses. Significant productivity gains could be made by re-focusing plant breeding activities away from the industry's current emphasis on sucrose production towards overall biomass production (Alexander, 1985). However, such a switch in emphasis is only likely to occur when government policy signals a long-term switch to biofuels.

Alternative starch and sugar crops are under development. Some of these alternative crops are already being produced for fuel-ethanol programmes around the world particularly in more arid regions which are unsuitable for sugarcane if irrigation is not available. These crops include:

i) *Cassava* – large programmes on developing cassava for bioethanol production are under way in Thailand, The Philippines and China. Recent emphasis was put on cassava for biofuel ethanol during the Gleneagles G8 summit and in NEPAD (particularly for Nigeria).

ii) *Sweet Sorghum* – whilst grain sorghum is actively being produced on a large scale in the US (see http://www.ksgrains.com/ethanol/kseth.html), its close relative sweet sorghum has only recently begun attracting attention as a serious, multipurpose option for bioethanol production (see www.sorghum.silvaeculture.co.uk). This crop produces sugars (including sucrose) in its stem in a similar way to sugarcane, and also a large seed-head and green leaves for fodder.

iii) *Others* – a range of other crops are available for biofuels ethanol production – see Figure 2-7. Maize in particular is primary feedstock for ethanol production in the huge US 'corn ethanol' programme. However, concerns about the quantity of fossil-energy-rich inputs and the competition for food production make maize an unlikely candidate for a large Tanzanian ethanol programme. In addition, concerns about developing over-dependence on hybrid seeds produced outside Tanzania would need to be allayed.

Future developments in conversion technologies may end the requirement for starch and sugar-rich feedstock for ethanol production, allowing crop residues and woody crops to be used, as described above. These thermochemical and / or biological conversion systems may allow the processing of any lingo-cellulosic material into ethanol. In advanced biological systems, the lignin would be separated from the cellulosic material and could then be burnt to produce heat and electricity or sold as a by-product. The thermo-chemical systems could theoretically use the whole biomass feedstock for bioethanol (or biodiesel) production. From the plant breeding perspective, by not having to focus on crop quality parameters such as sucrose purity and starch production, breeders could instead focus on primary productivity parameters such as RUE, NUE and WUE. However, factors such as final moisture content of heavy / alkaline metals, cold tolerance, etc are likely to be become more important.

2.3.3.2 Diesel

Compression ignition engines using diesel require fuels with different chemical characteristics to the spark ignition engines which use petrol. Vegetable oils were used to fuel the first engines and so provide a good opportunity to provide modern mineral diesel substitutes if such vegetable oil-derived biodiesel can be demonstrated to meet the requirements of modern diesel engines.

There are a large range of crops which produce oil rich fractions capable of either esterification or possibly for use as straight (un-esterified) vegetable oil, e.g. see Figure 2.13. The two most likely candidates for use in commercial-scale biodiesel production are Palm Oil and Jatropha although alternative indigenous (and exotic) plant species may emerge with better sustainable yield characteristics. Coconut derived biodiesel may also be an option in the coastal region of Tanzania.

Vegetable oils are prone to high melting points and thus can exhibit problems with viscosity. In turn, this can result in fuel line and injector blockages particularly during periods of cold weather. Crop selection and plant breeding can be used to address this problem e.g. to select oil crops with shorter chain fatty acids (FA) or to breed existing higher yielding crops so that the longer chain FAs are not produced or are transformed to short chain FAs in the plant.

As with petrol substitution by biofuels, conversion systems already under development can produce high quality mineral diesel replacement through thermo-chemical routes. Thermochemical conversion systems would either remove the requirement for oil-bearing crops altogether, instead preferring lower input woody or energy grass crops. Alternatively, such systems could make use of the residue fractions often co-produced in significant quantities with the production of vegetable oils to produce a supplementary biodiesel stream. For plant breeders, this would again mean a change in the quality parameters targeted away from high quality oil production towards total sustainable above ground biomass production.

2.4 References

AfDB/OECD. African Economic Outlook 2004/05 Tanzania Country Profile: AfDB/OECD. P 2, 2005. www.oecd.org/dev/aeo

Alexander, A. G. The Energy Cane Alternative. Sugar Sciences. Amsterdam: Elsevier. Pp509, ISBN: 0-444-42442-3. 1985.

Alexandratos, N. (ed.) Agriculture: Towards 2010 An FAO Study: Wiley 1995

Berg, C. World Fuel Ethanol Analysis and Outlook. April 2004 www.distil.com/World-Fuel-Ethanol-A&O-2004.html

Burland, P. personal communication August 2005

Carensa. Cane Resources Network for Southern Africa. Study report in print. 2005

Comesa. Investment Guide, http://www.comesa.int/investment/regimes/investment_area/Appendix%20%20B%20-%20Tanzania/en/view accessed August 2005

Daily News. Local firm to manufacture bio-diesel. P 2, August 29,2005.

DSD. Feasibility study on an effective and sustainable bio-ethanol production program by Least Developed Countries as alternative to cane sugar export. 2005

FAOSTAT (http://faostat.fao.org)

Grimm C. The Jatropha project in Nicaragua: Bagani Tulu (Mali). pp10-14, 1996. www.ibw.com.ni/~biomasa/tempate.htm

Hongo, H. personal communication August 2005

IEA. Biofuels for Transport An International Perspective: OECD. ISBN 92-64-01512-4 2004 Monthly Oil Market Report 11 August 2005

Msimbira, S.A.M. Sugar Board of Tanzania: personal communication August 2005.

Pereira, R.A. and Smith, P.D. Strategies to Improve Fermentation Yields at Triangle Ethanol Plant in 1999: Proceedings of the 74th Congress of the South African Sugar Technologists' Association. 2000

Scurlock, J., Rosenchein, A. and Hall, D.O. Fuelling the Future. Power Alcohol in Zimbabwe: ACTS Press. ISBN: 9966-41-030-9. 1991

Tatedo. Sustainable Energy and Development Forum. Newsletter of the Tanzania Traditional Energy Development Organisation Issue No. 1. pp6-9. ISBN: 0856-9266. January-May 2004

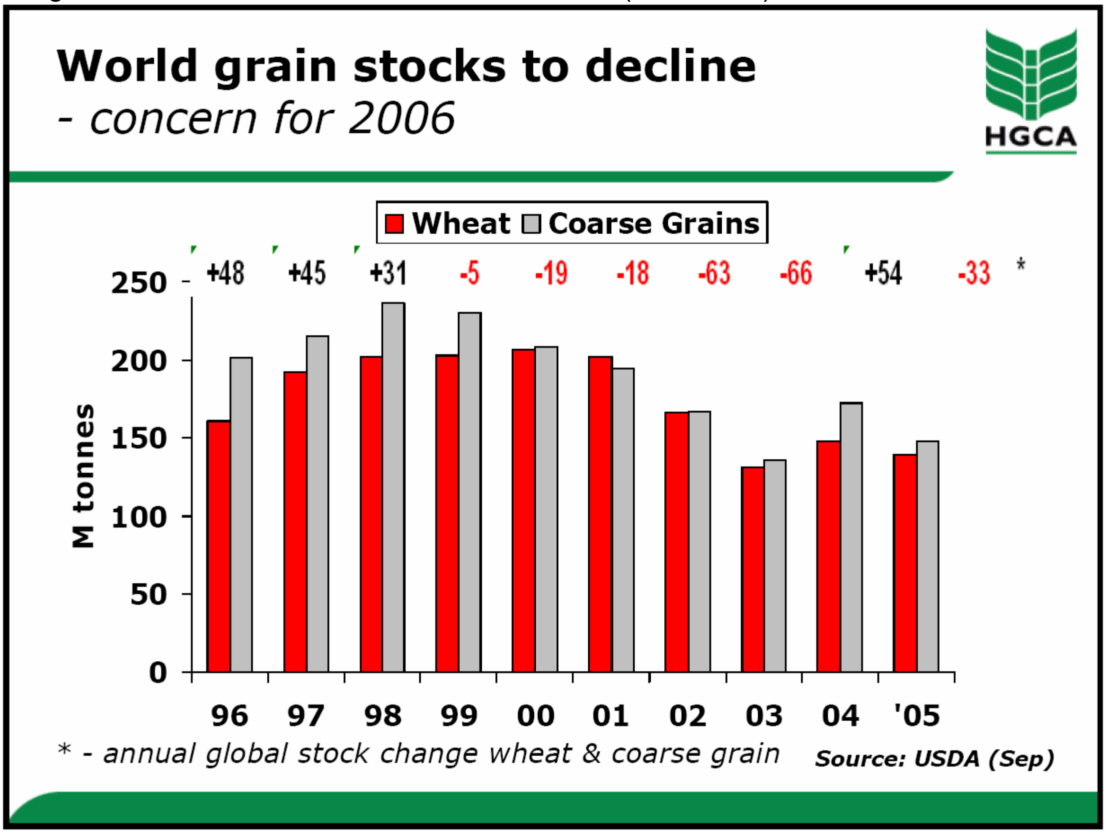
Chapter 3 – Sustainability Targets

3.1 Food security and energy provision

World food stocks (particularly cereals) are approaching an historic low as highlighted in Figure 3.1, leading many analysts to conclude that any significant expansion of biofuels production will directly impact on global food security (Bell, 2005; Monbiot, 2005). These concerns are based on the premise that biofuels production would lead to a competition for land that would otherwise be used for food production, further reducing global food stocks and marginalizing the poor. Bioenergy proponents dispute the logic of coupling global food stocks to bioenergy pointing out that much of the decline in the stocks is a result of restructuring of the highly inefficient agricultural production subsidies in Europe and USA. More information on the food versus fuel debate can be found in the Stockholm Environment / Partners for Africa newsletter dedicated to this issue (Morales, 2005).

Whilst poorly implemented, large scale bioenergy programmes could indeed lead to such displacement and marginalisation of the poor and to unwanted environmental impacts. However, when carefully implemented, such bioenergy programmes would provide local, value added activities and help to address the root causes of low productivity in subsistence agriculture. Outlined below are the main issues that need to be assessed in developing a sustainable bioenergy programme for Tanzania, including possible options for implementing monitoring of such sustainability criteria and rewarding good practice.

Figure 3.1 Global Grain Stocks- 1996 to 2005 (Bell, 2005)



3.1.1 Competition/synergies between specific food and energy crops

Perhaps unsurprisingly, many of the options for energy crops in Tanzania, and globally, are also major food crops e.g. palm oil, maize, sugarcane and sorghum (sweet and grain). This is not surprising because very substantial amounts of investment and historical development have been devoted to these crops. Sweet sorghum and Jatropha are notable exceptions which are still at an early stage in the development cycle of novel crops. Other novel dedicated energy crops are being developed which could not co-produce food including perennial woody crops e.g. willow, poplar, eucalyptus and acacia, and perennial herbaceous grasses e.g. miscanthus, reed canary grass, etc. The use of these novel non-food crops for bioenergy and in particular biofuels production is dependent on the successful transition of advanced conversion technologies from the R&D to commercial phase (see chapter 2). Basic and developmental information on each of these crop types can be found via www.ecoport.org.

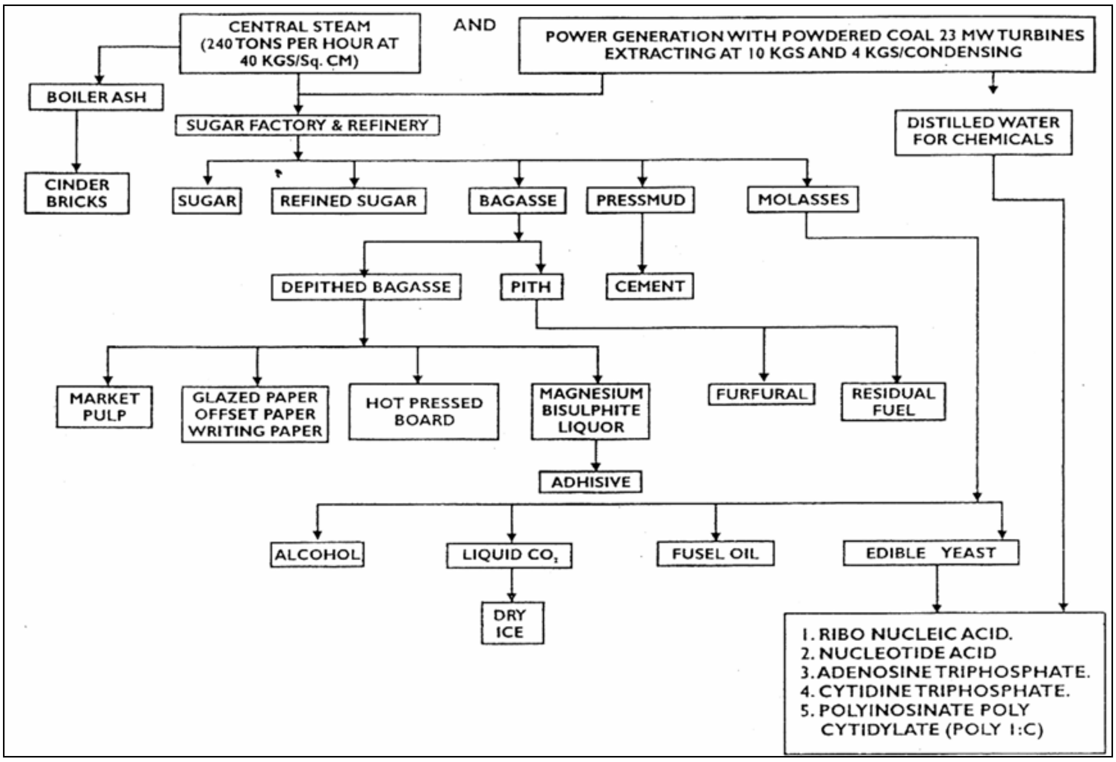
Where non-food crops can be grown on land that is not capable of supporting food cropping no competition for food will result except through secondary effects such as modification of hydrology and hence water availability and diversion of investment potential. A potential benefit of the development of perennial non-food energy crops is that they could be used to rehabilitate degraded and abandoned land. An example of this approach is that taken by the Indian Biodiesel Programme which is promoting the growth of Jatropha on degraded lands (TERI, 2005). Once rehabilitated, it may be possible to return some of this land to food production. In fact, dedicated bioenergy cropping can result in the use of the land which was previously not suitable for cropping or in making existing land use more productive. In Hosahali, a small village in India, this approach to rural development has been demonstrated. The village has established a 4ha woodlot using a mixed species approach. The sustainable harvested wood from this woodlot is used to power a 20kW gasifier and generator which in-turn provides electricity for domestic lighting, and water pumping, for both domestic and irrigation uses. The ability to irrigate has already brought 8 ha of land under production allowing cash crops to be produced (Ravindrinath, 2004).

In systems where bioenergy and food are co-produced business models are more complex and also more sensitive to cross-sectoral government policy. Two possible configuration options are discussed below.

3.1.1.1 Bio-refineries

When processed for biofuels production, most if not all of the conventional crops produce multiple products destined for food, non-food and animal feed markets. The large range of potential outputs from agro-processing facilities, particularly those designed to produce biofuels as their primary product, has led to the concept of the ‘bio-refinery’. One of the most developed examples of the bio-refinery concept is the Jiangmen Sugar and Chemicals Complex in China which produces 28 products from sugarcane processing (Figure 3.2; Rao, 2004). The benefit of producing multiple outputs is that the revenue stream can be buffered from market fluctuations as it is likely that a decrease in value of one product will be offset by increasing value of another. It is however, complicated to develop robust business models for bio-refineries with complexity increasing in proportion to the number of outputs.

Figure 3.2 Bio-refinery- Jiangmen Sugar and Chemical Complex (Rao, 2004)



3.1.1.2 Poly-generation

A simpler strategy may be to optimise the overall energy balance of such bio-energy complexes, particularly in a period when conventional energy prices are increasing and the processing of raw biomass to biofuels is itself an energy intensive process. Much of the process-energy is needed for ‘low-grade’ heating applications e.g. boiling water, maintaining feedstock temperatures, etc which can easily be provided by conventional combustion of the residues which are often co-produced at the plant. In fact, the energy content of the associated residue production is often significantly in excess of process requirements which historically meant that combustion and steam raising was carried out in at low efficiencies in order to dispose of the residues and provide process energy. However, two factors are now pushing a drive to the installation of much more efficient energy conversion technologies for the co-production of process heat and electricity (co-gen or CHP) from these residues:

i) Changing economics of conventional electricity generation and transmission – it is increasingly recognised that diffuse rural markets for electricity are extremely expensive to service with a centrally dominated point source generation strategy. Decentralised (distributed) electricity generation near point-of-use provides an alternative model for providing electricity in rural areas of developing countries. Large scale agro-processing plants can provide significant ‘surplus’ electricity generation capacity at lower cost.

ii) The incremental capital cost of installing high efficiency electricity generation capacity c.f. low-efficiency self-provision of heat and electricity, is justifiable if reasonable long-term contracts can be negotiated with national or local electrical utilities. National policy must be developed to assist with private purchase agreement (PPA) contracts on terms that allow a reasonable rate of return on the investment. That such assistance is required in establishing good government policy is clearly explained by the Ugandan case study provided by Kakira Sugar Works Co-Generation Project in which, despite good private sector economics and willingness to invest, perverse government policy has so far thwarted the development of the cogen capacity (Nakhooda, 2005).

3.1.2 Bottlenecks/restrictions for energy crops/area

Tanzania is almost uniquely gifted in the capacity for expansion it has in terms of the land area and resources (water and people) at its disposal for energy and food production (see Chapter 2). The 55 Mha of land currently unused for agriculture but capable of producing crops, represents a substantial development opportunity for this LDC but only if sustainability criteria are placed at the heart of its development policy. Bottlenecks for the development of a large biofuels industry currently exist at almost every level including; a lack of coherent long term policy at Government level, a fragmented industry approach to bioenergy, national and international development policy which fails to recognise the important role that bioenergy can play in development, complex land tenure issues, and the lack of capacity within industry, investors and government to address these issues as discussed below.

3.2 Environmental aspects

A broad and complex range of environmental issues affect the development of sustainable bioenergy programme(s). Despite the exceptionally large potential area of land available for the production of biomass for energy, Tanzania does have a complex and highly biodiverse ecology to protect. Equally, its people have the right as a minimum to meet the MDGs and aspire to the levels of welfare experienced in the developed countries.

In fact, the notion of sustainability is itself in a transitional phase moving from definition / proof of concept to the emergence of an implementation framework. Ensuring that such a sustainability framework is embedded in the processes of bioenergy production is complex, particularly as it is not possible to definitively state that any production system is ‘sustainable’. It is however, possible to categorise and monitor activities as either ‘not sustainable’ or consistent with ‘sustainability’. This is the basis of eco-labelling and fair trade.

Despite the apparent lack of maturity in the understanding of how sustainability criteria can be embedded in governmental, industrial, and agricultural and forestry policies it is essential for the future welfare of Tanzania’s people that it takes a leading role developing and implementing this area. By doing so it will help avoid historic mistakes in development policy which are at the centre of the current lack of development experienced by the vast majority of its population and provide a model for other nations that realise the growing importance of renewable energy and bioenergy in particular. A brief rational for this approach and indications of how the sustainability framework can be developed are provided below. Key criteria and standards for monitoring environmental sustainability are outlined in table 3.1.

