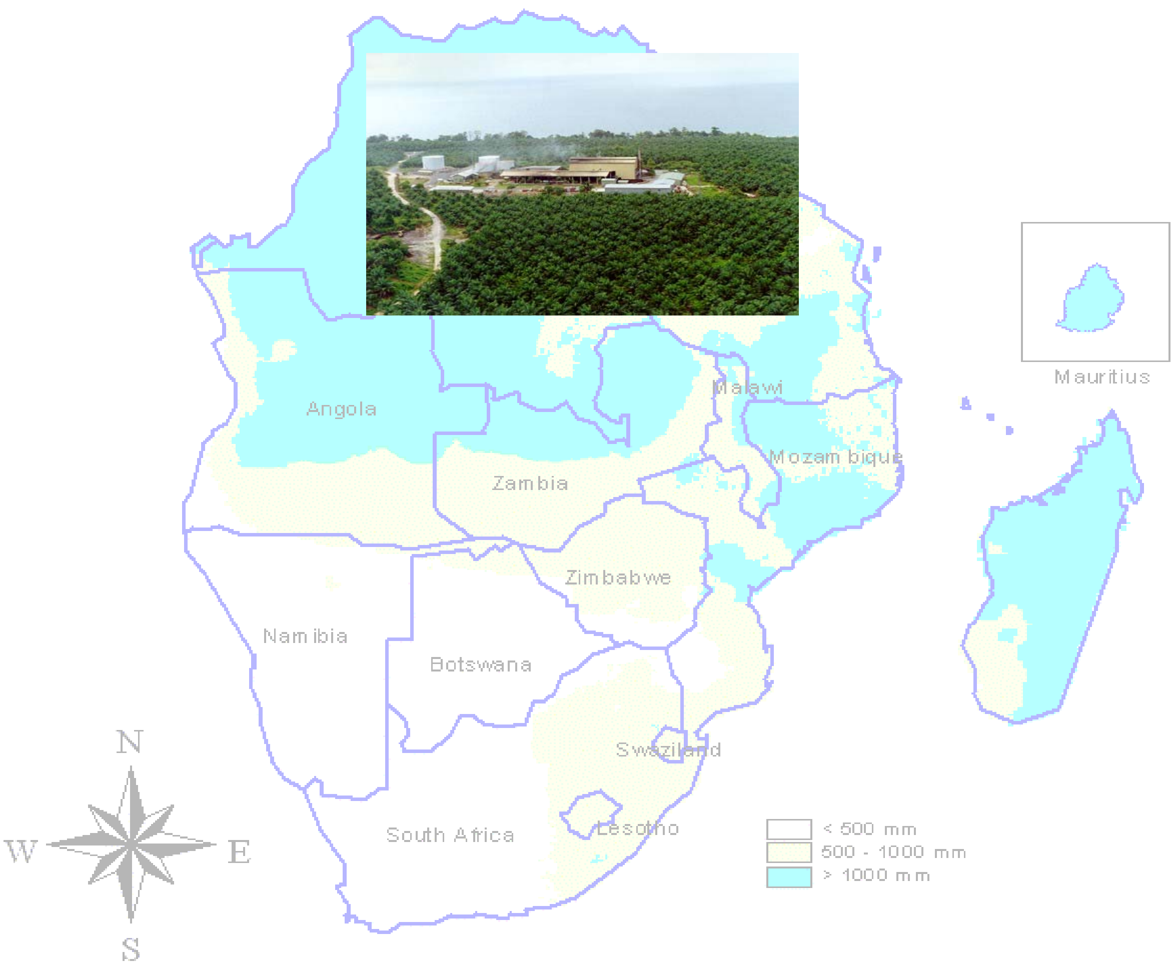
Feasibility Study for the Production and Use of



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DISCLAIMER

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CONTENTS

ABBREVIATIONS

ASTM	American Society for Testing and Materials
B100	100% bio-diesel
B20	Blending of Diesel with 20% bio-diesel
BOT	Build Operate and Transfer
CAADP	Comprehensive Africa Agriculture Development Programme
CDM	Clean Development Mechanism
CHP	Combined Heat & Power
CIF	Cost Insurance Freight
CO	Carbon Monoxide
CO_2	Carbon dioxide
COMESA	Common Market for Eastern and Southern Africa
cST	Kinetic Viscosity
DF	Diesel Fuel
DRC	Democratic Republic of Congo
E5	Ethanol Petrol blend of 5%
E10	Ethanol Petrol blend of 10%
E100	Ethanol Petrol blend of 100%
EAO	Environmental Affairs Office
EU	European Union
FAEE	Fatty Acid Ethyl Ester
FAME	Fatty Acid Methyl Ester – Biodiesel
FANR	Food Agriculture and Natural Resource
FAO	Food and Agriculture Organization
FFV	Flexible Fuel Vehicle
FIP	Fuel Injection Pumps
FOB	Free on Board
GEF	Global Environmental Facility
GHG	Green House Gas

GMO	Genetically Modified Organisms
GNP	Gross National Product
GREFF	Global Renewable Energy Fund of Funds
Ha	Hectares
HC	Hydrocarbons
HSD	High Speed Diesel
IEA	International Energy Agency
IIASA	International Institute for Applied System Analysis
IS	Infrastructure and Services
KW	Kilo Watt
MOA	Ministry of Agriculture
MNES	Ministry of Non-conventional Energy Sources, India
MMT	Methyl Cyclopentadienyl Manganese Tricarbonyl
MTBE	Methyl Tertiary Butyl Ether
MS	Molecular Sieve
MW	Mega Watt
NEPAD	New Partnership for Africa's Development
NGO	Non Government Organization
NOx	Oxides of Nitrogen
OECD	Organization of Economic Cooperation and Development
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
PPO	Pure Plant Oil
REEEP	Renewable Energy Efficiency Partnership
RISDP	Regional Indicative Strategic Development Plan
RME	Rape oil Methyl Ester
RS	Rectified Spirit – alcohol with concentration of between 80% to 95%v/v

RVO	Recycled Vegetable Oil
S	Sulphur
SABA	Southern Africa Biofuels Association
SADC	Southern African Development Community
SO_2	Sulphur Dioxide
SOx	Oxides of Sulfur
SPS	Sanitary and phytosanitary
SVO	Straight Vegetable Oil
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Program
WSSD	World Summit on Sustainable Development

EXECUTIVE SUMMARY

Background and justification of the study

The purpose of this consultancy study was to assess the feasibility for the production of biofuels in the SADC region. Persistent petroleum price increases put pressure on foreign exchange resources and slow down economic development. The SADC Extra-Ordinary Summit on Agriculture and Food Security (Dar es Salaam, 2004) noted that poor access to markets was a major barrier to the achievement of food security and agricultural development. A joint meeting of SADC senior officials of food, agriculture and natural resources and infrastructure and services (Gaborone, 2004) agreed that the biofuels initiative presented an opportunity for the region to produce its own renewable resources. This is consistent with the SADC Regional Indicative Strategic Plan (RISDP), and the World Summit on Sustainable Development (WSSD, South Africa, 2002). There is now substantial international experience with biofuels. Brazil was the first country to start a major biofuels programme in the 1970's, when it initiated the Ethanol programme. USA and Malawi followed suit in the 80's and Europe began its biodiesel program in 90's. Since then many countries including India, China, Thailand and Egypt have initiated the biofuels programme. The experience and policies of these countries deserves serious attention as SADC examines its potential for increased ethanol production.

Scope of the study

The consultancy, undertaken by a team of three experts (two from the region and one from India), was mainly a desktop study conducted over a period of five weeks (5 July to 5 August 2005) and implemented through the SADC Directorate for Food, Agriculture and Natural Resources (FANR), in collaboration with the Directorate for Infrastructure and Services (IS), in accordance with the terms of reference for the study. The process involved evaluating the potential for biofuel production and use in SADC, impact on employment, agricultural production, environment, trade and economic growth, and the potential bottlenecks that need to be addressed. Three case study countries, namely South Africa, Malawi and Zambia, were visited during the course of the study. Information was also obtained from a number of other SADC countries.

The findings of the study were overwhelming in terms of the potential and keenness to develop biofuels in the region. Key driving factors for the success of the programme are the need for a clearly defined policy on biofuels with mandatory blending standards, the sustainable availability of feedstock from agriculture and adequate financial incentives for investors and smallholder farmers.