A number of studies have begun to define the key issues in quantifying sustainable bioenergy systems. One such study, the European Commission funded 'Biocosts' study (EC JOR3-CT95-0006), provides a comprehensive comparative study of the environmental effects of different bioenergy and reference fuel chains in the European Union and is used as the basis for the discussions in this section. A second study by Greene and Martin (2002), carries out a similar evaluation but specifically for bioelectricity production in the USA.
The potential environmental benefits that can arise from well-managed energy crops, particularly perennial energy crops, include:

- Providing a CO_2 neutral fuel source as a substitute for fossil fuel use.
- Lower emissions of other atmospheric pollutants, such as sulphur, compared to use of certain fossil fuels.
- Soil and watershed protection.
- Raising or maintaining biodiversity.
- Other benefits such as reduced fire risk in forestry.

A detailed evaluation will be carried out of the national, European and international supply chains for bioethanol, both existing and in development. The activities required to deliver the evaluation of current and future sustainability of bioethanol fuel systems will be carried out through the activities described below.

Table 3.1 Environmental criteria for monitoring sustainability

Category	Comment
Land use change	Baseline date require e.g. 'land not converted to production after 1990. Changes in soil carbon levels are of particular relevance. Deforestation.
Soil management	Best practice management plans need to be developed for specific soil and crop types
GMOs	Track and trace requirements
Fertiliser use	NPK application rates. Source of P may be important in terms of heavy metal build up. N important for energy input / GHG inventories plus water quality.
Irrigation	Best practice guides / management plan
Crop protection	Type and rates of application of active substance.
Biodiversity	Best practice guides plus mandatory or voluntary management plans
Conversion Plant Environmental impact assessment	Adherence to national pollution control regulations other environmental management plans in operation.
Conversion Plant: Emissions monitoring	Voluntary reporting requirement
GHG emissions	LCA Gap analysis

These potential environmental benefits need to be considered in conjunction with other potential socio-economic benefits such as rural development and improved energy security. Despite the site-specific nature, heterogeneity and complexity of bioenergy production chains there are some general and more specific environmental considerations that can be applied to biofuels production in Tanzania as outlined below.

3.2.1 Energy and carbon balances- the importance of life cycle assessment

The assumption that modern bioenergy is a renewable source of energy is challengeable (Pimentel & Patzek, 2005; Woods & Bauen, 2003). Despite the conclusions of the Pimentel & Patzek paper being controversial it is possible to develop biofuels production chains with low or even negative energy balances. A negative energy balance is achieved when the energy inputs needed to produce a unit of biofuel are greater than energy contained in that unit of biofuels. Similarly, inefficient biofuels production chains with low or negative energy balances are also likely to have poor or negative GHG balances. A production chain with a negative GHG balance results in greater GHG emissions occurring when the biofuels is used than would have resulted from the original fossil fuel use e.g. petrol or diesel. Biofuels production chains can also have very positive energy and GHG balances when each part of the chain is optimised and when good logistics are in operation, particularly in tropical and sub-tropical climates which favour photosynthesis, (Figure 3.3 and 3.4).

Figure 3.3 Bioethanol energy balances versus Brazilian sugarcane ethanol energy balance (Woods, 2004)

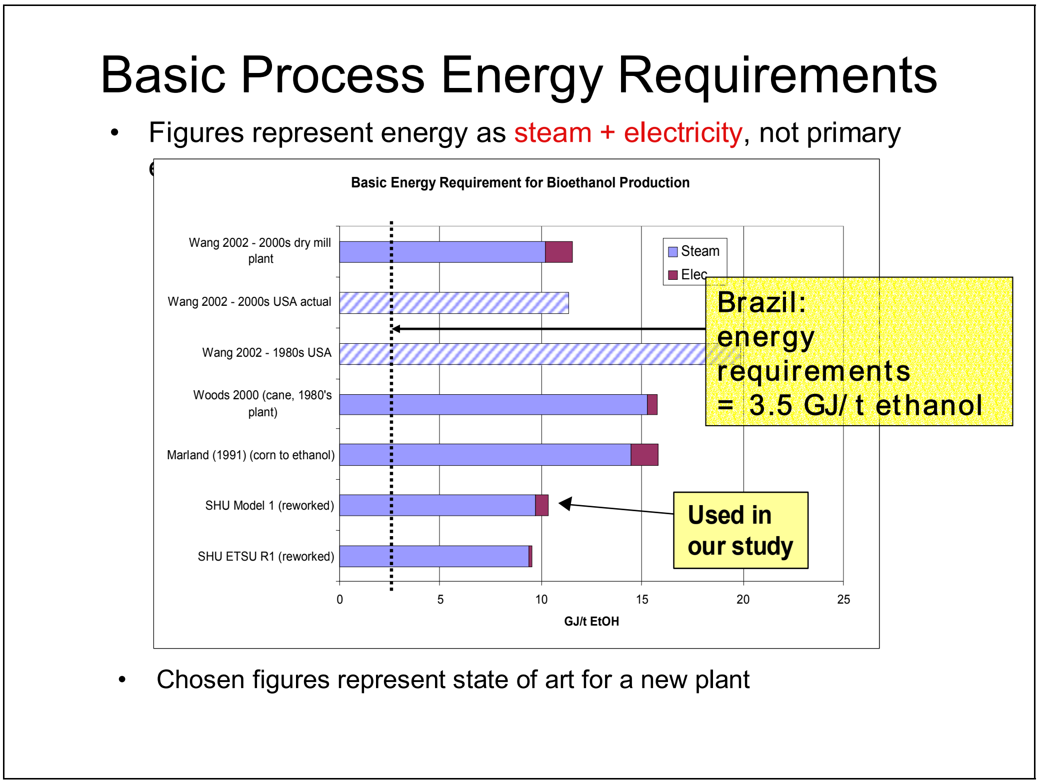
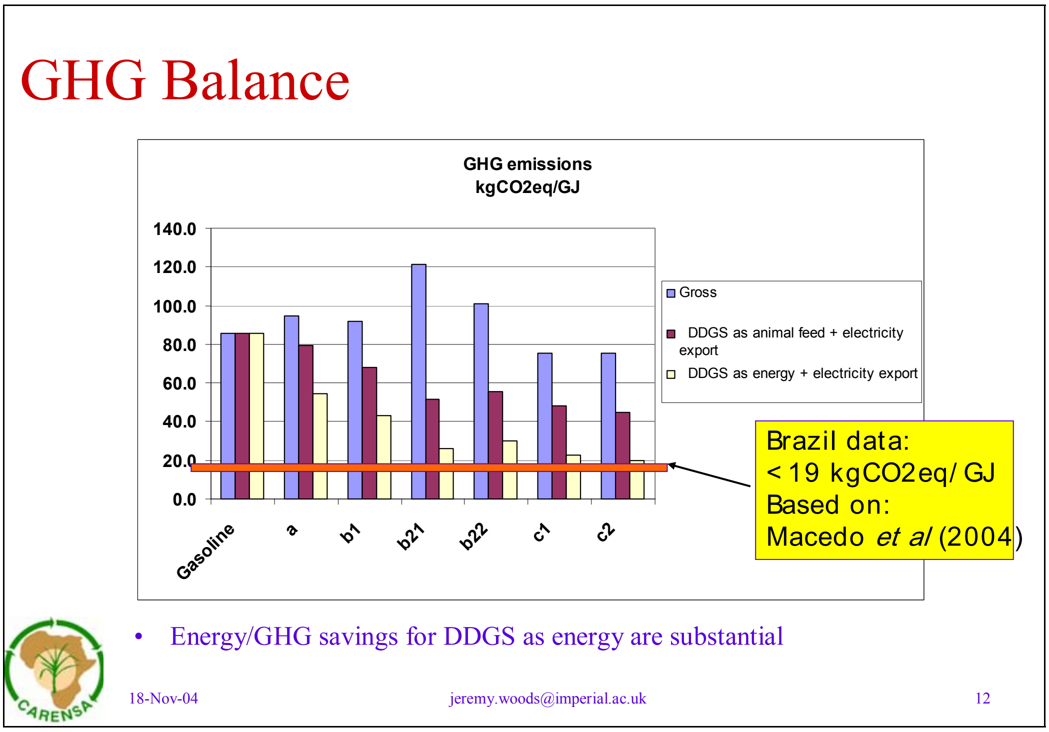


Figure 3.4 GHG balances for six wheat ethanol production chains (UK) versus Brazilian Sugarcane Ethanol Production (Woods, 2004)



3.2.2 Impact on biodiversity, water, soil, forestry and nature conservation

Large scale, widespread biofuels production activities in Tanzania will have impacts on biodiversity, hydrology, and soil and without careful implementation could also threaten natural forest and wildlife areas. This is common to all agricultural and forestry activities except that the potential demand for biofuels adds an additional demand for land and the resources required for biomass production, particularly water. Methods to manage and mitigate these impacts are being developed as part of the social and environmental assurance process that is being implemented by a range of agricultural and forestry industries. Because of the broad range of factors that need to be assessed and heterogeneity between sites managing environmental impacts generally occurs through the development of site specific good management guides e.g. the South African Cane Growers Environmental Handbook. (CANEGROWERS, 2004).

3.2.2.1 Biodiversity

The production of biofuels in Tanzania has the capacity to affect biodiversity in two ways:

i) biomass production is carried out in areas that directly or indirectly impact on biodiversity hotspots

ii) biomass production is carried out in non-biodiversity hotspot areas but in a way that either enhances or decreases the existing biodiversity

Outside the biodiversity hotspots, quantifiable evaluations of the impacts on biodiversity of producing significant levels of bioenergy are not yet possible. Again there will be both positive and negative impacts from the introduction of biomass feedstock for energy production which will be highly dependent on both the feedstock chosen and the system being replaced. Where perennial systems replace existing intensive annual agriculture, biodiversity will generally increase, as will be the case with carefully managed exploitation of residues. Managing biodiversity is a complex task and impacts will depend on the spatial structure of the operation. For example, a short-rotation tree plantation may be just as poor in terms of biodiversity as a cereal field. If small fields of different annual crops are substituted by large tracts of monoculture plantations, the impact on biodiversity may be unfavourable. Where existing grasslands or forests are to be replaced by energy crops negative impacts on biodiversity are likely and implementation would have to be balanced with the likely benefits arising from well-managed bioenergy.

Methods for managing biomass production which maximise biodiversity are being developed.

3.2.2.2 Water

Water consumption and contamination as a result of biomass production and conversion for biofuels production remains an important area for planning and monitoring. For example, during peak growing periods sugarcane can require up to 10mm of rain equivalent water per day to meet the crops evapo-transpiration requirements. Exploitation of water resources for irrigation therefore needs careful planning. Equally, sugar mills and ethanol plants require substantial amounts of water and can emit significant amounts of liquid pollutants with high biological and chemical oxygen demands (COD and BOD). Development of guidelines and licensing are therefore necessary pre-requisites for biofuels production.

Limiting emissions of pollutants and increasing water use efficiency represent only one part of the options available. The use of perennial crops and no-till buffer zones along water courses is already being actively considered as a cost effective method for reducing COD and BOD levels in agricultural water courses. This can occur directly as a result of decreased applications of fertilisers in vulnerable areas or as a result of the active interception and uptake (‘filtering’) of nutrients leached off adjacent intensively farmed land. Energy crops may allow the productive use and therefore income generation from these vulnerable areas but careful consideration is needed to ensure that biodiversity is protected or enhanced.

However, there may also be negative impacts from the introduction of energy crops on local and regional hydrology. For example, a recent study on the potential impacts of short rotation coppice (SRC) in South East England found that a significant increase in the interception and use of rainfall could result from a wide spread implementation, with potentially substantial reductions in rainfall infiltration (Lyons *et al.* 2001) and negative impacts of aquifers in the region.

3.2.2.3 Soil

Biofuels production in Tanzania will be based on the use of dedicated perennial woody and herbaceous crops. The use of perennial crops, where they replace annual crops, will result in reduced soil disturbance, greater soil cover and hence lower erosion, improved soil organic matter and soil carbon levels and increased biodiversity, particularly where the change results in a decreased application of inputs (fertilizers and pesticides). The recycling of ash and other nutrient-rich waste streams (e.g. stillage) from the conversion facility back to the fields will also be an important component of nutrient management. However, care should be taken to monitor the composition of the ash as plants can selectively and actively absorb toxins, including heavy metals and ash recycling could cause such toxins to be concentrated in the bioenergy plantation's soils. This characteristic of certain plant species to selectively absorb toxins is sometimes used to rehabilitate polluted soils in a process known as phytoremediation.

Any reduction in the use of fertilizers as a result of recycling will result in decreased N_2O and NH_4 (powerful GHGs) emissions and reduce or eradicate nutrient run-off into local water courses and the associated nitrification problems. Where bio-electricity production associated with biofuels production is to be based on exploiting agricultural and forestry residues monitoring may be required to ensure that soil organic matter and nutrient levels are maintained or even improved. Careful matching of fertilizer applications to soil type and yields can lead to significant reductions in application rates, run-off and leaching and should be encouraged. Improved productivities may occur with the careful exploitation of residues and fire risks can be substantially reduced, particularly in arid and semi-arid areas.

3.2.2.4 Atmospheric (Air)

Atmospheric emissions can result from all stages of the bioelectricity production chain, but it is critical to evaluate these emissions against the reference electricity production system or alternative use of the biomass feedstock in order to gain a realistic overview of the net benefits of the bioelectricity production system. Again, a life-cycle approach is necessary as significant emissions may result from displaced activities such as fertiliser manufacture or from alternative uses. For example, GHG emissions, primarily the powerful GHG methane, that result from simply venting landfill gas to the atmosphere can be used to gain useful energy (electricity) and at the same time convert the methane to CO_2 and hence significantly reducing the GHG warming potential.

Impacts from the biomass conversion stage in power plants will depend on the conversion technology used and need to consider alternative electricity sources. The greatest environmental and economic benefits are likely to occur by substituting coal or oil-based electricity compared to substituting natural gas-based electricity. The greatest benefit from the use of biomass compared to fossil fuels is likely to be in terms of CO_2 emissions.

Benefits with regard to emissions of other atmospheric pollutants (SO_x, volatile organic compounds, CO, NO_x and particulates) will depend on the conversion technology used and comparisons with alternative electricity sources. Modern 'conventional' conversion technologies can result in very low levels of atmospheric pollutants.

3.3 Socio-economic Aspects

In common with agricultural and forestry production serious doubt exists over the wider benefits to society that accrue when bioenergy (or other food/non-food production) occurs without meaningful involvement of local communities. The global trends towards increasing mechanisation of agriculture and forestry have resulted in a substantial decrease in labour requirements per unit of economic output from these sectors. In addition, particularly in Africa, issues such as HIV/AIDS, malaria and other diseases have seriously impacted on the productivity of the labour force in affected areas, again driving the move towards mechanisation. An opposing force to this trend has been the increase in small-holder production linked multi-national agro-industries, particularly the sugar and forestry industry in South Africa. Large scale, foreign-owned, highly mechanised agro-industries bring little micro or macro-economic benefits to the local communities with which they are associated with except where tax revenues are used to their benefit. Recent examples appear to be highlighting how large agro and forestry industries can bring benefits to local communities by enabling small-holder production access to international markets, professional know-how and private investment e.g. small-holder sugarcane production in South Africa, Zambia and Tanzania (e.g. Kilombero Outgrowers Association, Tanzania) and forestry in South Africa.

3.3.1 Employment effects

At the macro level, employment benefits are often highlighted by politicians as the key benefit of bioenergy production. Indeed, analysis by the World Bank (Utria, 2004) suggests that substantial investment in bioenergy simply by diverting money earmarked for conventional energy investment could result in the generation of many millions of jobs in Africa. In Brazil, the sugarcane-based ethanol fuel industry is credited with generating three quarters of a million direct jobs and between 1.5 to 3 million indirect jobs. However, job quality and worker welfare are also important developmental issues and the development of assurance (labelling / certification schemes) for ‘sustainable products’ have highlighted the key criteria involved in engendering development. Social criteria required for evaluating social sustainability have been derived through the Social Accountability Standards (as defined by SAI 8000:2001)- see Table 3.2.

Table 3.2 Social criteria for evaluating social sustainability (SAI8000:2001)

Category	**Comment**
Child Labour	ILO definition- a child is a person under the age of 15 years- some exceptions exist and ILO rules allow some exceptions for developing countries
Forced Labour	Work that is 'extracted under menace of any penalty for which a person has not offered themselves voluntarily or if such work is demanded as a means of repayment of debt.'
Health & Safety	Multiple. E.g. see SAI 8000:2001 or EUREP GAP IFA ver 2, 2005.
Freedom of Association & Right to Collective Bargaining	Rights of workers to meet together and join a trade union
Discrimination	
Disciplinary Practices	
Working Hours	
Remuneration	
Management Systems & Control of Supplier and Sub-contractors	

Note: Details of these standards and their associated definitions are published by SAI and are available on their website (www.cepaa.org).

3.3.2 Regional development and distribution of value-added

The last few decades have seen a relentless downward pressure on the value of global commodities, especially foods. Regional and international markets are developing rapidly, particularly for biomass residues (see: www.fairbiotrade.org for example). Whilst this trade in residues may add value to existing processes by providing a valuable market for output by-products which would otherwise have little or negative value (i.e. their disposal would incur costs), under some circumstances greater value could be derived through local processing. It is also important, particularly during the establishment of a Tanzanian bioenergy sector that primary biomass feedstock are not traded internationally. Instead, Tanzania should establish the capacity to carry out the processing and conversion internally and when sufficient capacity has been developed, sell the value-added product through international markets.

3.4 Macro-economics

From a macro-economic viewpoint policy development aimed at achieving national self-sufficiency in any specific commodity rather than economic security makes little sense. Instead, it is considered more economically efficient to encourage production capacity in areas where comparative advantage exists. Thus, substituting one land use e.g. tourism for an alternative land use e.g. biofuels production, should only be considered when the net return per unit land area is greater for biofuels production compared to Tourism. However, in practice, reliable evaluations of relative economic performance are difficult to carry out. In addition, it is difficult to account for rapid and unpredictable variations in frame setting economic variables such as the cost of oil (see section 2.2 for more details) which might rapidly make a hitherto un-attractive option comparatively attractive. This is currently the situation that is occurring in biofuels sectors around world where biofuels production is only recently becoming directly competitive with oil-products and with alternative agricultural products too.

The volatility in the price of oil and gas is in itself economically destabilising and so even if alternative energy supplies are more expensive in the long run, if their price remains stable and therefore predictable a price premium may be justified. After the 1973 world oil shock Brazil made the decision to reduce its dependence on imported oil by establishing the Proalcool fuel ethanol programme. Since 1973, petroleum products remained significantly cheaper than ethanol but the national benefits in terms of energy security, employment creation and wealth retention were sufficient for Brazil to maintain its support for the programme. During this period the cost of producing ethanol decreased significantly and the cost of petroleum has recently risen dramatically meaning that fuel ethanol production in Brazil is cost effective.

Tanzania is currently in a similar position to that which Brazil found itself in, in 1973. It is spending approximately 40% of its foreign exchange on importing oil products but it has a massive land and human resource that could be used for the production of biofuels which would currently almost certainly be cost effective compared to imported petroleum. The main risk is that the price of imported petroleum will fall in the future rendering indigenously produced biofuels un-economic.

Assuming that biofuels can be produced at a cost near to parity with imported petroleum products the impacts of establishing a significant capacity for biofuels production would have a positive impact on all relevant economic growth indicators. In addition, if well implemented such biofuels production would have a very significant employment generation potential. When coupled to viable carefully planned and implemented outgrower schemes (such as the Kilombero Outgrower Scheme) it would also help generate substantial sources of revenue to the local community allowing them to invest the infrastructure necessary to first meet and the exceed the MDGs. At the same time income through taxation would increase assisting national governmental budgets

3.5. Implementing sustainability

Bioenergy (and biofuel) supply chains are complex, cross-sectoral and site-specific in terms of monitoring for sustainability. As a result, claims about the beneficial or negative impacts of bioenergy systems are often controversial and open to legal and ethical challenge. In practice, this complexity also means that under enabling conditions bioenergy production chains can be incentivised to become highly efficient and environmentally beneficial. The complexity also means that it is difficult for governments to establish a credible evidence base to establish good policy.

Recent developments in the fair-trade and European supermarket sectors designed to assure local environmentally and socially aware consumers that the products they are purchasing are sustainable produced and are not detrimental to the local producers, can be modified to provide a framework for monitoring the sustainability of biofuels production chains (Bauen et al, 2005). A range of products produced in Tanzania are already certified to be sustainable and are produced for export to European markets, demonstrating that the system can work in practice and provide added value to products.

The development of certification systems to monitor and reward best practice should be considered as part of a carefully planned and implemented process of establishing a viable bioenergy sector in Tanzania. This process will need the close cooperation of the private and public sectors and the collaboration of relevant NGOs in a transparent consultation-led process. Tanzania needs to develop the capacity to engage with all the stakeholders in the dynamic process of developing a vibrant and sustainable bioenergy sector. The framework and criteria for establishing such a process are outlined here whilst the mechanisms will be developed in the following chapter.

3.6 References

Alexander, A. G. The Energy Cane Alternative. Sugar Sciences. Amsterdam: Elsevier. Pp509, ISBN: 0-444-42442-3. 1985.

Bell, J. Market Outlook for Cereals and Oil Seeds. www.hgca.com, London, UK: HGCA. 2005. http://www.hgca.com/events.past_events/32/32/Events/Events/press%20releases.mspx?fn=showRelease&menuId=1233

CANEGROWERS. Cane Growers Environmental Handbook. Eds.: Hay,D. South Africa: Cane Growers Association. Pg:1-14, 2004. http://www.sacanegrowers.co.za/

Greene, N. and Martin, J.H. From Plants to Power Plants: cataloging the environmental impacts of biopower, Final Draft: revision G2, NRDC, Washington D.C. (2002)

Lyons, H.A. Anthony, S.G. and Johnson, P.A. Impacts of increased poplar cultivation on water resources in England and Wales. Wellesbourne, UK:AAB. *Aspects of Applied Biology* 65:83-90, 2001. 0265-1491.

Monbiot, G. Comment & Analysis: Fuel for nought- The adoption of biofuels would be a humanitarian and environmental disaster. Ed.: Morales, M.M. SEI, Stockholm, Sweden: 2005. http://www.partners4africa.org/goto.php/library.htm

Morales, M.M. (ed) Policy Debate on Global Biofuels Development: Partners for Africa newsletter. SEI, Stockholm, Sweden: 2005. http://www.partners4africa.org/goto.php/library.htm

Nakhooda, F. Kakira Sugar Works Cogeneration Project (Uganda). Tanzania Partners for Africa Policy Workshop. Eds.: Janssen, R. WIP / Partners for Africa. 2005.

Pimentel, D. and Patzek, T.W. Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower. Springer Verlag KG. *J.Natural Resources Research* 14(1):65-76, 2005. ISSN: 1520-7439.

Rao, P.J.M. Technological Development and Opportunities for Sugarcane Co-Products. CARENSA Workshop, Mauritius (14 to 20 November 2004). Ed.: Johnson, F.X. Stockholm, Sweden: SEI. Pg:1-16, 2004.

Ravindrinath, N.H., Somasheker, H.I., Dasappa, S., and Jayasheela Reddy, C.N. Sustainable Biomass Power for Rural India: case study of biomass gasifier for rural electrification. *Current Science* 87(7):932-941, 2004.

Rickeard, D. J., Punter, G., Larivé, J.-F., Edwards, R., Mortimer, N. D., Horne, R., Bauen, A., and Woods, J. WTW Evaluation for Production of Ethanol from Wheat.. London: LCVP. Pg1-39, 2004. http://www.lowcvp.org.uk

TERI. Indian Non-Edible Oils Biodiesel Programme. Delhi, India: TERI. 2004CM24:1-200, 2005.

Utria, B. Modern Biomass Energy for Sustainable Development and Poverty Alleviation. IEA Task 40- Business Forum. Held FAO, Rome 28 to 29 October 2004. Eds.: Faaij, A. and Best, G. IEA Task 40. 2004. www.fairbiotrade.org

Woods, J. and Bauen, A. Technology Status Review and Carbon Abatement Potential of Renewable Transport Fuels (RTF) in the UK. DTI; AEAT. B/U2/00785/REP: URN 03/982:1-150, 2003. http://www.dti.gov.uk/energy/renewables/publications/pdfs/B200785.pdf

Chapter 4 – Synthesis: Recommendations for decision-makers

4.1 Introduction

As is discussed in the previous chapters of this study there is currently no liquid biofuels production for transport applications in Tanzania. On the other hand Tanzania has large suitable land resources that are potentially available for large- as well as small-scale production of biofuels in several regions of the country. It is therefore generally agreed upon that land availability will not be a barrier to bioenergy and biofuels production in Tanzania.

The exploitation of this resource potential is presently mainly hampered by lack of information on all levels of society (Government departments and institutions, industry, civil society). This fact is one of the reasons for the absence of clear policies and regulations for biofuels production and use in Tanzania. In order to develop an enabling framework there is an urgent need of close co-operations and consultations between several Government departments (e.g. Ministry of Energy and Minerals, Ministry of Agriculture and Food Security, Ministry of Transport and Communication, Ministry of Finance, etc.) as well as between Government and stakeholders engaged in the promotion of liquid biofuels in Tanzania.

Currently, the lack of policies and regulations make investment in the biofuels sector difficult in Tanzania, as the prospective return-on-investment remains largely unclear. Especially, the rather large investments required in the sugar industry to start the production of fuel ethanol from sugar cane would require an ensured market for the product (e.g. through a mandate for ethanol-gasoline blends), guaranteed ethanol prices, at least for the start-up phase, as well as an initial protection of local manufacturers against cheap import biofuels.

It was therefore one of the main objectives of the expert workshop and policy discussion organised in the framework of this study to support co-operation links between Government departments and involved stakeholders. In order to bring forward the important and promising issue of biofuels in Tanzania, it was concluded by the workshop participants, with strong support from the representative of the Ministry of Energy and Minerals, to establish a high-level Tanzanian Biofuels Task Force which shall be focussing on providing advice and recommendations for the elaboration of biofuels policies and regulations. Additionally, a Tanzania Biofuels Producers Association shall be established acting as one of the important stakeholders of the Biofuels Task Force.

With its large potential for biofuels production and the lack of biofuels policies and regulations, Tanzania is a good example for a variety of developing countries worldwide which currently are in the very early stages of investigating the biofuels option for their country as a contribution to a future more sustainable energy supply.

4.2 Motivation for biofuels programmes in Tanzania

During discussions with several high-level representatives of Government Ministries it became very clear that Tanzanian policy-makers are well aware of the large variety of benefits offered by displacing gasoline and diesel fuels with liquid biofuels for transport.

The following benefits act as the main drivers for potential biofuels programmes in Tanzania:

- Agricultural/rural development – Creation of new jobs and income opportunities
- Reduction of oil imports – Foreign exchange savings
- Improved energy security
- Creation of new industries
- Reduction of GHG emissions – Opportunities for CDM and carbon trading
- Reduction of air pollution (Lead, SO_2, CO)
- Improved vehicle performance (ethanol as octane enhancer)

Agricultural/rural development

The Tanzanian Government has been attracted by the potential role biofuels can play in stimulating domestic agricultural production and expanding the markets for domestic agricultural products. Production of biofuels from crops such as sugarcane (for ethanol production) and palm and jatropha (for PVO or biodiesel) provides new product market opportunities for farmers, with the potential to increase farming revenues or expand the productive capacity of existing cropland.

In the sugar sector, Tanzania may face a future reduction of the income due to reduced prices offered by the European Union after the reform of its Common Agricultural Policy (CAP) (DSD, 2005). Therefore, a diversification of the income through the combined production of sugar and ethanol will be of large benefit to secure future employment in this sector.

In the field of oil seed crops, several grassroot initiatives (e.g. KAKUTE's initiative of jatropha plantations in Northern Tanzania) have already proven the potential of small-scale rural income generation.

Improved balance of trade

Tanzanian annually spends about 40% of its FOREX on petroleum product imports, being the main single cause for the country's trade deficit. As Tanzania does not have own crude oil resources, the import of petroleum products will continue to force the country into the well-known development trap caused by increasing foreign debts. Debt releases by the rich industrialised countries will only result in a temporal release of the burden, as within few years the trade deficit will have built-up again, especially with the high and increasing prices for petroleum products on the world market. Introducing domestically produced biofuels in the Tanzanian transport market (e.g. as 10% blend of ethanol in gasoline or biodiesel in diesel) would therefore lower the trade deficit and benefit the macro-economy by spurring domestic economic activity.

Improved energy security

The issue of energy security is gaining increased worldwide importance and it affects developing countries in the same way as industrialised countries. The current limited number of oil exporting countries (most of them located in the politically unstable region of the Middle East) poses significant risks due to market concentration. The greater the number of suppliers or fuel supplies, the lower the risk dependence (Neff, 1997). Therefore, biofuels provide the opportunity to reduce the risk dependence in two ways, namely by the introduction of alternative fuels and by the introduction of additional countries involved in the global fuel supply.

Creation of new industries

The introduction of biofuels programmes can lead to the creation of healthy new industries, as impressively shown by the Brazilian ethanol experience. The ProAlcool programme has accelerated the pace of technological development and reduced costs within agriculture and other industries. Brazil has developed efficient agro-businesses and the Brazilian alcohol industry is today among the country's largest industrial sectors. Brazilian firms export alcohol technology to many countries including distillery hardware improving the performance of ethanol production.

Although it is obvious that the biofuels industry in Tanzania (as well as in other developing countries) will be significantly smaller than the one in Brazil, biofuels production in Tanzania has the potential to spur successful agro-businesses throughout the country, which will also lead to stimulating rural development.

Reduction of GHG emissions

On a global scale, vehicle emissions contribute nearly 20% of energy-related greenhouse gas emissions (IEA, 2002). Both ethanol and biodiesel can provide significant 'well-to-wheel' reductions in GHG emissions compared to gasoline and diesel fuel. Studies indicate up to a 40% net reduction from grain ethanol versus gasoline, a significantly higher 92% net reduction for ethanol produced from sugar cane in Brazil (Macedo et al., 2003) and up to a 70% reduction from biodiesel relative to diesel fuel.

For biofuels production in Tanzania no estimates for GHG emission reductions exist up to date. But, given the climatic framework conditions, it should be possible to achieve GHG reductions larger than the ones realised in Europe and the United States. Nevertheless, a detailed 'well-to-wheel' emission analysis for biofuels production in Tanzania will be necessary, both in order to implement the most favourable biofuel production options as well as to exploit the financial opportunities offered by Clean Development Mechanism (CDM, under Kyoto Protocol) and international carbon trading.

Reduction of air pollution

Biofuels can provide certain air quality benefits when blended with petroleum fuels, particularly in urban ares. Benefits from ethanol blending include lower emissions of carbon monoxide (CO), sulphur dioxide (SO_2) and particulate matter (PM). Benefits from biodiesel include all these plus lower hydrocarbon emissions. Biofuels are also generally less toxic than conventional petroleum fuels. On the other hand, ethanol may lead to increased aldehyde and evaporative hydrocarbon emissions and both ethanol and biodiesel may cause increases in NO_x, particularly on a 'well-to-wheel' basis.

In Tanzania the benefit of reduced air pollution will be of prime importance for the municipality of Dar es Salaam, where an increasing traffic is already today causing significant health hazards for the urban population.

Improved vehicle performance

Biofuels can provide significant vehicle performance benefits. Biodiesel improves the performance of conventional diesel fuel even when blended in small amounts (e.g. B5). Ethanol has a high octane number and can be used an octane enhancer in gasoline. It has not traditionally been the first choice for octane enhancement due to its relatively high costs, but as other options such as lead and MTBE are being discouraged or banned demand for ethanol as oxygenate is rising.

For Tanzania the use of ethanol as octane enhancer and lead replacement in gasoline may be of particular importance. The country has signed an agreement reached in June 2001 at the Dakar Conference, Senegal, which obliges the countries of sub-Saharan Africa to launch national programmes to phase-out leaded gasoline by 2005. In order to reach this goal, an action plan demonstrating the benefits of leaded gasoline phase-out has been developed by the World Bank's Energy Sector Management Assistance Program (ESMAP) (ESMAP, 2003).

During this present study no clear outlines for a coherent strategy for the phase-out of leaded gasoline in Tanzania was brought to the attention of the authors by the involved Government departments and the Tanzania Association of Oil Marketing Companies (TAOMC). Therefore, the implementation of an ethanol programme in Tanzania seems to be an attractive option for addressing Tanzania's international obligation to eliminate lead in gasoline. Certainly, co-ordination of international leaded gasoline phase-out programmes with fuel ethanol programmes could provide large synergistic benefits.

The abovementioned benefits all constitute important drivers for the implementation of biofuels production and use in Tanzania. These benefits are acknowledged by Tanzanian policy-makers who are willing to move quickly ahead with the development of biofuels programmes.

Nevertheless, several crucial questions concerning the introduction of biofuels in Tanzania have not been satisfactory addressed and cause considerable concern among policy-makers:

- How do the benefits of biofuels compare with the costs?
- What will be the effects of diverting crops towards biofuels production on other markets (e.g. food)?
- Which policy measures should be pursued to maximise the benefits?
- Where should future research and development be focussed?

The establishment of a high-level Biofuels Task Force (see section 4.6.2.), which is one of the major recommendations of this study, will serve to identify solutions to these important questions and provide guidance to policy-makers for the development of successful biofuels programmes.

4.3 Lessons learnt from other biofuels programmes

The implementation of a biofuels programme in Tanzania can largely benefit from experiences made – and currently in progress – in other countries. This section briefly presents the biofuels programmes in Brazil, Zimbabwe and Malawi and summarize key lessons learnt for the implementation of biofuels programmes in developing countries.

Brazilian alcohol programme (ProAlcool)

The Brazilian ProAlcool programme, launched in 1975, remains the largest commercial application of biomass for energy production and use in the world. It involves co-operation between the Brazilian Government, farmers, alcohol producers and car manufacturers. It succeeded in demonstrating the technical feasibility of large-scale production of ethanol as a transport fuel, and its use in high-level blends as well as in dedicated ethanol vehicles. Prompted by the increase in oil prices, Brazil began to produce fuel ethanol from sugar cane in the 1970s. Production increased from 0.6 billion litres in 1975 to 11.6 billion litres in 2002, the highest production of fuel ethanol in the world.

For a detailed description of 'Biofuels for Transportation in Brazil' refer to the national biofuels study 'Brazil' commissioned to GTZ by the German Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL) in the framework of the current study 'Biofuels for Transportation – Potential and Implications for Sustainable Agriculture and Energy in the 21st Century'.

Here, only the following key results of ProAlcool are highlighted:

- Creation of 720,000 direct and 3.5 million indirect jobs (annual production of 350 million tons of sugar cane)
- Establishment of a strong sugar and ethanol sector
- Ethanol production (2002): 11.6 billion litres
- Production costs: 0.23 US$ cents per litre (i.e. 0.32 cents per gasoline equivalent)
- Hard currency savings (1975 to 2002): US$ 52.1 million *versus* Subsidies: US$ 4.92 billion
- 10% reduction of Brazil's total carbon emissions
- Reduction of CO, PM and SO_x emissions (e.g. São Paulo, Rio de Janeiro)

In the following, emphasis will be placed on the ***institutional conditions for the production and marketing of alcohol in Brazil*** (Martins, 1996), as the implementation details of the ProAlcool programme can provide guidelines for the development of biofuel programmes in other countries worldwide, especially in developing countries.

Apart from ProAlcool's main objective of reducing oil imports, other broad objectives of the programme were to protect the sugarcane plantation industry, to increase the utilization of domestic renewable-energy resources, to develop the alcohol capital goods sector and process technology for the production and utilization of industrial alcohols, and to achieve greater socio-economic and regional equality through the expansion of cultivable lands for alcohol production and the generation of employment.

Achievement of these objectives involved an intricate and politically difficult combination of technology and economic policy in the agricultural and industrial sectors. The Government established several support mechanisms: agreeing that the State-owned oil company, Petrobras, would purchase a guaranteed amount of ethanol; providing financial incentives such as low interest rates and $US 2.0 billion in loans to ethanol producers; establishing a price policy to ensure an effective remuneration to alcohol producers; encouraging consumers by selling ethanol at 60-80 per cent of the price of gasoline; public investment in agricultural research; and incentives for alcohol production and utilization technology as well as for private innovation and investment.

ProAlcool operating aspects - Production

In Brazil the production of fuel alcohol is an activity exclusively conducted by private initiative. Throughout the production process, from sugarcane planting to alcohol distillation, management of the business is the entrepreneur’s responsibility. However, since liquid fuels are a product of strategic interest, Governmental control is exercised through annual planning of the production to be compatible with the estimated alcohol demand for the year. The Alcohol and Sugar Department, Secretariat of Basic Products of the Ministry of Industry, Commerce and Tourism annually stipulates the amount of alcohol to be produced and made available. Distribution of the volumes between the producing units also is subject of Governmental approval. To this effect, factors such as the past record of each unit, the current plant capacities and the increase of planted sugarcane area as well as the improvements of agricultural and industrial efficiencies are taken into consideration for the elaboration of the annual ‘crop plan’.

ProAlcool operating aspects - Marketing

Although alcohol production in Brazil takes place only in the seven months coinciding with the sugarcane crop season, marketing of the product takes place throughout the year, thereby requiring the build-up of sufficient ethanol stocks. Sale of fuel alcohol is an activity restricted exclusively to producers, i.e. only producers are allowed to sell the alcohol to the distributing companies and to Petrobras. The Government, however, has the role of co-ordinating the process, aiming at ensuring both monthly sales according to the expected demand and equitable distribution thereof among producers. On the basis of the estimated monthly demand for fuel, an order is made for the volume of alcohol to be purchased by the distributing companies and Petrobras. The entire output of anhydrous ethanol (for blending) is sold to Petrobras, which resells it to the distributing companies at an invoiced price equal to that fixed for gasoline. Mixing of ethanol and gasoline is done by the distributing companies.