Potential benefits of biofuels

What are biofuels?

Biofuels are liquid fuels from plant origin. It can either be biodiesel or ethanol. Biodiesel is diesel obtained from organic oils, mostly vegetable. Biodiesel is produced by modifying vegetable oils and reducing their viscosity by various methods. Ethanol is produced from sugar and starch.

The energy challenge is especially acute in the transport sector, as most vehicles will continue to rely on liquid fuels for the decennia to come. Diesel and petrol (gasoline), obtained from fossil oil, will gradually be replaced by renewable liquid fuels, which are called biofuels. The most important among them are pure plant oil or PPO, biodiesel (diesel derived from PPO) and ethanol made from starch or sugar. The crops that are used for biofuel production are called energy crops; these include palm oil, soyabeans, sunflower, coconut, jatropha, etc for biodiesel production and sugar cane, sweet sorghum, cassava, etc for ethanol production. Both of these groups of energy crops are widely grown in the SADC region suggesting that the region has a high potential to produce biofuels.

Benefits of biofuels

The potential benefits of biofuels are immense, and these include the following:

- Enhancing energy security, especially in the transport sector.
- Creation of rural employment and diversification of the rural economy.
- Creation of a huge market for agricultural products.
- Savings of foreign exchange equal to the value of imports substituted.
- Contribution to a cleaner environment through reducing green house gas and other vehicular emissions.
- Biofuel programs have potential to halt deforestation and desertification, as they also include use of oilseed-bearing drought resistant trees like jatropha.

The potential of biofuel production in SADC

Millions of SADC smallholder farmers are living in extreme poverty as they have limited or no access to both inputs and markets. They cannot afford fertilizers, as these are very expensive in remote areas with small trading volumes. Even for those farmers that can afford to pay for the inputs, there are little incentives to produce surpluses, as the markets for their products are remote. Huge transport costs make their competitiveness an illusion even on the assumption that policies on trade would be fair.

Most of the SADC Member States can grow most of the suggested energy crops. The ecology of the region can accommodate most crops. In some of the Member States land is still abundant e.g. in Angola, DRC, Mozambique, Tanzania, Zambia and Zimbabwe such that production of energy crops will not disturb food production. Agricultural research and the seed industry have untapped capacity to improve yields and productivity for all energy crops.

Climatic data exists for the past 30 to 40 years for most countries in the SADC region. These data can be used to model the growth of crops and determine their potential success rate. This would then allow a statistical determination of the potential success rate of each crop, and hence its suitability for biofuel production. This will be a critical component for informed decision-making in the biofuel programme.

Technical aspects of biofuels

Major liquid biofuels - straight or recycled vegetable oils (SVO or RVO), biodiesel and ethanol, blended with petroleum products or without blending, can be used in many applications. The applications include all areas in which petrol or diesel can be used in many diverse sectors such as transport, railways, marine, electricity generation, mining, agriculture, industry, commerce, defense and other multifunctional platforms.

Biofuels improve the properties of petroleum fuels and engine performance, and reduce health harming toxic emissions. The quality standards and process for manufacture of biofuels are well established in the world and achieving increasing degree of efficiency and economies of scale. Biofuels are safer and easy to handle, store, transport, blend and use. They are easily biodegradable while petroleum products are not. Minor technical drawbacks are easily addressed. Eco-friendly ethanol offers a unique opportunity as an ideal replacement of lead as it is phased out in the SADC region. All large vehicles and engine manufacturers offer warranties for blends of ethanol and biodiesel. It is important for the SADC region to formulate practical and simple standards, and build up manufacturing capacity and infrastructure for blending of ethanol at the earliest opportunity.

Location and size of biofuel processing plants

Appropriate location of processing plants is critical to the success of any venture including biofuels. Probably the most important factor is the adequate availability of desired quality of feedstocks that are accessible and are in close proximity. The availability of fairly well developed infrastructure, which can transport feedstocks and products efficiently and cost effectively is another major factor. A suitable location also must have reliable and efficient communication, commercial and banking network. In order to attract trained and skilled manpower the site must have social infrastructure including schools, medical and recreational facilities etc. Accessibility and proximity to markets is another important criterion. Environmental factors also determine the location of a biofuels unit. Industry and farmer friendly policies with political and economic stability are also major criteria in selecting locations for such units.