ProAlcool operating aspects – Price framework

Until recent years (with an oil price below 30 US$ per barrel), the price paid for ethanol by the consumers in Brazil was not enough to cover all costs of production, marketing and distribution. The fixed relationship between the prices of alcohol and gasoline (i.e. between 60-80%) was a fundamental aspect of the Brazilian alcohol programme and provided incentives for consumers in favour of ethanol. During most of ProAlcool’s history, the result of this fixed ratio was that alcohol needed to be subsidized. The difference between the procurement price from the producers and the price paid by the customers was covered through a system of cross-subsidies between petroleum products and alcohol. The prices of anhydrous and hydrated ethanol were fixed in relation to the price of petroleum products, not bearing any relationship with the purchase prices, which were derived from the actual costs of ethanol production.

This system of cross-subsidies worked well in the heavily regulated fuel market in Brazil as long as an administered price regime prevailed implemented through a state petroleum monopoly. The worldwide process of change towards a break-up of monopolies, the privatisation of companies and liberalisation of markets started late in Brazil. Only in 1995, the National Congress approved Constitutional Amendment No. 9 which regulated the break-up of the state petroleum monopoly.

In a free price regime, the financial viability of fuel alcohol may be guaranteed through differentiated taxation or selective taxes, or alternatively through ethanol production prices which are competitive with the price of gasoline on the world market. It has been reported (Lèbre La Rovere, 2004) that Brazilian alcohol is a competitive commodity with oil prices in excess of 30-35 US$ per barrel. Currently, with oil prices at 60-70 US$ per barrel – and forecasts pointing at future prices of more than 100 US$ per barrel – Brazilian ethanol constitutes a cheaper option for transport fuels with respect to its fossil competitors.

Pre-requisites for successful biofuels programmes

Based on the abovementioned institutional and regulatory experiences drawn from the Brazilian alcohol programme, the following pre-requisites for a successful biofuels programme in Tanzania can be summarised:

- Broad involvement and close co-operation between all stakeholders (Government Ministries, farmers, alcohol producers, oil marketing companies and car manufacturers), both for the elaboration and the implementation of the biofuels programme
- Establishment of long-term, stable and clear policies, regulations and incentives
- Legislation on mandatory blending (as one option to support the development of biofuels), starting with low blends (e.g. E10, B10) to avoid necessary vehicle changes
- Initial price guarantee for biofuels (e.g. through fixed prices by the Government) in order to secure return on investment in the biofuels sector
- Initial protection of local manufacturers against cheaper biofuels imports in order to facilitate the build-up of a strong national biofuels industry
- Establishment of revenue sharing mechanisms to ensure that small-scale farmers benefit from additional revenues generated through the production of biofuels

Ethanol programmes in Zimbabwe and Malawi

Malawi and Zimbabwe began looking at ethanol in the 1970's for the same reasons Brazil did, namely to address rising oil prices, save foreign exchange and develop a domestic resource (ESMAP, 2005). In both cases, public-private partnerships and market coordination (for blending, distribution and transportation) were critical to establishing the programmes. In both cases, ethanol distilleries were built adjacent to existing sugar factories, where the availability of molasses as feedstock could be assured and the price of ethanol was linked to that of gasoline, plus an incentive of about 5%.

Triangle Ltd. (Zimbabwe) began ethanol production in 1980. Domestic labor and local construction reduced construction cost by 60 percent compared with a turnkey plant. All key aspects of prices, distribution, marketing, and related infrastructure had been finalized before the plant was built. The targeted blending ratios established through the national oil company were 8-13 percent. Annual production during the 1980s ranged from 30 to 40 million litres. A drought in 1991-93 resulted in almost no sugarcane production and thus almost no ethanol production, due to unavailability of molasses. After the drought, attempts to settle the arrangements to begin blending again were unsuccessful. Triangle needed to optimise sugar production for financial reasons, resulting in less molasses and less ethanol, and the national oil company was reluctant to blend at a lower scale. At the same time, structural adjustment programs and tax incentives in Zimbabwe were encouraging exports, and Triangle found international buyers for potable alcohol (for spirits and liquor), which generally commands a price premium. Consequently, even though Triangle is again producing 30 million litres of ethanol per year, it is mainly sold on the potable market and is no longer blended with gasoline.

ETHCO Ltd. (Ethanol company of Malawi) has operated since 1982, with annual production reaching 15-20 million litres and blends ranging from 15 to 22 percent. Since irrigation water is available from Lake Malawi, ETHCO is not susceptible to the climate-induced interruptions that affected Triangle. But the company has faced some difficulties in molasses supply. Unlike Triangle (where ownership of ethanol plant and sugar factory is unified), ETHCO is owned separately from the adjacent Dwangwa sugar factory, resulting in the need for price negotiations, additional costs, and increased uncertainty in feedstock supply. This factor, along with spare plant capacity and the desire to maintain blending targets, prompted ETHCO to secure additional molasses supply (as much as 40 percent) from the Sucoma sugar factory, located several hundred kilometers to the south. Use of diesel trucks to transport molasses from Sucoma reduces the otherwise positive environmental and economic benefits of ethanol substitution. Recently, this problem has been solved by the construction of a second distillery in Malawi by the company PressCane adjacent to the Sucoma sugar factory.

Key Lessons for Developing Countries

A comparison of the two ethanol programmes in Malawi and Zimbabwe reveals the following key lessons for developing countries looking at the biofuels option for their transport sector:

1. Public-private coordination among oil companies, government and biofuels entrepreneurs is critical to establishing and sustaining biofuels programs
2. Feedstock availability must be assessed including long-term climatic and market conditions
3. Consistency in Government policies and support
4. Careful planning of inputs (e.g. molasses) and waste streams (e.g. stillage) is needed for overall economic and environmental benefits

4.4 Biofuels implementation opportunities for Tanzania

During the last years Tanzania has experienced growing interest from both industry and NGO's in sugarcane and oil seed crop cultivation for biofuels production. This fact was highlighted by the strong participation of stakeholders in the expert workshop and policy discussion organised in the framework of the present study on 28 September 2005 in Dar es Salaam. Most of these stakeholders have already established individual contacts with Government Ministries, such as the Ministry of Energy and Minerals and the Ministry of Agriculture and Food Security in order to secure institutional support for their activities. Until today, these contacts are established on a case-by-case basis and a coherent overall strategy is lacking. It was one of the aims of the expert workshop to provide a linkage for activities in the field of biofuels in order to work towards coherent policy development.

Roughly, the current biofuels activities and opportunities in Tanzania can be divided into large-scale and small-scale approaches. Thereby, large-scale biofuels production, such as the production of ethanol from sugarcane promoted by the sugar industry as well as the activities of companies such as D1 Oils in the plant oil sector, will have a prime focus on biofuels for transportation and will require supportive policies and regulations in place for start-up in order to secure the rather large investment.

On the other hand, smaller-scale activities by organisations such as FELISA and KAKUTE are currently mainly concerned with the creation of rural income and revenue opportunities from oil seed crops, either through the production of plant oils (for food and/or fuel) or other commodities such as soap production from jatropha oil. The production of biofuels for transportation in these cases may (or may not) be an objective for the up-scaling of current activities.

Large-scale ethanol production from sugarcane

Representatives from three out of the four existing large sugar factories in Tanzania (Kilombero Sugar Company, Mtibwa Sugar Estates, Kagera Sugar Limited) as well as from the Tanzanian Sugar Board were present at the expert workshop in Dar es Salaam. They confirmed the large interest of the Tanzanian sugar sector to get involved in the production of ethanol as transport fuel in order to diversify their income opportunities. Furthermore, the sugar producers have already conducted internal feasibility studies for ethanol production, which may serve to quickly proceed to the ethanol production implementation stage.

Nevertheless, it was clearly stated by the stakeholders of the sugar sector, that the development of clear, stable and supportive policies and regulations are an essential pre-requisite for them to engage in investment. Among the policies proposed were a mandatory blending of gasoline with ethanol in Tanzania (e.g. E10) as well as initial price guarantees for ethanol and an initial protection of local ethanol producers against cheap imports in order to secure return of investment.

As a main outcome of this study it can be stated that a 10% blend of ethanol with gasoline seems feasible until the year 2010 based on the production of ethanol from C-molasses only. But, in order to enact a mandatory E10 blend the Tanzanian Government will require detailed information from the sugar industry about the projected ethanol production costs in order to estimate the costs of such a biofuels programme in Tanzania. Again, it is envisaged that the proposed high-level Biofuels Task Force will serve to provide information to the Government necessary for the development of successful biofuels programmes.

Finally, for the implementation of large-scale ethanol production in Tanzania a suitable revenue sharing mechanism has to be established which ensures that small-scale farmers (e.g. sugarcane outgrowers) get their fair share from the additional revenues generated through the production of biofuels.

Large-scale bio-oil/biodiesel production

D1 Oils, a UK company based in Newcastle, is engaged in the worldwide large-scale production of biodiesel from plant oil seeds with special focus on jatropha. Thereby, D1 Oils will be importing to the UK vegetable oils from developing countries for refining into biodiesel. D1 has made South Africa the headquarters for all African operations and it has established the subsidiary D1 Oils Tanzania Limited.

Contacts with D1 Oils Tanzania could not be established in the framework of the present study and currently their level of involvement in Tanzania remains unclear. Furthermore, the business concept of D1 Oils holds the danger that most of the revenues from the biodiesel production from Tanzanian raw material will be generated outside of the country and a suitable revenue sharing mechanism has to be put in place.

A further company engaged in the initial stages of large-scale biofuels production in Tanzania is Diligent Energy Systems, a Dutch Eindhoven-based company marketing fuels of biological origin in the Netherlands. A representative of the recently established Diligent Tanzania Limited was present at the expert workshop, but did not reveal any details of the company's current level of engagement. On 29 August 2005 an article was published in the Tanzanian Daily News quoting a representative of Diligent that they are optimistic to increase jatropha production in Tanzania to 10,000 ha in two years time and to produce 1.5 million litres of biodiesel (in a factory to be constructed in Arusha) that would be exported to European markets. For this large-scale biodiesel activity similar concerns hold true as in the case of D1 Oils stated above.

Small-scale bio-oil/biodiesel production

Representatives from several stakeholders engaged in smaller-scale plantation of oil seed crops, including representatives from KAKUTE and FELISA, were present at the expert workshop in Dar es Salaam.

Since 2000 KAKUTE Limited is involved in pilot projects focussing on the production, processing and use of jatropha in North Eastern Tanzania. The projects ARI-Monduli (Alternative Resources of Income for Monduli women) and ARI-Arumeru are financed by the American McKnight Foundation and executed in close cooperation with Heifer International Foundation. The objectives of these projects include erosion control and natural resource management, promotion of economic activities for women, poverty reduction and the creation of rural industries as well as the provision of renewable household energy for rural communities.

Economic activities within KAKUTE's projects comprise oil and seedcake production for household energy, soap making for income generation and (potentially) biodiesel production for off-grid electrification (and transport). Currently, the largest profit from jatropha plantations can be realised through the production of soap. Jatropha oil in North Eastern Tanzania (Arusha, Engaruka) is traded in small quantities for 2 US$ per litre, which is a too high price for the economically viable production of biodiesel from Jatropha oil (Henning, 2004). Whether economies of scale and larger production quantities of jatropha oil in Tanzania will sufficiently reduce the price still has to be investigated.

Until today KAKUTE has succeeded in promoting the 'jatropha system' in Tanzania and in increasing the demand for jatropha seeds and its products. Currently, an insufficient jatropha seed supply for the commercial market is experienced and further resources are required to expand jatropha activities to larger areas and other regions of Tanzania (e.g. Mwanza). Thus, KAKUTE is looking for co-operation opportunities with (international) investors in order to up-scale jatropha activities in Tanzania.

The newly established company FELISA (Farming for Energy for Sustainable Livelihoods) Limited focuses on the promotion of biofuels production and marketing in Tanzania with the aim of developing rural areas through job creation and improved energy security. FELISA fosters partnership with other entrepreneurs, smallholder farmers and Government Ministries for the production of palm oil, biodiesel and by-products. FELISA's activities will focus on the Kigoma region (Western Tanzania) where palm oil is a common food and cash crop. In order to start business activities FELISA will engage in increasing the current yields of palm oil plantations in co-operation with local palm oil farmers, initially for the production of straight palm oil either as food oil or as fuel. The potential for biodiesel production from palm oil in Tanzania will be assessed by operating a pilot biodiesel reactor, and in a second project phase production of biodiesel as transport fuel is envisaged.

FELISA has developed a detailed business plan for its palm oil activities and is highly interested in establishing co-operations with (international) investors. In order to seek institutional support, contacts have already been established with the Tanzanian Ministry of Energy and Minerals and the Ministry of Agriculture and Food Security.

In the view of the authors of present study, the biofuels development in Tanzania will be characterised by two different schemes, namely the large-scale dedicated production of ethanol and biodiesel (plant oil) with the sugar sector and international investors as the main drivers, as well as a smaller-scale development of oil seed plantations (e.g. palm, jatropha) focussing on rural development through the production of a variety of commodities including biofuels for transport. In both cases, the export of biofuels (ethanol, biodiesel or plant oil) to international market may be a viable option to secure investment.

4.5 German-Tanzanian collaboration opportunities

Currently, co-operation links between German and Tanzanian organisations in the field of biofuels production are limited to a small number of activities. The following section presents on-going and prospected activities and the German organisations involved.

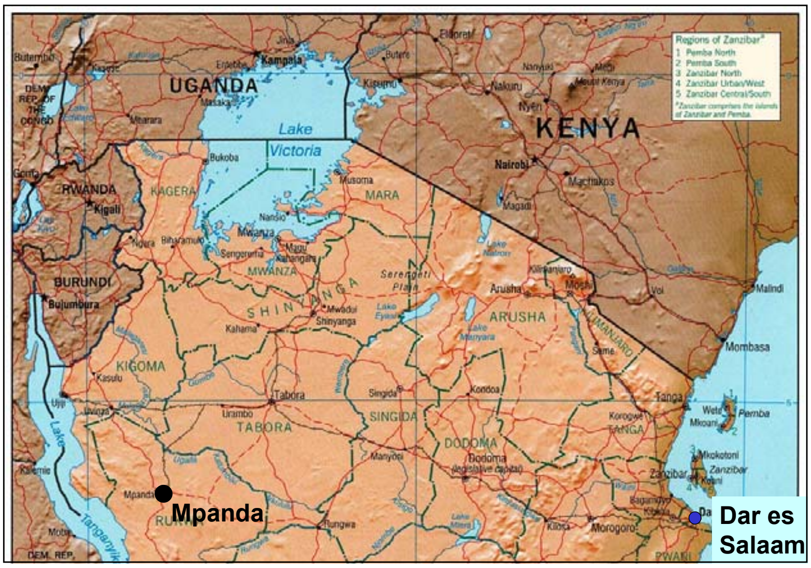
PROKON Kapital GmbH

PROKON was founded in 1995 and its main business activity is the planning and financing of wind energy projects in Germany. Currently, PROKON is running 25 wind farms with 162 wind turbines with a capacity of more than 250 MW and a total investment involved of 300 million EURO.

Since 2001 PROKON is also working is the biofuels sector which presently shows the potential of fast economic growth worldwide. In 2005, the company's turnover from the biofuels sector is expected to be about 8 million EURO. PROKON's focus thereby is on pure vegetable (plant) oil, as it is cheaper than biodiesel due to the additional process step involved in the production of biodiesel from plant oil. The company's main activity in the field is to adapt diesel (truck) engines to be able to run with plant oil. Additionally, PROKON operates an own oil mill to supply the fuels for the adapted truck engines. Up to date 600 truck engines have been successfully adapted with a further 1500 on order. As the capacity of the oil mill has already been reached, the company is looking for additional fuel sources, potentially through the import of plant oil.

PROKON's activities in Tanzania were triggered by the company's social engagement and (by chance) through the personal contact of an employee with a small German NGO promoting a secondary school project in Mpanda (see map below). Contacts were established and after intensive research it was decided to start the cultivation of jatropha in the Mpanda region. Jatropha seeds received from the company KAKUTE in Arusha were provided to about 300 farmers who agreed to co-operate with PROKON. Farmers were motivated by the fact that PROKON confirmed to buy all produced jatropha oil at prices comparable to the current world market price of other plant oils, thereby ensuring market and (additional) income for the farmers in Mpanda.

The Mpanda region is very suitable for this activity for the following reasons. The farmers in Mpanda have sufficient suitable land and (in the absence of local markets) are looking for cash crops with secure income for the coming years. Thus, there is no competition with food production in the Mpanda region. From the infrastructure perspective, Mpanda is connected to the railway line to Dar es Salaam, and there is an oil mill with spare capacity in operation.



In the view of PROKON, this activity in Tanzania has a great potential, as the production of biofuels will gain increasing economic importance due to the high and growing crude oil prices. PROKON is able and willing to create a market for the full quantity of the produced plant oil, thereby providing an alternative income for farmers. The necessary experience in the cultivation of jatropha is secured through the involvement of the Tanzanian organisation KAKUTE. Additionally, PROKON is prepared to adapt engines to run with plant oil in Tanzania and to build a new oil mill in case the capacity limit of the existing mill is reached.

In case of success of the jatropha based biofuels activity of PROKON in Tanzania, the following next steps are envisaged:

- Co-operation with the Tanzanian energy utility TANESCO in order to adapt an existing diesel electricity generator to run with jatropha oil. PROKON would adapt the generator free of charge and supply the plant oil for a price below the current price of diesel.
- Modify the German technology for the adaptation of trucks to Tanzanian standards
- Establish a local market for jatropha oil as well as export oil to Germany
- Increase the cultivation of jatropha in Mpanda region and spread the concept to other areas in Tanzania

On the occasion of the expert workshop in Dar es Salaam, the presentation by Mr. Lorenz Kirchner, PROKON Sales Manager, stimulated large interest among the Tanzanian participants. Several organisations have already expressed their interest to co-operate with PROKON in order to spread the business concept to other regions in Tanzania. Additionally, Mr. Kirchner has established high-level Governmental contacts which may provide institutional support for PROKON's activities in Tanzania.

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bagani gbr

Bagani, founded in 1997, is focussing on consultation services on the production and use of plant oil as fuel as an integrated approach for rural development. Mr. Reinhard Henning, founder of bagani and renowned expert in the field of jatropha cultivation and use, has established close working contacts with the Tanzanian organisation KAKUTE and supports its activities on the 'jatropha system' in Tanzania. Additionally, Mr. Henning is responsible for the KAKUTE web page www.jatropha.de/tanzania and has recently published the study 'Jatropha curcas L. in Africa' (Henning, 2004) commissioned by the Global Facilitation Unit for Underutilised Species.

Currently, Mr. Henning is engaged in performing a feasibility study for jatropha cultivation in Madagascar. This project in Madagascar will be implemented in co-operation with KAKUTE (for the supply of jatropha seeds) and PROKON (for the potential application of jatropha oil in adapted engines). A possible use for jatropha oil in Madagascar investigated in the framework of this project is the operation of diesel generators for the electricity supply of hospitals.

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Energiebau Solarstromsysteme Gmbh

Since 1983 Energiebau Solarstromsysteme has been offering photovoltaic systems and it is today one of the most experienced suppliers in the German market. Energiebau has business partners in whole Germany and in the neighbouring European countries. On the African continent Energiebau realises projects for rural electrification.

Energiebau favours stationary applications of plant oil engines in Africa to using biofuels for transport. Their generators for large-scale loads for rural electricity supply can be powered by diesel and plant oil. Trained experts are available in Mali, Ghana, Tanzania and Madagascar for installing and maintaining systems. In order to test engine performance, 1000 litres of jatropha oil have been bought from KAKUTE and engine tests are currently under way.

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Opportunities for co-operation

As underlined by the PROKON project, German-Tanzanian co-operation activities in the field of biofuels are unlikely to be limited by the availability of suitable land and human resources. What is required is a clear business concept ensuring the market, and thereby the income revenue for the local farmers involved.

This situation may change as soon as the Tanzanian Government has put in place long-term and stable policies and regulations promoting the development of biofuels and stimulating the creation of strong national markets for biofuels.

It is important for German companies interested in business activities in Tanzania to establish good co-operation links with Tanzanian organisations active in the field of biofuels, which are familiar with the local social and economic framework conditions.

Finally, several Tanzanian organisations have already expressed their interest on the occasion of the expert workshop in Dar es Salaam to co-operate with (German) investors in the field of biofuels. Among the interested organisations are Quality Food Products Ltd. from Arusha operating an crushing facility for various oilseeds and the NGO ENVIROCARE working towards wealth creation and environment protection together with farmer groups in Kilimanjaro, Tanga and the Coastal region.

In conclusion it can be stated, that certainly the production and use of biofuels in Tanzania has the potential to offer large opportunities for investors. For the time being, these opportunities have to be carefully identified on a case-by-case basis (in close co-operation with local partners), until the Tanzanian Government has committed itself to actively promote the national biofuels sector development and biofuels market.

4.6 Recommendations for biofuels introduction in Tanzania

The following section provides an overview of potential policies which could be adopted by the Tanzanian Government to stimulate the development of biofuels in the country. Details on the proposed establishment of a high-level Tanzanian Biofuels Task Force are presented, which shall provide advice and recommendations for the elaboration of biofuels policies and regulations. Furthermore, an outline of the proposed Tanzania BioFuels Producers Association is presented which shall be established as one of the main stakeholders of the Biofuels Task Force.

Finally, a list of concrete recommendations for action for the Tanzanian Government is presented which was a main outcome of the expert workshop and policy discussion organised in the framework of the present study on 28 September 2005 in Dar es Salaam.

4.6.1 Overview on policies to promote increased use of biofuels

Despite the currently very high world market prices of crude oil of 60-70 US$ per barrel, the development of a strong biofuels sector in Tanzania will initially require supportive policy pressure. Since many countries are still considering how best to promote biofuels, this section discusses a variety of traditional and non-traditional policy approaches (IEA, 2005).

Fuel Tax Incentives

Typically, the most daunting aspect to the use of biofuels (e.g. for refineries, as an octane enhancer) is the purchase price. Fuel tax incentives can therefore be a very effective tool for encouraging the use of biofuels, making them more price-competitive with petroleum fuels (and with competing octane enhancers, oxygenates, etc.). These incentives can be especially effective during the early years of fuel market development, if costs are expected to come down as the scale and experience of biofuels production increases (i.e. Brazil). Since fuel excise taxes comprise a significant percentage of the price consumers pay for motor fuels in Tanzania, exempting alternative fuels from a portion of this tax burden is an available and powerful tool for ‘levelling the playing field’. This incentive also sends a clear signal to consumers regarding the relative social costs of different fuels. If the externalities associated with the use of biofuels are lower than those of petroleum fuels, a lower tax on biofuels is economic.

One common concern about setting a lower tax for biofuels (and other alternative fuels), however, is that it will reduce Government revenue. This can be avoided by adjusting the taxes on all fuels so that total revenues are maintained. Tax rates would have to be modified periodically to adjust to changes in demand for each fuel. But it is often difficult for legislatures to frequently change tax rates.

Fuel tax incentives are a viable option for promotion biofuels in Tanzania and tax incentives have been proposed and requested by several stakeholders from the sugar and plant oil sector. On the other hand, representatives of the Government have voices their concern of reduced revenues, which in Tanzania depend at a significant share on revenues from fuel taxes. Therefore, an adjustment of all fuel taxes to maintain the revenue may be a promising policy choice.

Carbon-based Fuel Taxes

Carbon taxes are fuel taxes based on the carbon content of the fuel. Carbon taxes make sense economically and environmentally because they tax the externality (carbon) directly. They can be an effective stimulant for alternative fuels (and alternative-fuel vehicles) in cases where lower emissions result in a significantly lower levied tax rate. However, while carbon-based fuel taxation is relatively straightforward, for biofuels to appear attractive it would be necessary to develop a scheme that takes into account well-to-wheel emissions, not just tailpipe emissions. This is a complex undertaking, because the scheme would vary considerably depending on how biofuels (and other fuels) are produced.

As well-to-wheels emissions have not been assessed for biofuels production on Tanzania, this policy option seems to be of limited immediate importance. Nevertheless, the implementation of a detailed well-to-wheel emission is strongly encouraged for Tanzanian biofuels production, as it will also be a pre-requisite for the exploitation of CO_2 trading and Clean Development Mechanism (CDM).

Vehicle Taxes and Subsidies

In addition to fuel-rated incentives, fuel consumption can be affected by policies which encourage the purchase of vehicles running on certain types of fuel, or running on fuels that emit less CO_2. Denmark, the Netherlands and the UK have recently introduced new vehicle tax rates based at least in part on CO_2 However, this approach provides little incentive to use biofuels since they have little effect on vehicle emissions of CO_2. The scheme would have to take into account upstream CO_2 for biofuels to receive a tax break.

CO_2 Trading

Under an emissions trading system, the quantity of emissions allowed by various emitters is ‘capped’ and the right to emit becomes a tradable commodity, typically with permits to emit a given amount. To be in compliance, those participating in the system must hold a number of permits greater or equal to their actual emissions level. Once permits are allocated (by auction, sale or free allocation), they are then tradable.

A well-functioning emissions trading system allows emissions reductions to take place wherever abatement costs are lowest, potentially even across international borders. Since climate change is global in nature and the effects (e.g. coastal flooding, increasing incidence of violent storms, crop loss, etc.) have no correlation with the origin of carbon emissions, the rationale for this policy approach is clear. If emissions reductions are cheaper to make in one country than another, emissions should be reduced first in the country where costs are lower.

Emissions trading systems could include biofuels and create an incentive to invest in biofuels production and blending with petroleum fuels (e.g. by oil companies) in order to lower the emissions per litre associated with transport fuels, and reduce the number of permits required to produce and sell such fuel. However, as for tax system, the full well-to-wheel GHG must be taken into account.

Clean Development Mechanism (CDM)

Under the Kyoto Protocol, countries can engage in projects through which an entity in one country partially meets its domestic commitment to reduce GHG levels by financing and supporting the development of a project in another country. CDM projects are between an industrialised and a developing country. One country provides the other with project financing and technology, while receiving CO_2 reduction credits that can be used in meeting its emissions reduction commitments. A major requirement for CDM projects is that they also have to further the sustainable development goals of the host country. In addition, CDM projects must involve activities that would not otherwise have occurred, and should result in real and measurable emissions reductions. The two most common types of the projects tend to be land use and energy – which demonstrate potentials for biofuels (i.e. crops planted in exchange for energy related vehicle emissions reductions). For this reason, there is an increasing awareness of the opportunities for producing biofuels from community-scale plantations in developing countries.

Despite this promising tool for stimulating biofuels production and use, there are several reasons why only recently the first GHG emissions reduction projects involving biofuels and transportation have emerged. One is the limited experience and methodologies for estimating, monitoring, and certifying potential well-to-wheel emissions reductions from transport projects. This is changing quickly, with the proliferation of well-to-wheel GHG assessments, though there still are very few studies for non-IEA countries.

A related reason is the lack of a commonly agreed CDM methodology and data for estimation of emissions baselines for this type of project. In general, a fuel-switching project should not pose particularly difficult baseline-measurement issues, but, as mentioned, tracking the emissions from all upstream fuel production-related activities is difficult, and any required change to vehicles complicates matters somewhat. However, several recent CDM projects have been approved that focus on biomass-to-electricity generation, and an extension of this methodology to biofuels production (or co-production with electricity) should be possible.

As for all sectors, projects will not have value until a market develops where emissions reduction credits have a tradable value. If costs per tonne of GHG reduction can be brought down well below $50, as appears to be occurring in Brazil, this will certainly make biofuels projects more attractive.

As mentioned above, detailed well-to-wheel emission as well as baseline measurements for Tanzanian biofuels production will be necessary to exploit the opportunities for CO_2 trading and Clean Development Mechanism (CDM). In this field, Tanzania can certainly benefit from the on-going activities worldwide to develop suitable methodologies for the implementation of CDM projects.

Fuel Standards (Blending Mandates)

Governments can also implement fuel standards as a mechanism for altering the transport sector fuel mix. By implementing a standard for minimum fuel content of non-petroleum (or renewable) fuel, governments can use regulation to drive the market. This approach has the advantage of clearly defining the market share reserved for specific types of fuels, such as biofuels. It creates a stable environment to promote fuel production and market development. A disadvantage of this approach is that costs are uncapped, i.e. fuel providers must comply regardless of costs.

The introduction of a blending mandate (e.g. E10, B20) for blending ethanol with gasoline and biodiesel with diesel is one of the options for the introduction of biofuels in Tanzania as it supports the development of strong markets and will have the potential to attract international investors to invest in biofuels production, marketing and use in Tanzania. In order to implement a blending mandate the Tanzanian Government needs a detailed estimate of the biofuels production costs in order to assess the overall (additional) costs of biofuels for the country.

Incentives for Investment into Biofuels Production Facilities

Apart from fuel-related incentives, an important barrier to the development of a market for biofuels is the required investment in commercial scale production facilities. Fuel providers have little incentive to make large investments in these facilities in the current uncertain market. Even if governments put into place fuel incentives that generate demand for the fuel, investors will be wary that such policies can change at any time. In order to encourage the necessary investment, governments may consider certain investment incentives such as investment tax credits or loan guarantees.

At the expert workshop in Dar es Salaam several potential biofuels producers voiced their concern that fixed price guarantees for biofuels are required in the initial stages of market development to serve as incentive for investment and secure return on investment.

Additionally, tax free debt bonds for biofuels production equipment and low interest rate loans to biofuels producers may be a viable option for promotion biofuels in Tanzania.

Trade Policy to Remove Barriers to International Biofuels Trade

Given the wide range of biofuels production costs worldwide and the wide range in the production potential for biofuels in different countries, there appears to be substantial potential benefits from international trade in biofuels.

Failing specific rules, biofuels are generally subject to customs, duties and taxes without any particular limits. These tariffs vary substantially from one country to the other. The ethanol market in several developed countries is strongly protected by high tariffs. However, ethanol is included in a list of environmental products for which accelerated dismantling of trade barriers is sought, so there are some prospects for the eventual elimination of these tariffs.

For Tanzania, an initial protection of local manufacturers (e.g. through import duties) against cheaper imports will most probably be necessary in order to enable the build-up of a strong national biofuels industry. This is the strategy taken by most of the developing countries and shall also be the option of choice for Tanzania. After a stable biofuels market is established, and given the potentially low production costs of biofuels can be realised, Tanzania may look into the opportunities for large-scale biofuels export in a later phase of its biofuels programme.

Vehicle Requirements for Compatibility

A non-traditional policy tool available to governments could be the introduction of vehicle technology standards that require compatibility with specific mixtures of biofuels. Brazil has essentially done this through a fuel standard, requiring all gasoline to be blended with 22% to 26% ethanol. This has forced manufacturers to ensure that their vehicles are compatible with these blends. In the US, and now in Brazil, several manufacturers have introduced flexible fuel capability in a number of vehicle models. Such vehicles can run on low or high-level ethanol blends, and the conversion cost (estimated at no more than a few hundred dollars per vehicle) is included in the vehicle price.

Given the framework conditions in Tanzania, it is recommended to start with low blends of biofuels in conventional fuels (e.g. E10, B20) in order to avoid necessary changes in the vehicle fleet. The large-scale introduction of flexible fuel vehicles into the Tanzanian market will certainly be an issue of the future, after these cars have significantly penetrated the market in the US, Brazil and Europe.

4.6.2 Establishment of a Tanzanian Biofuels Task Force

The Tanzanian Government is well aware of the variety of benefits offered by the introduction of biofuels for transport applications as outlined in section 4.2. and it is seriously assessing the different options for the development of policies and strategies for an increased use of biofuels.

Activities towards an implementation of biofuels policies are currently mainly driven by the Tanzanian Ministry of Energy and Minerals (MoE). At the expert workshop and policy discussion in Dar es Salaam the representatives of the MoE strongly supported the proposed establishment of a high-level Tanzanian Biofuels Task Force which can provide advice and recommendations for the elaboration of biofuels policies and regulations suitable for the Tanzanian framework conditions.

Among the objectives of this Task Force will be to ensure close co-operation between the different Government Ministries involved in the development of biofuels policies, as well as to provide an information channel between Government and biofuels stakeholders from industry, farmers associations, NGOs and civil society.

Consultations between Government representatives and biofuel stakeholders will for instance help to address several important issues, such as the comparison of economic, environmental and social benefits (e.g. employment generated, rural development, FOREX saved) and costs (e.g. reduces tax revenues) of biofuels programmes in Tanzania, and the potential effects of diverting crops towards biofuels production on other markets (e.g. food markets).

The Biofuels Task Force will be a body independent of, but with strong co-operation links to the Tanzanian Government. The administrative structure will consist of a ***Task Force Secretariat***, the ***Chairman of the Task Force*** and the ***Task Force Members***. It is recommended, that the Biofuels Task Force is convened by the Ministry of Energy and Minerals as soon as possible.

Task Force Secretariat

The Task Force Secretariat will be established independently from the Tanzanian Government. The secretariat will be responsible for the day-to-day work of the Task Force and will provide administrative support to the Chairman and the Task Force Members.

It is recommended to establish the Task Force Secretariat at a Tanzanian organisation with sufficient capacity and expertise in the field of biofuels including strong links with international players active in the field of biofuels.

Task Force Chairman

The Task Force Chairman will be independent from the Tanzanian Government and act as the main driver of the Task Force activities. Therefore, the selection of the Chairman is of crucial importance for the effectiveness of the Task Force. Specifically, the Chairmen should have close links both with different Government Ministries and with the major stakeholder involved in the biofuels sector in Tanzania.

Task Force Members

The Task Force will include representatives from the Tanzanian Ministries involved in the elaboration of biofuels policies and regulations. Additionally, the Task Force will include major stakeholders from the oil marketing industry, car industry, sugar industry, biofuels producers as well as NGOs and other stakeholders engaged in rural development. Finally, a Tanzania Biofuels Producers Association shall be established (see section 4.6.3.) acting as one of the important stakeholders of the Biofuels Task Force.

In the following a non-exclusive list of potential Task Force Members is presented:

Government Bodies:

- Ministry of Energy and Minerals (MEM) (Lead actor)
- Ministry of Agriculture and Food Security (MAFS)
- Ministry of Transport and Communication (MTC)
- Ministry of Industries and Trade (MIT)
- Vice President Office (VPO)
- National Environment Management Council (NEMC)
- Planning and Privatisation Commission PPC
- Ministry of Regional Administration and Local Governments
- Ministry of Finance (MoF)
- Tanzania Revenue Authority (TRA)

Associations and Utilities

- Energy and Water Utility Regulatory Authority (EWURA)
- Tanzania Petroleum Development Cooperation (TPDC)
- Tanzania Association of Oil Marketing Companies (TAOMC)
- Sugar Board of Tanzania
- Tanzania Sugarcane Growers Association (TASGA)

Biofuels producers and other stakeholders

- Kilombero Sugar Company
- Mtibwa Sugar Estates
- Kagera Sugar Limited
- KAKUTE
- FELISA
- Diligent Tanzania
- TaTEDO

Financial support for the establishment of the Biofuels Task Force can be pursued through international facilitation options, such as the Partnership Dialogue Facility (PDF) of the European Union Energy Initiative, the International Energy Agency, the International Bioenergy Programme of the Food and Agriculture Organisation of the United Nations (FAO) and the Global Bioenergy Partnership launched by the G8 at their 2005 Summit in Gleneagles (UK).

4.6.3 Establishment of a Tanzania Biofuels Producer Association

In addition to the Biofuels Task Force the participants of the expert workshop in Dar es Salaam recommended to set-up a Biofuels Producer Association in order to lend a strong voice to all actors which are or plan to get involved in the production, marketing and use of biofuels in Tanzania. This association shall also be acting as one of the important stakeholders of the Biofuels Task Force.

The following potential members of the Tanzania Biofuels Producer Association have been drawn from the participants list of the expert workshop in Dar es Salaam:

- Tanzania Forest Conservation Group (TFCG)
- Tanzania Sugarcane Growers Association (TASGA)
- Sugar Board of Tanzania
- Kilombero Sugar Company
- Mtibwa Sugar Estates
- Kagera Sugar Limited
- Tanganyika Planting Company
- Kilimanjaro Development Forum
- KAKUTE
- FELISA
- Diligent Tanzania
- Tanzania Commission for Science and Technology (COSTECH)
- Tanzania Specialist Organisation on Community Natural Resource and Biodiversity Conservation (TASONABI)
- Biofuel for Africa
- Environmental, Human Rights Care and Gender Organisation (ENVIROCARE)
- Coastal Flowers Ltd.
- Quality Food Products Ltd.
- TaTEDO

Financial support for the elaboration of the TOR (Terms of Reference) and the establishment of the Tanzania Biofuels Producer Association can be pursued through international facilitation options.

4.6.4 Recommendations for action

To conclude section 4 of this study on recommendations for decision-makers in Government and industry, the following list of concrete recommendations for action for the Tanzanian Government were elaborated as a follow-up of the expert workshop and policy discussion organised in the framework of the present study on 28 September 2005 in Dar es Salaam.

Recommendations for action in Tanzania

1. **Establish a high-level Biofuels Task Force (see section 4.6.2)**

   The aim of this Task Force is to provide advice and recommendations to the Government for the elaboration of biofuels policies and regulations suitable for the Tanzanian framework conditions (e.g. mandate, obligation, tax breaks, enabling fuel standards). This Task Force will ensure close co-operation between the different Government Ministries involved in the development of biofuels policies, as well as provide an information channel between Government and biofuels stakeholders from industry, farmers associations, NGOs and civil society.