In summary, the size of biofuel plants will be determined by many factors including availability of feedstock and their proximity to the plant, the cost of transporting the biofuels and state of road and rail infrastructure, availability of reliable water supply, proximity to social infrastructure (hospitals, schools, shopping centres etc), market size and accessibility, economies of scale, availability and accessibility to finance, major risk factors, technological constraints, government policies and technical support.

The SADC region already has a centralized spatial database and Geographical Information Systems (GIS) that contains most of the information needed to carry out multi-criteria decision- making studies. These include digital maps of roads, railways, airports, water reservoirs and urban areas, among others.

Important issues for the success of biofuels

Since biofuel production involves many stakeholders from diverse sectors, it leads to a large number of issues for successful implementation of such a complex programme with many facets, some of which are summarized briefly here. There needs to be awareness and capacity building in this sector with sensitizing of political and administrative leadership of this region to the benefits of biofuels. In addition the other stakeholders need to be fully aware and undertake capacity building including relevant government departments, farmers, persons involved in agro-forestry, funding and financial institutions, related industries such as petroleum, automobile, engine, biofuels, industry associations, NGOs, academic and R&D institutions. It is important to have a vision and mission statement regarding the use of biofuels announced by the leadership of SADC at the earliest. A road map is required to be formulated with yearly incremental targets for use of biofuels. A detailed stable, long-term, holistic biofuel friendly policy needs to be formulated.

An institutional, legislative, and regulatory framework needs to be established at the earliest for the whole region with harmonized policies and tariff structures with adequate tax breaks for environment friendly biofuels. In addition to that, an institutional structure needs to be created such as a Biofuels Development Board or any other suitable name with a 'Biofuels Development Fund', which may be supported by imposing a small 'levy' on petroleum products. Commercial, investment and financial incentives that promote the implementation of national biofuel programs need to be in place. The issues related to agriculture and farmers that will lead to efficient development, production and purchase of feedstocks at reasonable prices are most important at the start of the program. The issue of reliance on single or multiple most appropriate feedstocks for each agro-climatic region needs to be addressed.

The technology and supply of plants for production of biofuels are well established and readily available internationally, but in depth analysis of most appropriate technology for the region is yet to be undertaken. The issue of effective utilization of by-products and effluents is essential. The issues of biodiversity, ecology and most importantly of pollution control need to be taken into account. The petroleum companies and engine manufacturers have to encourage and give consent to blending and use of blends of biofuels in their vehicles, as per agreed and reasonable quality standards, as has been done in many other countries in the world. A supply and distribution chain for biofuels along with development of market will have to be created for the region. Last but not the least R&D efforts need to be taken into account in the production of energy crops for biofuels and applications of biofuels.

Recommendations

The study came up with the following five major recommendations in order of priority:

- Set up an institutional framework to promote biofuels by establishing a Regional Biofuels Development Board or a similar autonomous organization to coordinate all aspects of the biofuel programme in the region;
- Study the available international experience in all aspects of biofuels including

policies, feedstocks, technologies and business models;

- Formulate and adopt holistic and biofuels friendly policies and a workable and practical implementation strategy;
- Showcase pilot projects at the earliest to demonstrate technology and the workability of the biofuel programme; and
- In each Member State Ministries or Departments responsible for energy, agriculture, environment, science and technology, trade, transport and finance in particular, should come together to discuss policy, technical issues, blending ratios, standards, markets, etc, and come up with a common position.

Way Forward

As a follow up to this study, it is suggested that a regional workshop be hosted to present the results of the study and obtain feedback from relevant Ministries. The hosting of national level workshops involving all stakeholders should follow this. The selection of a regional advisory team of experts on biofuels, and fostering linkages with financial institutions involved with biofuels, should be undertaken at the earliest. There will be need to liase with institutions specialising in GIS and agro-ecological zoning (such as FEWSNET, FAO, APIS) so as to map out best options for feedstock production. Early action is needed to calculate at the national level the volumes of the different biofuels to be produced in the individual countries, and to evaluate in greater depth the role of labour and capital issues in the production of biofuels.

Proposed Implementation Plan for the SADC Biofuels Programme

The report has also proposed an implementation plan for the SADC biofuels programme, based on the above-mentioned recommendations. A matrix is presented at the end of Chapter eight, including some specific activities. The five major expected outcomes for the implementation plan include the following:

- Increased awareness of the potential for the production of biofuels in the SADC region;
- Effective national and regional structures for executing the SADC biofuels programme;
- National and regional policies and strategies for the production and marketing of biofuels;
- Regional biofuels training and research and development programme;
- Budget and financing plan for the SADC biofuels programme.

Chapter One
Background

Origin and Purpose of the Study

The purpose of this study was to assess the feasibility for the production of biofuels in the SADC region. For the scope of this study biofuels are defined as liquid fuels of plant origin that can partially or totally replace fossil petroleum in all its uses. Biofuels have been examined, namely ethanol, vegetable oils and bio-diesel. It is important to mention at the outset that this study has not been about the whole range of alternative sources of renewable energy, which generally include solar power, wood, electricity and other non-petroleum products. It has been about liquid biofuels derived from agricultural crops that can be used in internal combustion engines for transportation and other related purposes. Ethanol is produced from a wide range of feedstocks such as cassava, sugarcane and sweet sorghum, maize, wheat and sugar beet and is used as a gasoline substitute or as an additive. Biodiesel can be obtained from most vegetable oils including: oil palm, rapeseed, soyabeans, sunflower and tree seeds (jatropha carcus). It can be used on its own or blended to any proportion with fossil diesel.

The intention of the study is not to suggest that fossil fuels should be replaced by biofuels, but rather to allow countries to diversify their energy portfolio using locally grown products. Persistent fuel price increases, potential disruption of supplies and foreign exchange shortages threaten energy security and slow down the rate of economic development. Biofuels will not displace land and agricultural resources for food security, but will stimulate investment in agriculture by opening new markets for farmers who produce the feedstocks for biofuels and ensure access to food and better living conditions.

The SADC Extra-Ordinary Summit on Agriculture and Food Security (Dar-es-Salaam, 15 May 2004) stressed among other things that farmers "access to markets was a major barrier to agricultural development and achievement of food security." This is also noted in the NEPAD Comprehensive Africa Agriculture Development Programme (CAADP). There are activities in the SADC Regional Indicative Strategic Plan (RISDP), which support the development of biofuels as highlighted later.

At the joint meeting of SADC senior officials from Ministries of Agriculture and Energy (Gaborone, 12 October 2004) held to strategise on 'Farming for Energy', it was agreed that the biofuel initiative presents an opportunity for the region to produce its own renewable energies. The participants noted the rocketing price of fossil fuel and its potentially devastating effect on SADC economies. The rise in oil prices has made biofuels to become viable alternative sources of energy. Even if fuel prices were to fall (which is highly unlikely in the long term), fuel production through farming would create massive increases in rural employment, and is fully in line with the Kyoto protocol on greenhouse gases (GHG) and the recommendations of the World Summit on Sustainable Development (WSSD), (South Africa, 2002). During this meeting SADC member states were called upon to consider biofuel production as a major priority and to take immediate action to avoid oil price induced crises, by creating the necessary harmonised legal and institutional framework to promote the production and use of biofuels.

The meeting also agreed that this process would require creation of awareness on biofuels in the region, the conducting of a feasibility study on the use of biofuels, establishment of successfully run pilot plants, the creation of a SADC biofuels association to facilitate interaction between public and private stakeholders, and the removal of financial and technical barriers to promote trade in biofuels and raw materials. Agricultural research and extension would also need to give serious attention to the development of bio-energy crops and agro-forestry and enhance the transfer of technology to smallholder farmers. Resource persons from Brazil, India and Germany and the South African oil company (SASOL) also attended the meeting and shared their experiences with biofuels.