2. **Establish a Tanzanian Biofuels Producer Association (see section 4.6.3)**

   The Biofuels Producer Association will give a strong voice to all actors which are or plan to get involved in the production, marketing and use of biofuels in Tanzania. This association shall also be acting as one of the important stakeholders of the Biofuels Task Force.

3. **Start immediate Government Action to promote increased use of biofuels**

   In order to quickly proceed with the introduction of biofuels in Tanzania, the Government should take immediate action to enter the learning-by-doing process – and not wait for results and policy advice from the Task Force.

   a. Establish biofuels demonstration facilities; 1 large-scale ethanol and 1 large-scale biodiesel (or Pure Vegetable Oil) production facility with scales of more than 10.000 tons per year of biofuel output

   b. Establish a production/user group for small-scale biodiesel (or PVO) production for transport fuel and bio-electricity production

   c. Encourage the sales of flex-fuel vehicles and companies which modify diesel vehicles to run on Pure Vegetable Oils; investigations may be required on the relative benefits of esterified bio-oils and PVO for mineral diesel replacement

   d. Investigate the option of using ethanol blends in gasoline as lead replacement in order to comply with Tanzania's obligation to phase-out leaded gasoline by 2005

   e. Encourage financing options (e.g. capital allowances, tax breaks) and set-up incentives for (local and foreign) investors; consider revenue neutral options including additional taxes on fossil fuels to cover implementation costs of biofuels

   f. Evaluate assurance as a practical method for ensuring the sustainable development and use of biofuels and to quantify the national impact of their use

4. **Assess the role of Government in promoting biofuels**

   The Tanzanian Government needs to consider carefully its role in promoting biofuels, i.e. what should be internal Government activities and what should be carried out by the private sector, NGOs and local Governments.

5. **Pursue international facilitation options**

   The Tanzanian Government should pursue international facilitation options, such as the Partnership Dialogue Facility (PDF) of the European Union Energy Initiative, the International Energy Agency, the International Bioenergy Programme of the Food and Agriculture Organisation of the United Nations (FAO). These international institutions have the mandate to assist with the development of biofuels through (for example) Kyoto and G8 (Global Bioenergy Partnership).

6. **Establish co-operation with other African Governments**

   For example, the Tanzanian Ministry of Energy and Minerals should get in contact with their Zambian counterparts to ensure regional co-operation on the development of the Biofuels Task Force and relevant policy instruments.

7. **Integrate actions of the Biofuels Task Force with the Tanzanian Renewable Energy Agency and the Tanzanian Investment Centre**

   Effective cross-departmental actions on biofuels (and bioenergy) need to be ensured through careful considerations on how to integrate activities of the Biofuels Task Force with the Tanzanian Renewable Energy Agency and the Tanzanian Investment Centre.

8. **Promote applied research and development**

   Continued, applied research and development will be required and local and international academic institutions and private sector research organisations should be encouraged to collaborate on research and development in this critical emerging sector.

9. **Promote awareness raising activities**

   In order to provide solid grounds for the development of a biofuels sector in Tanzania, the population has to be informed about the significant benefits and opportunities offered by biofuels as alternative transport fuel.

The above list of recommendations for action identifies first steps to be taken as soon as possible in order to exploit the opportunities offered through the development of a biofuels sector for the production of alternative transport fuels in Tanzania.

4.7 References

DSD, 2005, Feasibilty study on an effective and sustainable bio-ethanol production program by Least Developed Countries as alternative to cane sugar export, Dutch Sustainable Development Group (DSD), in commission of Ministry of Agriculture, Nature and Food Quality, May 2005, http://www.swilion.com/DSD%20Rapport.pdf

ESMAP, 2003, Phase-out of Leaded Gasoline in Oil Importing Countries of Sub-Saharan Africa, The Case of Tanzania – Action Plan, Clean Air Initiative Working Paper Number 14, ESMAP (Joint World Bank/UNDP Energy Sector Management Assistance Programme) Technical Report Number 039/03, December 2003

ESMAP, 2005, Advancing Bioenergy for Sustainable Development: Guidelines for Policymakers and Investors, Volume II: Project Profiles and Case Studies, p. 3-4, ESMAP Report Number 300/05, March 2005

Henning, R.K., Jatropha curcas L. in Africa, Assessment of the impact of the dissemination of the 'jatropha system' on the ecology of the rural area and the social and economic situation of the rural population in selected countries in Africa, Case Study performed for the Global Facilitation Unit for Underutilized Species, available at: wwwJatropha.org

International Energy Agency (IEA), 2005, Biofuels for Transport – An International Perspective, IEA Publications (ISBN 92 64 01 51 24), OECD/IEA, Paris, available at the IEA Online Bookshop www.iea.org/books

Lèbre La Rovere, E., The Brazilian Ethanol Programme – Biofuels for Transport, presented on the occasion of the International Conference for Renewable Energies (renewables 2004) in Bonn, Germany, 1-4 June 2004

Macedo, I.C. et al, 2003, Greenhouse Gas Emissions in the Production and Use of Ethanol in Brazil: Present Situation (2002), prepared for the Secretariat of the Environment, São Paulo

Martins Borges, J.M. and Arbex J.G., 1996, Institutional conditions for the production and marketing of alcohol in Brazil, in: Energy for Sustainable Development, Volume II No. 6, p.12-16, March 1996

Neff, T.L., 1997, Improving Energy Security in Pacific Asia: Diversification and Risk Reduction for Fossil and Nuclear Fuels, Centre for International Studies, Massachusetts Institute of Technology, December 1997, http://www.nautilus.org/papers/energy/NeffPARES.pdf

Chapter 5 – Summary and Conclusions

This section serves to briefly summarise the main results of the present study on biofuels for transportation in Tanzania.

Current Situation

As Tanzania does not have own oil reserves, the country is totally dependent on the import of petroleum products. The petroleum sector in Tanzania was heavily regulated until 1997 and the sole operating refinery was the outdated TIPER refinery, which refined imported crude oil into end products. TIPER could only process around 50% of national requirements and the balance was imported by the Tanzania Petroleum Development Corporation (TPDC). In 1997, the government liberalized marketing of petroleum products to promote competition in the petroleum sector. As a result of the market liberalisation, the TIPER refinery was closed at the end of 1999. Currently, about 70 small as well as large international oil marketing companies, the latter with own storage facilities, are engaged in the marketing and distribution of refined petroleum products in Tanzania.

The import of petroleum products (1.2 million tons in 2003) accounts for about 40% of all imports to Tanzania, and is thus responsible for a significant fraction of the country's foreign exchange spending. Thereby, the transport sector consumes more than 40% of the imported refined petroleum products. In 2002, the consumption of petrol and diesel in Tanzania was about 134.000 and 390.000 metric tons, respectively, and for projections of fuel demand to 2010 the TPDC forecasts an annual growth of 5% for both petrol and diesel.

As a response to the rising world market prices for crude oil, the prices for petroleum products in Tanzania have been increasing considerably. In summer 2005, fuel prices of unleaded petrol ranged between Tshs 1,120 and 1,195 per litre and diesel prices between Tshs 1,075 and 1,095 per litre (1 EURO = 1350 Tshs). Tanzania has a complex taxation system for petroleum products consisting of three main taxes (i.e. excise duty, road toll, Value Added Tax), which together comprise about 40% of the final fuel price charged to the consumers.

As an oil importing country the currently high prices for petroleum products put a heavy burden on the country's economy, and the pressing need to explore alternatives to fossil fuel consumption in the transport sector is being acknowledged by the Tanzanian Government Ministries. Thereby, biofuels have recently gained increasing interest and the Government is showing strong interest to cooperate with different stakeholders to support the development of biofuels in Tanzania.

Currently, there is no commercial biofuels production in Tanzania. But, several stakeholders are engaged in the development of biofuels, such as FELISA (palm oil), KAKUTE, Diligent and D1 Oils (jatropha oil) in the field of commercial biodiesel production as well as the 4 main sugar companies (Kilombero Sugar Company, Mtibwa Sugar Estates, Kagera Sugar Limited) in the field of sugarcane based bioethanol production.

Roughly, the current biofuels activities and opportunities in Tanzania can be divided into large-scale and small-scale approaches. Thereby, large-scale biofuels production, such as the production of ethanol from sugarcane promoted by the sugar industry as well as the activities of companies such as D1 Oils in the plant oil sector, will have a prime focus on biofuels for transportation and will require supportive policies and regulations in place for start-up in order to secure the rather large investment.

On the other hand, smaller-scale activities by organisations such as FELISA and KAKUTE are currently mainly concerned with the creation of rural income and revenue opportunities from oil seed crops, either through the production of plant oils (for food and/or fuel) or other commodities such as soap production from jatropha oil. The production of biofuels for transportation in these cases may (or may not) be an objective for the up-scaling of current activities.

Potential

A recent assessment by the Food and Agriculture Organisation of the United Nations (FAO) found that Tanzania has 55.2 million hectare (Mha) potential area for rain-fed crop production from the total land area of 93.8 Mha. 10.8 Mha of this area are in use for crop production, leaving 44.4 Mha of land potentially available for (food and non-food) crop production. While these figures present only a broad picture of land use in what is a very large and diverse country, they do suggest that land availability is not likely to be a barrier to bioenergy production in Tanzania.

The following estimate of the potential for bioenergy production from the "potentially available land" (44.4 Mha) can be used to gauge the limits of any real production. Using a range of biomass production of 75-300 GJ per hectare per annum, the limits of bioenergy production in Tanzania would be in the range 3.3 to 13.3 exajoules per annum. This compares with total annual primary energy consumption in Tanzania of 0.602 exajoules. For an introduction of a biofuels industry in Tanzania, the following expected energy yields for the production of different transport fuels in Tanzania are important, namely biodiesel from palm oil (186 GJ/ha), ethanol from cane juice (173 GJ/ha), biodiesel from jatropha oil (59 GJ/ha) and ethanol from C-molasses (20 GJ/ha).

Tanzania has more than 30 million hectares of land classified by the FAO as very suitable or suitable for cultivation of oil crops with intermediate levels of input. The corresponding areas for sugar crops, cereals and root crops are 570,000 ha, 24 million ha and 14 million ha, respectively. Sugar crops provide the simplest and most cost-effective feedstock options for bioethanol production, and with the area under sugarcane growing from 23,000 to 39,000 hectares in the last five years alone, increasing availability of suitable feedstock for ethanol production is expected. Current production of oil crops is much lower than even current demand, and a biodiesel programme of any real impact would require very much more land planted with oil crops than is currently the case.

In the near term, the level of demand for biofuels is most likely to be set by requirements for blending with petroleum fuels at levels that do not require modifications to vehicles. This may limit blend levels to E10 (10% ethanol by volume) for petrol-fuelled vehicles and B20 (20% biodiesel by volume) for older diesel-fuelled vehicles, though biodiesel can be used straight or in any blend ratio in newer vehicles. The projected requirements in 2010 are for E10 about 27 million litres of ethanol and for B20 about 139 million litres of bio-diesel.

Current (2004/2005) production of C-molasses by the cane sugar industry in Tanzania (about 90.000 tons) could be converted into more than 20 million litres of ethanol per year, or enough for an E10 blend. If all the C-molasses resulting from the Tanzanian sugar industry's projected production were used for ethanol production, total ethanol produced in 2006/07 would be over 28 million litres. This would be enough for a nationwide 12.2% blend by volume, or equivalent to 7.9% of national petrol consumption on an energy basis. The potential national blend percentage would grow to 13.6% in 2008/09, after which sugarcane production would be surplus to national crystalline sugar requirements and a choice between producing more sugar for export and producing more ethanol would exist. If all the "surplus" cane is used for ethanol production, the potential blend would rise to 28.5% (E28.5 blend; 76 million litres; equivalent to 18.4% on energy basis) by 2010. If the "surplus" is used for producing sugar, the potential would still reach 22.1% (E22 blend; 59 million litres; equivalent to 14.3% on energy basis) by 2010.

Oil palm and Jatropha curcas are the two oil crops most likely to be used as feedstock for biodiesel production in Tanzania. Of the oil crops available, oil palm has the highest potential yield of oil per hectare of land harvested. However, there is currently great demand for palm oil for food and other uses, and local production meets less than 5% of this.

There is a current proposal for a palm oil biodiesel project in the Kigoma region. The proposed project would involve cultivation of 8,000 hectares of oil palm, firstly to produce palm oil to meet local food and soap production demands, and then eventually to produce biodiesel. If the project achieves the target oil yield of 5000 litres per hectare, palm oil production could approach 40 million litres per year. This production would itself not be enough to displace current imports (about 172 million litres of palm oil were imported into Tanzania in 2002). Alternatively, 40 million litres of palm oil could be converted into about 39 million litres of biodiesel. Diesel fuel consumption in Tanzania is projected to be about 700 million litres in 2010. Thus, if all the projected palm oil production in the Kigoma project were to be converted to biodiesel, a 5.7% national blend would be possible (equivalent to 5.2% on an energy basis).

The other crop most favoured as a feedstock for biodiesel production is *Jatropha curcas* or physic nut. There is experience in Tanzania of cultivation of jatropha for small-scale oil production, and this has been particularly promising in its demonstration of the potential for aiding rural poverty alleviation and empowerment of women. Cultivation of jatropha around the world has tended to be on a small scale, and production and yield data for plantation-scale cultivation is limited. The oil yield from jatropha plantations is reported to be about 1600 kg oil per hectare from the fifth year onwards, although some local experience in Tanzania suggests that actual yields in Tanzania may be significantly less than this. On the basis of a yield of 1600 kg oil per hectare, 19,700 hectares of jatropha would have to be harvested each to produce enough biodiesel for a 5% national blend with petroleum diesel in 2010. For a B20 blend, 78,800 hectares would be required.

Based on reasonable assumptions the ethanol threshold price (i.e. the ethanol price below which ethanol is competitive with petrol in Dar es Salaam) was estimated. In August 2005, the retail price of petrol in Dar es Salaam was Tshs 1120/litre. At that price, ethanol would be competitive at a retail price of Tshs 729/litre, or about US$ 0.64/l. Ethanol production costs in Brazil have been reported at US$ 0.23 per litre, and a recent study by the Dutch Sustainable Development Group reported an ethanol production cost for least developed countries at between US$ 0.36 and US$ 0.60 per litre. Therefore, at current petroleum prices, production of ethanol in Tanzania is likely to be competitive with petrol. A more detailed feasibility study would be required to confirm this, and the economic viability of biodiesel from palm oil or jatropha was not determined, due to lack of data and the limited time available for the study.

Outlook

Currently, the exploitation of the large resource potential for the production of biofuels in Tanzania is mainly hampered by lack of information on all levels of society (Government departments and institutions, industry, civil society). This fact is one of the reasons for the absence of clear policies and regulations for biofuels production and use in Tanzania. In order to develop an enabling framework there is an urgent need of close co-operations and consultations between several Government departments (e.g. Ministry of Energy and Minerals, Ministry of Agriculture and Food Security, Ministry of Transport and Communication, Ministry of Finance, etc.) as well as between Government and stakeholders engaged in the promotion of liquid biofuels in Tanzania.

The lack of policies and regulations make investment in the biofuels sector difficult in Tanzania, as the prospective return-on-investment remains largely unclear. Especially, the rather large investments required in the sugar industry to start the production of fuel ethanol from sugar cane would require an ensured market for the product (e.g. through a mandate for ethanol-gasoline blends), guaranteed ethanol prices, at least for the start-up phase, as well as an initial protection of local manufacturers against cheap import biofuels. With its large potential for biofuels production and the lack of biofuels policies and regulations, Tanzania is a good example for a variety of developing countries worldwide which currently are in the very early stages of investigating the biofuels option for their country as a contribution to a future more sustainable energy supply.

Today, the Tanzanian Government is well aware of the benefits offered by the introduction of biofuels for transport applications and it is seriously assessing the different options for the development of policies and strategies for an increased use of biofuels.

Activities towards an implementation of biofuels policies are currently mainly driven by the Tanzanian Ministry of Energy and Minerals (MoE). At the expert workshop and policy discussion in Dar es Salaam, which was organised in the framework of this study, the representatives of the MoE strongly supported the proposed establishment of a ***high-level Tanzanian Biofuels Task Force*** which shall provide advice and recommendations for the elaboration of biofuels policies and regulations suitable for the Tanzanian framework conditions.

Among the objectives of this Task Force will be to ensure close co-operation between the different Government Ministries involved in the development of biofuels policies, as well as to provide an information channel between Government and biofuels stakeholders from industry, farmers associations, NGOs and civil society. Consultations between Government representatives and biofuel stakeholders will for instance help to address several important issues, such as the comparison of economic, environmental and social benefits (e.g. employment generated, rural development, FOREX saved) and costs (e.g. reduces tax revenues) of biofuels programmes in Tanzania, and the potential effects of diverting crops towards biofuels production on other markets (e.g. food markets).

In addition, it was recommended to set-up a ***Biofuels Producer Association*** in order to lend a strong voice to all actors which are or plan to get involved in the production, marketing and use of biofuels in Tanzania. This association shall also be acting as one of the important stakeholders of the Biofuels Task Force.

Finally, the following concrete recommendations for action are put forward as conclusions of this study on biofuels for transportation in Tanzania:

1. Establish a high-level Biofuels Task Force

2. Establish a Tanzanian Biofuels Producer Association

3. Start immediate Government Action to promote increased use of biofuels

In order to quickly proceed with the introduction of biofuels in Tanzania, the Government should take immediate action to enter the learning-by-doing process – and not wait for results and policy advice from the Task Force.

a. Establish biofuels demonstration facilities; 1 large-scale ethanol and 1 large-scale biodiesel (or Pure Vegetable Oil) production facility with scales of more than 10.000 tons per year of biofuel output

b. Establish a production/user group for small-scale biodiesel (or PVO) production for transport fuel and bio-electricity production

c. Encourage the sales of flex-fuel vehicles and companies which modify diesel vehicles to run on Pure Vegetable Oils; investigations may be required on the relative benefits of esterified bio-oils and PVO for mineral diesel replacement

d. Investigate the option of using ethanol blends in gasoline as lead replacement in order to comply with Tanzania's obligation to phase-out leaded gasoline by 2005

e. Encourage financing options (e.g. capital allowances, tax breaks) and set-up incentives for (local and foreign) investors; consider revenue neutral options including additional taxes on fossil fuels to cover implementation costs of biofuels

f. Evaluate monitoring/ verification as a practical method for ensuring the sustainable development and use of biofuels and to quantify the national impact of their use

4. Assess the role of Government in promoting biofuels

The Tanzanian Government needs to consider carefully its role in promoting biofuels, i.e. what should be internal Government activities and what should be carried out by the private sector, NGOs and local Governments.

5. Pursue international facilitation options

The Tanzanian Government should pursue international facilitation options, such as the Partnership Dialogue Facility (PDF) of the European Union Energy Initiative, the International Bioenergy Programme of the Food and Agriculture Organisation of the United Nations (FAO). These international institutions have the mandate to assist with the development of biofuels through (for example) G8, Global Bioenergy Partnership.