Synergy with RISDP

The SADC biofuels initiative is in line with the Regional Indicative Strategic Development Plan (RISDP), which has been designed to provide strategic direction for priority intervention areas. RISDP projects and activities, which have a bearing on bio-energy, include the development of science and technology, harmonization of environment policies and standards to achieve sustainable development, promotion of public-private partnerships, the trade and industrial development strategy and the development of small and medium enterprises.

Another major thrust of RISDP is the proposed establishment of a regional integrated energy market including the harmonization of energy policies, regulations and legislation, and research and technology development on renewable energy sources. In the area of sustainable food security, strategies for increasing fertilizer use, access to land, the doubling of crop land under irrigation, removal of agricultural trade barriers and steps towards seed security and food reserve facility - all augur well for the production of biofuels in the region.

Following from the World Summit on Sustainable Development (WSSD) Member States were expected to develop their national strategy for sustainable development and implement through centers of excellence four priority areas of the SADC programme of action to combat desertification which are: range management, rural energy, environmental law and indigenous knowledge and appropriate technology, as part of implementation of RISDP.

International experiences with biofuels

The historical development of biofuels has been driven largely by the need to find outlets for surplus agricultural production and help keep farmers on the land. There was renewed interest in biofuels in the 1970s when prices of crude oil shot up in the wake of supply disruptions in the Middle East. Since then biofuels have been developed in their own right as an alternative source of renewable energy. Brazil for instance was the first country to start a major biofuels programme in the 1970's, when it initiated the ethanol programme. USA and Malawi followed suit in the 80's and Europe began its biodiesel program in 90's. Since then many countries including India, China, Thailand, Egypt have initiated the biofuels programme .The experience and policies of these countries deserves serious attention as SADC examines its potential for increased ethanol production.

The major factors which have generally tended to limit consistent investment in the production of biofuels are fluctuations in the availability and prices of feedstock, production costs in relation to crude oil prices, value of by-products and their marketability, and level of productivity in agriculture, processing technology and lack of policies for bioenergy products. On the other hand though, the advantage of biofuel is that it can be produced from a wide range of feedstocks many of which are already being grown and whose production can easily be increased.

The recent rapid increase in greenhouse emissions due mainly to uncontrolled growth in the use of fossil fuels and their impact on global warming have become issues of great concern internationally, leading to the signing of a number of international protocols (Rio Conference, Kyoto Protocol). The use of biofuel provides immense environmental benefits in terms of decreased GHG emissions. For example the White Paper on Energy Policy for the EU (1996) and the White Paper for Renewable Energy Resources (1997) projected that energy demand and dependency on imported energy would increase drastically unless urgent progress is made in renewable energy, and suggested a target to double the share of renewable energy (from 6% to 12% for bio-energy) in the total EU energy consumption by 2010. In the EU, the US and Canada, oilseed rape and soyabean oils are converted into biodiesel. The biodiesel capacity grew from almost nothing in 1990 to 1,800,000 tonnes a year in 2004, mostly in Europe. The EU is targeting to use 5.75% of biofuels in motor vehicles by2010. Malaysia has constructed a palm oil extractor with a capacity of 500,000 tonnes. Ethanol programmes also continue to grow rapidly in the many parts of the world.

The United Nations Conference on Trade and Development (UNCTAD) recently launched the biofuels initiative in Paris on 21 June 2005 which is aimed at helping developing countries build capacity in the production, use and trade of biofuel resources and technologies, and raise public and private sector awareness of the challenges and opportunities of increased biofuel use. An international expert group to be coordinated by UNCTAD has been set up and will work with other UN agencies, the private sector, non-governmental organizations and applied research centers as testimony to the amount of renewed attention being given to bio-energy internationally.