6. Establish co-operation with other African Governments

For example, the Tanzanian Ministry of Energy and Minerals should get in contact with their Zambian counterparts to ensure regional co-operation on the development of the Biofuels Task Force and relevant policy instruments.

7. Integrate actions of the Biofuels Task Force with the Tanzanian Renewable Energy Agency and the Tanzanian Investment Centre

Effective cross-departmental actions on biofuels (and bioenergy) need to be ensured through careful considerations on how to integrate activities of the Biofuels Task Force with the Tanzanian Renewable Energy Agency and the Tanzanian Investment Centre.

8. Promote applied research and development

Continued, applied research and development will be required and local and international academic institutions and private sector research organisations should be encouraged to collaborate on research and development in this critical emerging sector.

9. Promote awareness raising activities

In order to provide solid grounds for the development of a biofuels sector in Tanzania, the population has to be informed about the significant benefits and opportunities offered by biofuels as alternative transport fuel.

This list of recommendations for action identifies first steps to be taken as soon as possible in order to exploit the opportunities offered through the development of a biofuels sector for the production of alternative transport fuels in Tanzania.

Liquid Biofuels for Transportation in Tanzania

Potential and Implications for Sustainable Agriculture and Energy in the 21st Century

Annexes

Annex 1: PETROLEUM PRODUCT STATISTICS IN TANZANIA

Annex 1.1: Projected Total Demand for Petroleum Products 1997 to 2010

YEAR	MT
1997	990,147
1998	1,089,161
1999	1,198,077
2000	1,317,885
2001	1,449,673
2002	1,594,640
2003	1,674,372
2004	1,768,090
2005	1,856,494
2006	1,949,318
2007	2,046,783
2008	2,149,122
2009	2,256,278
2010	2,369,915

Source: TDPC, 2004

Annex 1.2: Petroleum Products Sales (CM) of TAOMC Members for the Year 2004

		BP	CALTEX	ENGEN	FUCHS	GAPCO	GAPOIL	KOBIL	MGL	NATOIL	OILCOM	ORYX	SHELL	TOTAL	TOTAL SALES	% SALES VOLUME
FUEL	**AVGAS**	2,461	0	0	0	0	0	0	0	0	0	0	0	0	2,461	**0.19%**
	LPG	933	0	0	0	0	0	0	0	4	0	4,635	0	16	5,588	**0.43%**
	MSP	31,962	6,565	13,586	0	21,419	15,211	15,468	7,974	10,732	20,236	32,656	0	20,977	196,786	**15.21%**
	IK	8,521	3,123	7,174	0	13,031	18,271	8,588	108	16,908	23,800	13,832	0	9,266	122,622	**9.48%**
	JET A1	96,531	0	445	0	31,226	4,361	154	0	0	3,603	0	0	7,602	143,922	**11.12%**
	AGO	82,675	56,208	37,878	0	60,512	72,745	19,095	14,695	24,418	65,190	80,958	54,144	84,030	652,548	**50.42%**
	IDO	11,673	0	52	0	35	1,454	0	0	0	0	6,501	0	0	19,715	**1.52%**
	FO	10,059	340	42	0	50,603	19,015	0	0	0	0	24,489	37,086	8,881	150,515	**11.63%**
TOTAL FUELS		244,815	66,236	59,177	0	176,826	131,057	43,305	22,777	52,062	112,829	163,071	91,230	130,772	1,294,157	**100.00%**
MARKET SHARES		18.92%	5.12%	4.57%	0.00%	13.66%	10.13%	3.35%	1.76%	4.02%	8.72%	12.60%	7.05%	10.10%	100.00%	

LPG : Liquid Petroleum Gas
MSP : Motor Super Premium
JET A1 : Jet Fuel
IDO : Industrial Diesel Oil

Annex 1.3: Petroleum Product Sales – 2003 (CM)

PRODUCT	**DOMESTIC TAXABLE SALES**			**TAX EMPT SALES**			**TOTAL**	**% PRODUCT**
	CONSUMER	**RETAIL**	**TOTAL**	**DOMESTIC**	**EXPORT**	**TOTAL**	**SALES**	**SALES**
LIQUID FUELS								
AVGAS	2,287	0	2,287	0	0	0	2,287	0.18%
LPG	4,301	663	4,964	0	0	0	4,964	0.40%
MSP	49,654	119,857	169,511	8,245	22,878	31,123	200,634	16.15%
IK	54,280	69,352	123,632	1,308	6,933	8,241	131,973	10.61%
JET A1	39,286	6,514	45,800	561	74,397	74,958	120,758	9.72%
AGO	293,849	170,941	464,790	64,730	97,057	161,787	626,577	50.43%
IDO	19,479	0	19,479	0	0	0	19,479	1.57%
FO	125,756	0	125,756	5,291	4,972	10,263	136,019	10.95%
TOTAL	558,892	367,327	956,219	80,135	206,237	286,372	1,242,591	100.00%
LUBES & GREASES								
AV. OIL	46	0	46	0	0	0	46	0.28%
AUTO. OIL	11,911	1,325	13,236	24	12	36	13,272	80.61%
IND. OIL	1,878	2	1,880	0	0	0	1,880	11.42%
BATCH. OIL	227	0	227	0	0	0	227	1.38%
GREASES	1,015	25	1,040	0	0	0	1,040	6.32%
TOTAL	15,077	1,352	16,429	24	12	36	16,465	100.00%

Annex 1.4: Oil Industry Sales Exchange Figures For 2005 (Volume In M3/Tonnes)

ALL COMPANIES		TOTAL SALES FIRST QUARTER						
	PRODUCT	TAXABLE SALES		TAX EXEMPT SALES			TOTAL	% PRODUCT
FUELS		RETAIL	TOTAL	DOMESTIC	EXPORT	TOTAL	SALES	SALES
	AVGAS	-	615.2	-	-	-	615.2	0.2
	LPG	2.1	1,254.2	-	-	-	1,254.2	0.4
	MSP	22,826.3	45,131.1	-	4,496.3	4,496.3	49,627.4	16.7
	IK	11,708.4	23,964.0	-	2,439.6	2,439.6	26,403.6	8.9
	JET A-1	-	11,739.0	-	21,989.3	21,989.3	33,728.2	11.3
	AGO	36,699.6	121,510.8	11,558.4	11,615.5	23,174.0	144,684.8	48.6
	IDO	-	7,258.2	-	-	-	7,258.2	2.4
	FO	-	19,201.9	10,123.9	-	10,123.9	29,325.8	9.9
SUB-TOTAL 1		71,236.4	230,674.3	21,682.3	40,540.7	62,223.1	292,897.3	98.4
LUBES AND GREASES								
	AV. OIL	-	307.5	-	-	-	307.5	0.10
	AUTO. OIL	827.0	3,196.3	413.7	186.0	599.7	3,795.9	1.28
	IND. OIL	-	328.7	151.9	-	151.9	480.6	0.16
	BATCH. OIL	-	41.0	-	-	-	41.0	0.01
	GREASES	5.3	109.5	29.3	-	29.3	138.8	0.05
SUB-TOTAL 2		832.3	3,983.0	594.8	186.0	780.9	4,763.9	1.60
TOTAL		72,068.7	234,657.3	22,277.2	40,726.7	63,003.9	297,661.2	100.00

Source: Tanzania Association of Oil Marketing Companies

Annex 1.5: Oil Marketing Companies Sales Year 2002 (CM) - Local Market

COMPANY	PRODUCT QUANTITY								TOTAL	AUTO	IND.
	LPG	AVGAS	MSP	JET A1	IK	GO	IDO	FO	FUELS	OIL	OIL
BP	1,575.00	2,390.60	40,562.00	23,151.80	19,579.10	106,092.20	6,495.10	32,807.60	232,653.40	2,258.20	938.70
CALTEX	-	-	11,604.10	-	14,136.90	30,595.30	-	-	56,336.30	2,642.70	-
ENGEN	-	-	4,795.10	-	4,953.90	21,406.70	-	152.50	31,308.20	138.80	-
GAPOIL	-	-	17,558.50	-	17,136.00	87,454.20	6,505.50	16,556.40	145,210.60	39.60	13.20
GAPCO	-	-	27,224.20	-	22,025.90	74,960.90	2,926.60	48,164.90	175,302.50	-	-
KOBIL	-	-	9,037.00	-	12,569.00	20,237.00	-	-	41,843.00	-	-
NATOIL	49.90	-	5,080.70	-	10,297.50	15,463.50	-	-	30,891.60	48.30	-
OILCOM	-	-	13,486.10	-	22,709.70	49,646.30	-	-	85,842.10	-	-
ORYX	3,260.70	-	20,165.80	-	9,564.40	45,384.10	1,402.00	4,672.00	84,449.00	4,148.40	-
SHELL	-	-	-	-	-	62,202.20	-	-	62,202.20	-	1,354.10
TOTAL	17.40	-	15,369.60	679.40	7,460.80	25,628.50	87.00	1,518.80	50,761.50	3,074.50	-
SUM (CM)	**4,903.00**	**2,390.60**	**164,883.10**	**23,831.20**	**140,433.20**	**539,070.90**	**17,416.20**	**103,872.20**	**996,800.40**	**12,350.50**	**2,306.00**
AVG DAILY CONS.	13.43	6.55	451.73	65.29	384.75	1,476.91	47.72	284.58	2,730.96	33.84	6.32
SUM(MT)	**4,903.00**	**2,390.60**	**121,326.78**	**18,735.22**	**110,403.46**	**449,225.75**	**14,822.30**	**97,624.25**	**819,431.36**		

Annex 1.6: Oil Marketing Companies Sales Yr 2002 (Cm) - Export Market

COMPANY	PRODUCT QUANTITY								TOTAL	AUTO	IND.
	LPG	AVGAS	MSP	JET A1	IK	GO	IDO	FO	FUELS	OIL	OIL
BP	-	-	4,047.90	35,994.60	-	12,192.60	-	-	52,235.10	-	-
CALTEX	-	-	11,543.70	-	3,739.20	17,969.90	-	-	33,252.80	-	-
ENGEN	-	-	10,068.50	-	3,474.80	13,002.60	-	1,189.10	27,735.00	-	-
GAPOIL	-	-	-	-	-	-	-	-	-	-	-
GAPCO	-	-	14,535.10	25,009.00	5,780.50	21,086.10	-	2,128.40	68,539.10	-	-
KOBIL	-	-	1,821.00	171.00	701.00	3,949.00	-	-	6,642.00	-	-
NATOIL	-	-	2,056.50	-	96.00	3,172.80	-	-	5,325.30	-	-
OILCOM	-	-	-	-	-	-	-	-	-	-	-
ORYX	-	-	10,893.20	-	1,541.90	9,586.40	-	32.00	22,053.50	-	-
SHELL	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	2,875.80	588.60	652.00	11,312.60	-	-	15,429.00	10.40	-
SUM	**-**	**-**	**57,841.70**	**61,763.20**	**15,985.40**	**92,272.00**	**-**	**3,349.50**	**231,211.80**	**10.40**	**-**

Source: Tanzania Association Of Oil Marketing Companies

Annex 2: Petroleum Fuel Prices Build-up

	GAS OIL (GO)-DIESEL			HEAVY FUEL OIL-HFO			JET FUEL			GASOLINE-MSP		
	Insurance	0.10%		Insurance	0.10%		Insurance	0.10%		Insurance	0.10%	
	LTS IN MT	1,200		LTS IN MT	1,272		LTS IN MT	1,272		LTS IN MT	1,359	
PRICE BUILD UP	Ex. rate $=	TZS 1,120.00		Ex.rate $=	TZS 1,120.00		Ex. rate $=	TZS 1,120.00		Ex. rate $=	TZS 1,120.00	
	$ PER LT	$ PER MT	TSHS PER TL	$ PER LT	$ PER MT	TSHS PER TL	$ PER LT	$ PER MT	TSHS PER TL	$ PER LT	$ PER MT	TSHS PER TL
(i) FOB June 2005	0.421	505.13	471.4546667	0.239	253.8	267.1578947	0.434	552.49	486.4691824	0.401	509.61	448.7132075
(ii) Freight & Suppliers Premium	0.033	40	37.33333333	0.047	50	52.63157895	0.0314	40	35.22012579	0.0294	40	32.96541575
(iii) Insurance 0.1 % C&F	0.0005	0.54513	0.509	0.000	0.3038	0.320	0.0005	0.59249	0.522	0.0004	0.54961	0.453
1,CIF DSM	$0.455	$545.675	$509.297	$0.286	$304.104	$320.109	$0.466	$593.082	$522.211	$0.430	$550.160	$482.132
2 (a). E.DUTY	$0.113	$136.07	TZS 127.00	$0.012	$13.93	TZS 13.00	$0.025	$30.00	TZS 28.00	$0.131	$157.50	TZS 147.00
2. (b) ROAD TOLL	$0.080	$96.43	TZS 90.00	$0.000	$0.00	TZS 0.00	$0.000	$0.00	TZS 0.00	$0.080	$96.43	TZS 90.00
3.VAT (CIF +E.DUT+R.TOLL * 20%)	$0.130	$155.64	TZS 145.26	$0.059	$71.38	TZS 66.62	$0.098	$117.90	TZS 110.04	$0.128	$154.10	TZS 143.83
4.THA=(1.6% +20%)*CIF	$0.009	$10.48	TZS 9.778	$0.005	$6.59	TZS 6.146	$0.009	$10.74	TZS 10.026	$0.008	$9.92	TZS 9.257
5.TBS=2% OF C&F	$0.008	$10.06	TZS 9.386	$0.005	$6.00	TZS 5.602	$0.009	$10.33	TZS 9.644	$0.008	$9.47	TZS 8.843
6.Local Insp= $0.15@MT	0.0001	$0.15	TZS 0.140	0.0001	$0.15	TZS 0.158	0.0001	$0.15	TZS 0.132	0.0001	$0.15	TZS 0.124
7.Dest.Inspect=1.2% FOB	$0.00	$5.91	TZS 5.512	$0.00	$3.47	TZS 3.241	$0.005	$6.07	TZS 5.667	$0.005	$5.56	TZS 5.186
8.Tiper Manifold=$0.15@MT@Mt	$0.00	$0.15	TZS 0.140	$0.00	$0.17	TZS 0.158	$0.0001	$0.14	TZS 0.132	$0.0001	$0.13	TZS 0.124
TOTAL LANDED PRICE	$0.800	$960.55	TZS 896.51	$0.371	$405.79	TZS 415.04	$0.612	$768.42	TZS 685.85	$0.792	$983.42	TZS 886.49

Annex 3: AGRICULTURAL CROPS IN TANZANIA

Annex 3.1: Summary of Marketed Quantities and Value of Principal Cash Crops

Crop	Quantity (Tons)										
	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	Change % 02/03-03/04
Sisal	24716	28902	25022	22180	23229	41084	23542	23641	23280	26758	14.90%
Cotton[1]	125434	221148	251751	202217	105853	100500	123558	148180	188689	139969	-49.40%
Cashew nuts	63403	81729	63033	99915	106442	121207	122283	79280	95000	80000	-15.80%
Sugarcane	1284	1369	1298	984	1268	1248	1334	1523	1813	2342	29.20%

Source: Respective Marketing Boards.

1 Seed Cotton

Annex 3.2: Domestic Production and Consumption of Sugar

Season [1]	Sugar Cane				Sugar		
	Farmers					Consumed [3]	
	Public ('000 Tons)	Private ('000 Tons)	Total ('000 Tons)	Price [2] (Shs/Ton)	Production Ton	Total Ton	Kg. Per Person [4]
1977/78	1008	116	1124	96.2	132979	111546	6.69
1978/79	1169	197	1366	96.2	114267	127712	7.42
1979/80	1180	210	1390	101.2	122530	112282	6.34
1980/81	854	193	1047	106.2	114667	115961	6.37
1981/82	1135	203	1338	137.3	124326	120629	6.44
1982/93	1090	113	1203	170	101996	93179	4.84
1983/84	1372	160	1532	238	131525	108369	5.48
1984/85	1148	105	1253	323.7	108102	111433	5.48
1985/86	1003	104	1107	352.3	100287	95379	4.56
1986/87	991	72	1063	463	94815	109462	5.09
1987/88	997	102	1099	600	101266	96271	4.35
1988/89	787	91	878	750	96227	126771	5.29
1989/90	963	98	1061	1748.45	111236	190750	5.47
1990/91	1068	116	1184	2525.9	118560	212585	5.93
1991/92	967	114	1081	3476.85	108480	202478	6.07
1992/93	1098	273	1371	5267.67	121414	204126	6.11
1993/94	1105	362	1467	6200	123949	139829	5.38
1994/95	914	370	1284	8600	104624	238424	5.38
1995/96	997	372	1369	8900	116810	268910	
1996/97	951	347	1298	9500	116100	275700	5.54
1997/98	808	176	984	10500	116100	271790	5.7
1998/99	948	320	1268	12500	113622	101272	5.87
1999/00	907	341	1248	12500	116927	100127	6.7
2000/01	1050	284	1334	14000	135534	122534	10
2001/02	1134	389	1523	14700	164498	142398	10.1
2002/03	1402	411	1813	15000	190120	167300	10.42
2003/04	1672	670	2342	16800	223839	290711	10.9
Change (%) 02/03-03/04	0.19	0.63	0.29	0.12	0.18	0.74	0.05
Increase (%) 77/78-03/04	13.41	-0.4	23.35	-0.87	1.01	1.61	0.63

Source: Tanzania Sugar Board
1. Season is between July and June
2. Price is for Sugar cane with 10.5% of Sucrose
3. Includes sugar transported to Zanzibar
4. For Tanzania mainland

Annex 3.3: Production Data for Sugar, Molasses and Bagasse in Small Sugar Mills

No	Site/Owner	Location	Sugarcane Tons/day	Sugar Produced (kg/day)		Molasses Produced (kg/day)			Bagasse (tons/day) predicted
				Reported	Recovery	Reported	Predicted	Sold	
1	Mara (Patel)	Babati, Arusha	22	840	3.8%	580	880	580	1.3
2	Dudumera (Mr Chaghan)	Babati, Arusha	8	370	4.6%	300	320	300	4
3	Hanang (Mr. Odedra)	Babati, Arusha	-	-	-	-	-	-	-
4	Magugu (Mr Odedra)	Babati, Arusha	-	-	-	-	-	-	-
5	USA river (Mr Kanji)	Arumeru, Arusha	-	-	-	-	-	-	-
6	Mwembe (Mr. Mrutu)	Same, Kilimanjaro	5	150	3.0%	180	200	180	2.5
7	Mungu Nisidie (Mr. Kinyero)	Songea, Ruvuma	4 15	200 600	5.0% 4.0%	200 800	160 600	165 565	2 7.5
8	Zombo (Mr. Huwel)	Kilosa, Morogoro	6	200	3.3%	100	240	100	3
9	Yovi Estate (Mr. Salum)	Kilosa, Morogoro	22.5	1,100	4.9%	1,000	900	900	11.25

Source: REPOA, 2001

Annex 4: RESIDUES AND ENERGY ESTIMATES OF SELECTED CROP RESIDUES GENERATED FROM 1995-2002

Annex 4.1: Sugarcane Bagasse and Energy Value Potentials

Year	Quantity of sugarcane in 000' tonnes	Estimated residue quantity in 000'tonnes	Energy content (000' MJ/yr)	Ash %
1994/95	1284.0	372.36	67397.160	37236.0
1995/96	1369.0	397.01	71858.810	39701.0
1996/97	1298.0	376.42	68132.020	37642.0
1997/98	983.9	285.331	51644.911	28533.1
1998/99	1268.9	367.981	66604.561	36798.1
1999/00	1255.0	363.95	65874.950	36395.0
2000/01	1333.0	386.57	69969.170	38657.0
2001/02	1523.0	441.67	79942.270	44607.0

Conversion factors used:- RPR (0.29) Bhattacharya ea '93
LHV (18.10) Bhattacharya ea '93
Ash % (10-12) Ryan ea '91

Annex 4.2: Sorghum Straw Residue and Energy Value Potentials

Year	Quantity of sorghum in 000' tonnes	Estimated residue quantity in 000'tonnes	Energy content (000' MJ/yr)	Ash %
1994/95	838.8	1048.5	12980.43	
1995/96	872.4	1090.5	13500.39	
1996/97	498.5	623.125	7714.2875	
1997/98	563.4	704.25	8718.615	
1998/99	561.2	701.5	8684.570	
1999/00	598.2	747.75	9257.145	
2000/01	691.7	864.625	10704.0575	

Conversion factors used:- RPR (1.25) Bhattacharya ea '93
LHV (12.38) Bhattacharya ea '93

Annex 4.3: Millet Straw Residue and Energy Value Potentials

Year	Quantity of millet in 000' tonnes	Estimated residue quantity in 000'tonnes	Energy content (000' MJ/yr)	Ash %
1994/95	342.0	598.5	7415.41500	
1995/96	585.0	1023.75	12684.2625	
1996/97	347.0	607.25	7523.82750	
1997/98	235.9	412.825	5114.90175	
1998/99	194.4	340.2	4215.07800	
1999/00	219.0	383.25	4748.46750	
2000/01	206.5	361.375	4477.43625	

Conversion factors used: - RPR (1.75) Bhattacharya ea '93
LHV (12.39) Bhattacharya ea '93

Annex 4.4: Wheat Straw Residue and Energy Value Potentials

Year	**Quantity of wheat in 000' tonnes**	**Estimated residue quantity in 000'tonnes**	**Energy content (000' MJ/yr)**	**Ash %**
1995	47	82.25	1018.255	6.226325
1996	49	85.75	1061.585	6.491275
1997	51	89.25	1104.915	6.756225
1998	53	92.75	1148.245	7.021175
1999	68	119.0	1473.220	9.008300
2000	67	117.25	1451.555	14.51555
2001	65	113.75	1408.225	8.610875
2002	68	119.0	1473.220	9.008300

Conversion factors used: - RPR (1.75) Bhattacharya ea '93
LHV (12.38) Bhattacharya ea '93
Ash % (7.57) Strehler '87

Annex 5: VEGETABLE OIL PRODUCTION IN TANZANIA

Oil Crops	Production (000 tons/year)	% Oil content	Favourable climatic conditions	Regions grown
Coconut	370	65		Tanga, Coast,
Cottonseeds	210	18	Tropics, Sub-tropics &Temperate climates.	Tabora, Mwanza, Shinyanga, Mara, Kagera, Tanga, Morogoro, Singida, Lake zone & Coast.
Groundnuts		45 - 55	Tropics, Sub-tropics &Temperate climates.	Dodoma,
Palm oil	6	43 - 51	Tropics & Sub-tropics.	Tanga, Dar es salaam, coast.
Soybeans		18 - 48	Tropics, Sub-tropics &Temperate climates.	
Sunflower seeds		25 - >85	Tropics, Sub-tropics &Temperate climates.	
Copra		45 - 75		Coastal areas.
Kapok		25	At the Coast and along coastal areas.	Korogwe, Mombo, Tanga, Coast, Morogoro & Shinyanga
Cashew nuts	123	46 - 47		Lindi, Mtwara, Ruvuma, Dar es salaam, Tanga & Coast
Simsim		45 - 58		Lindi & Mtwara.
Jatropha		33 - 60	Tropical & Sub-tropical climates.	Arusha, Bukoba.
Allanblackia spp		51	Montane forests of the East Usambara & Uluguru.	Morogoro
Adansonia digitata		29.7 - 37		Dodoma, Iringa, Shinyanga & Singida
Eucalyptus *(Globolus)*		10 - 85	Loam soils, (Moisture climates), Wet Montane climates, Over 2,000m a.s.l.	Arusha, Mbeya & Iringa.
Sugarcane	1,600		Tropics& Sub-Tropics climates.	Morogoro, Kagera.
Sissoo			High rainfall areas, along canal banks,	Muheza, Korogwe,
Macadamia Nuts (*Macadamia tetraphylla*)		60 - 78	Coffee-growing areas of the Tanzania highlands.	Kilimanjaro, Bukoba,
Drumstick Seeds		38 - 40	Well-drained sandy soils with high water table/ Coastal areas, low latitudes (0-500m)	
Pappea (*Pappea capensis*)			Drier forests, Savannah & Open woodlands.	Arusha, Dodoma, Morogoro, Babati.
Avocado		3 –80 (dry fruit).	Moist Plateau, wet lowlands& transitional wet Montane, Northern areas & along the coast, 0-2,200m.	Kilimanjaro, Mbeya, Tanga,
Madras thorn *(P. Dulce)*			Along the coast (0-1,600m), Arid & Semi-Arid conditions (Tolerable of Most Soils, very poor sands & Wet Salty soils).	

Oil Crops	Production (000 tons/year)	% Oil content	Favourable climatic conditions	Regions grown
Castor bean *(Ricinus communis)*		20 –50	Preferring Humus-rich& disturbed ground, (Its drought resistant)	Widely spread all over Tanzania.
S. Caffra		60	Low attitudes, woodlands& wooded grassland, 100-1,600m. 200-1,600mm rain/year. Salt tolerant.	Widely distributed all over the country.
Pigeon wood *(T. Guineensis)*			Higher rainfall areas, 0-200m.	Found in riverine forest or forest margins.
Cape mahogany *(T. Roka)*		55 - 65	Well-drained, rich soils & high ground water areas.	Bukoba, Mwanza, Mbeya & Kilimanjaro.
Wild plum *(Ximenia Americana)*		65	Savannah climates, coastal, Rift valley & open Sandy woodland, on stony slopes, scattered thorn bush, arid& semi-arid zones, 0-2,000m. (Drought resistant)	Arusha, Tabora, Dodoma, Coast and Iringa.
Margosa seeds *(Azadirachta indica)*		20 - 45	Pan-tropical in semi-arid & arid regions (withstanding drought). Very dry areas, & poor soils, 1-1,500m. (Does not stand water logging).	
Desert date *(Balanites aegyptiaca)*		40 - 46	Form arid and semi- arid regions to sub-humid savannah, 200-800 mm rainfall, and 0-2,000m.	Shinyanga, Nzega, Singida, Dodoma and Babati.
African fan palm *(Borassus aethiopum)*			Less dry areas of tropical Africa. In Tanzania-along the coast and along water courses.	Coastal Regions.
Grape seeds *(Vitis vinifera, Vitacae)*	14	4 - 21	Temperate Regions.	Dodoma,
Mango oil *(Mangifera indica)*		10		
Peasic/Peach oil (*Persia vulgaris*)		40 - 50		Kilimanjaro, Arusha,
Pumpkin seed oil (*Cucurbita pepo L.)*		35 - 50		
Cocoa		50 - 60	Areas with <300m a.s.l, 25-28°C Temperature, 80% humidity, 1,500-2,000mm rain/year.	Mbeya, Tanga, Morogoro.

*a.s.l – above sea level.
Source: Author, 2005

Annex 6: ECONOMY OF SMALL SCALE JATROPHA UTILIZATION IN TANZANIA

The following economic evaluation of the use of **Jatropha** for oil and soap production is based on experiences of KAKUTE in its **Jatropha** project ARI-Monduli (Alternative Resources of Income for Monduli women). The economic calculation is differentiated between seed collection, oil extraction and soap making. It is obvious, that the collection of seeds and its sale gives the least added value. Oil extraction is more profitable than seed collection, but not as good as soap making.

Collection and sale of seeds

Collection of seeds: (figures from KAKUTE, 2003)
Collection of seeds: 2 kg in 1 hour
Sale of seeds: 150 TZS per kg
Value added for 1 hour work 300 TZS (0,29 USD) per hour

Extraction and sale of oil

Oil extraction: (figures from KAKUTE, 2003)5 kg of seed for 1 litre of oil is 1.7 hours of work
1.0 hour of work to extract 1 litre of oil
Input: 5 kg of seed 750 TZS (0.71 USD) per litre
1.5 hours of work to extract (1 litre of oil depreciation of ram press 0.02 USD / kg) for 5 kg:
105 TZS (0,10 USD) per litre

Output:

Sale of 1 litre of oil 2.000 TZS (1,90 USD)
Value added for 1 hour of work 1.145 TZS (1,09 USD) per hour

Production and sale of soap

Soap making: (figures from KAKUTE, 2003)
16 hours work for 252 bars of soap
1 bar sold for 500 TZS
Purchase of 20 litres of oil @ 2.000 TZS = 40.000 TZS
Purchase of 3 kg of Caustic Soda @ 2.000 TZS = 6.000 TZS
Plastic for wrapping soap = 3.000 TZS
10 hours for miscellaneous work (organizing purchase of oil, wrapping the soap, etc)
Input: 20 l oil 40.000 TZS (38,10 USD)
Plastic 3.000 TZS (2,86 USD)
Caustic Soda 6.000 TZS (5,71 USD)

Total input for 26 hours work 49.000 TZS (46,67 USD)
Output: 252 bars @ 500 TZS 126.000 TZS (120,00 USD)
Total of revenues 77.000 TZS (73,33 USD)
Value added for 1 hour of work 2.962 TZS (2,82 USD)

Annex 7: RAINFALL PATTERNS BY REGIONS

Annex 7.1: Monthly Rainfall (in mm) for the Year 2000

Station/Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bukoba	52.2	90.7	115.7	199.2	212.8	39.2	48.2	69.8	77.7	130.2	234	223	**1493.3**
Mwanza	88.7	41.0	51.0	67.6	14.1	5.9	0.0	0.0	0.0	69.9	129.8	-	**468.0**
Musoma	11.8	37.1	122.7	106.4	41.9	9.4	0.0	43.8	15.2	39.2	88.6	190.3	**706.4**
Arusha	38.2	26.7	44.3	144.3	30.8	10.5	3.3	15.8	4.0	0.0	101.4	104.3	**523.6**
K'njaro	10.0	3.1	13.8	41.4	52.0	22.2	4.2	15.9	11.5	1.1	123.3	46.4	**344.9**
Moshi A/P	1.4	2.0	121.4	121.9	54.1	27.0	4.4	15.3	2.2	6.0	16.9	29.0	**401.6**
Same	0.0	0.4	104.3	60.2	38.5	40.1	1.1	4.9	17.6	2.1	56.5	26.4	**352.1**
Karume	7.4	0.0	157.5	369.9	19.9	82.7	35.4	0.7	13.6	14.7	76.6	104.0	**882.4**
Zanzibar	1.4	0.0	270.9	352.0	86.9	195.9	40.6	4.4	35.3	6.2	191.1	217.0	**1401.7**
D'salam	1.8	3.5	108.4	261.2	70.0	126.9	18.7	24.0	3.2	6.2	79.2	220.0	**923.1**
Morogoro	68.8	37.9	183.0	110.3	47.8	48.0	5.2	0.3	4.9	0.0	49.5	205.0	**760.7**
Mtwara	127.6	60.3	360.5	72.4	54.9	25.1	28.7	16.6	20.3	10.1	97.1	154.1	**1027.7**
Dodoma	126.0	85.9	172.5	35.8	0.0	0.0	0.0	0.0	0.0	0.0	60.7	274.0	**754.9**
Tabora A/ P	94.4	97.8	178.3	126.4	0.0	0.0	0.0	0.0	1.0	23.5	239.3	192.0	**952.7**
Kigoma	44.7	58.9	140.2	59.9	32.8	0.0	0.0	0.0	2.0	4.0	204.1	-	**546.6**
Iringa A/P	97.8	52.8	87.3	50.4	0.0	0.0	0.0	0.0	0.0	0.0	199.0	90.0	**577.3**
Mbeya A/P	147.3	174.0	205.5	70.1	0.0	0.0	0.0	0.0	0.0	0.0	163.0	259.0	**1018.9**
Songea A/P	191.4	162.7	189.3	120.6	11.4	1.0	0.0	3.1	0.0	0.0	111.8	248.0	**1039.3**
Tanga A/P	-	0.0	109.3	164.4	246.6	266.1	80.7	35.5	34.1	44.7	35.3	51.7	**1068.4**

Source: Food Security Department (Meteorological Unit), Ministry of Agriculture and Food Security 'A/P (Air Port)

Annex 8: SITES IDENTIFIED AS SUITABLE FOR SUGAR CANE PRODUCTION

The descriptions below are based on summaries of the current assessment by the Sugar Board of Tanzania of the main sites identified as suitable for sugar cane production (Msimbira, 2005):

Ruipa:

- This is an area in the Kilombero valley in the Morogoro region of central Tanzania. Its location is close to the Ruipa/Mbingu station on the Tazara railway. Local soils are of recent alluvium, with excellent texture and high fertility. The land is assessed to be capable of producing sugar cane to support about 224,000 tonnes sugar per year. Potential ethanol production from C-molasses only would be about 18 million litres.
- Mean annual rainfall is approximately 1,726mm. Rainfed cane production is possible but for good cane yields, irrigation is required for most of the year since in most cases the potential evaporation exceeds effective rainfall.
- Irrigation water is available from either the Kilombero river or the Ruipa river. Extraction from the Ruipa river is considered technically simpler. The water quality is assessed as good and the quantity is adequate for an irrigation project of 110,000 tonnes of sugar with a simple weir (proposed Ruipa I). It has been estimated that construction of a dam upstream with a capacity of 92.5 million cubic metres would enable development of a second project to provide an additional 114,000 tonnes of sugar per year (Ruipa II), bringing the total potential for the Ruipa site to 224,000 tonnes sugar.
- At 1977 prices the estimated investment for Ruipa project was Shs.613 million (about US $ 76.6 mill) for Ruipa I and Shs.881 million (US$ 110 mill) for Ruipa II.

Ikongo:

- This site is located in North West Tanzania East of Lake Victoria, in the Mara region close to the Kenya border. Reconnaissance surveys indicate that soils are suitable for sugar cane production. Detailed soil studies have not yet been done, but the assessed sugar production potential is in the order of 82,000 tonnes per year. Potential ethanol production from C-molasses only would be 6.6 million litres.
- Irrigation is required and water is available from the Mara river. A number of irrigation-related constraints have been noted:
- Water storage (dams) is required, so the project may be best implemented as integral part of a hydropower project. The dam(s) is also needed for flood control and training the river.
- The river catchments are mostly in Kenya. Therefore, the exploitation of the river requires a bilateral agreement between Kenya and Tanzania.
- Substantial pumping is required to raise the water to high ground.
- Access to the site is poor (poorly developed infrastructure).
- The temperature and attitude conditions lead to long cane maturity periods (20 - 22 months). Yields in this area are expected to be high.

Mahurunga – Mtwara:

- This site is in South - East Tanzania in the region of Mtwara, 40 km South of Mtwara town. The land available nearby covers about 8,900 hectare but suitable land is scattered in the whole area. A concentration of suitable land that can be developed as a cane estate amounts to only 1,300 ha.
- Irrigation water available from the Ruvuma river. The area is prone to flooding and the entire land requires flood protection and a drainage system.
- The potential project size is about 10,000 tons sugar per annum, with potential ethanol production from C-molasses of 810000 litres.
- If the scattered patches of suitable land are also put under cane intercropped with say paddy, the maximum- potential is about 30,000 tons sugar per annum (Potential ethanol production from C-molasses only of 2.4 million litres).
- Whether the land is still available would need to be verified because there have been plans for a rice project in that area.

Usangu Plains:

- This is a very large area of land Southern highlands of Tanzania in the Mbeya region.
- The soils are variable but areas with suitable soils are available.
- Availability of water is limiting and large storage dams would be required.
- The site could support production of 66,000 - 70,000 tonnes of sugar per annum (5.3-5.7 million litres ethanol from C-molasses).
- Any irrigation project in the area may impact upon the Ruaha river water balance and have an effect on hydropower. Clarification of this potential complication would be required before any irrigation project in the area could proceed.

Malagarasi (Luiche):

- This is a vast area Western Tanzania in Kigoma region. It is in the flood plain of the Malagarasi river. The soils are generally thought to be suitable for cane production, although detailed soils studies have not yet been done.
- Accessibility to area extremely difficult.
- This area is prone to flooding and a major drainage system would be needed.
- The cane production potential of this area is unknown but the overall potential is considered to be very large indeed. Detailed assessment of the potential is impeded by a lack of infra-structure.

The Wami coastal plain:

- This is a vast area in the alluvial flood and delta plain of the Wami River and its distributaries as it enters the Indian Ocean. The coastal plain covers an area of about 50,000 ha of which about 38,000 ha is considered potential agricultural land.
- Flood control is a pre-requisite to exploitation of the area.
- Rainfall in the area is 1,100 mm, evenly distributed over the year.
- Potential crops identified as being suitable include sugarcane but more detailed studies would be needed to confirm this.

Kilosa:

A large part of the Kilosa District is considered suitable for cane production. However, as the land is generally under peasant agriculture, the sugar development potential would be that largely based on outgrower cane production. The most suitable location for a sugar plant is the vicinity of Ulaya area where much cane is already grown. With a well planed outgrower cane production programme a sugar project in the order of 50-60,000 tonnes of sugar per annum would be possible.

Babati/Hanang:

There are a number of farms in the Babati and Hanang districts which grow sugarcane under irrigation for production of jaggery or which have the potential to grow cane. There is a possibility of farms close to each other (within a radius of 20 km) becoming sugar cane producers and supplying cane to a centrally located sugar mill/distillery.

Masaki Plains:

This is a large plain mainly in the coastal region but also extending into the Morogoro region. This plain was sited in the 1970s as being suitable for cane and sugar production. Little detailed information exists on the site, but the Sugar Board of Tanzania reports that a reconnaissance survey is to be undertaken to confirm that potential exists.

Of the nine potential sites identified, the Sugar Board considers Ruipa to be the most favourable for development in the short term. This site is seen as having the following advantages:

- This is a well studied area and much data and information on its potential for sugar production is available.
- The area is accessible by road and rail and is comparatively close to Dar es Salaam, the port and commercial centre.
- Proximity to the Kilombero Sugar Company and to some extent Mtibwa would make it easier to procure some project inputs like seed-cane etc.
- The area has a potential for future expansion to over 200,000 tonnes of sugar per annum.