Methodology

The terms of reference for the feasibility study are shown in the Annex V. This consultancy assignment was mainly conceived as a desktop study conducted over a period of five weeks (5 July to 5 August 2005) and implemented through the SADC Directorate for Food, Agriculture and Natural Resources (FANR), in collaboration with the Directorate for Infrastructure and Services (IS). It involved evaluating the potential for biofuel production and use in SADC, impact on employment, agricultural production, environment, trade and economic growth, and the potential bottlenecks that need to be addressed. The seven energy-crops that grow in the region that were examined in the study include oil palm, sunflower, soya and Jatropha carcus for the production of biodiesel; and sugar cane, sweet sorghum and cassava for the production of ethanol. Field visits were made to South Africa, Malawi and Zambia. Zambia represents a landlocked country of the region with significant biofuel potential. Malawi has for a long time been blending ethanol with petrol, and South Africa has examined at considerable length the use of biofuels. While it would have been desirable to visit all member states, it was not feasible since the priority was to produce an initial macro-level assessment that would pave the way for in-depth country studies. The study reviewed some major available literature from developed countries and developing countries facing similar challenges, the history of biofuels, the global environmental context, and current initiatives worldwide. It assessed the relevance of biofuels in relation to the SADC Regional Indicative Strategic Development Plan (RISDP).

The field visits involved interviewing a cross-section of biofuel stakeholders that included government departments, farmers, oil companies, bankers, biodiesel, ethanol and sugar companies, and other private companies. General questions asked were on the definition of biofuels, production capacity, and linkage with energy policy, and the desired policy and institutional framework for biofuels. The full details of the meetings held with stakeholders are shown in Annex III. Annex IV shows the list of persons and organizations consulted during the field visits.

The consultancy team of three included a development economist as team leader (Dr Tobias Takavarasha), a fuel expert (Mr Jai Uppal) and an agronomist (Dr Hamimu Hongo), backstopped by Stefan De Keyser who is Crop Development Advisor at the SADC Secretariat. Annex VI shows brief profiles of the three consultants

Chapter Two

POTENTIAL BENEFITS OF BIOFUEL

Introduction

What is Biofuel?

Biofuel is liquid fuel produced from plant origin. It can either be biodiesel or ethanol. Biodiesel is diesel obtained from organic oils, mostly vegetable. Modifying vegetable oils and reducing their viscosity by various methods produce biodiesel. The most widely used process is transesterification, in which an alcohol from an ester is re-placed by another. Ethanol is produced from sugar-based crops such as sugar cane, sweet sorghum, and starch-based crops such as maize, cassava, or any type of grain or tuber.

Imagine SADC farmers growing on their fields the fuel necessary for all the vehicles and machines in the region, and kerosene for cooking and lighting. Technically it has been possible for many years, but the availability of cheap fossil oil has made the idea irrelevant.

Mother Nature had always satisfied man's energy needs in a renewable manner, until the industrial revolution pushed him to start exploiting the earth's fossil reserves: coal, fossil oil and 'natural' gas. These energy reserves, although abundantly available, are not unlimited and will become exhausted in a few decennia. Meanwhile the competition for energy is growing fierce with the price to be paid for the fossil reserves escalating, both in monetary and political terms. The much awaited miracle energy source, nuclear fusion, is not yet beyond its conceptual phase, and man's bitter experience with nuclear fission compels us to caution. The current circumstances bring renewable energy back under the spotlight. After all, our global energy needs (~ 4 10^{20} Joule/yr) are only a fraction of what the earth receives from the sun (~ 5 10^{24} Joule/yr).

The energy challenge is especially acute in the transport sector, as most vehicles will continue to rely on liquid fuels for the decennia to come. Diesel and petrol (gasoline), obtained from fossil oil, will gradually be replaced by renewable liquid fuels, which are called bio-fuels. The most important among them are pure plant oil or PPO, bio-diesel (diesel derived from PPO) and ethanol made from starch or sugar. Study results (International Energy Agency, 2004) [1] suggest that by 2050, bio-fuels could represent fifty percent of the fuels for transport. Brazil was the first country to venture into bio-fuels. The country started large-scale ethanol production from its sugar cane some twenty-five years ago. Today it can produce bio-fuel for its own consumption as well as for export. The Brazilian example has inspired others, and we now observe a spectacular growth in the global production of ethanol (to be blended with gasoline) and bio-diesel. Bio-fuels may soon become the single most important agricultural commodity.

[1] See 'Bio-fuels for Transport: an International Perspective'. (International Energy Agency, May 2004)

The crops that are used for bio-fuel production are called energy crops. Indications are strong that for the production of these, farming systems from the temperate regions will not be competitive vis-à-vis farming systems in the tropics. As a result, bio-fuels from the tropics will be much cheaper. In fact they already became price competitive with fossil oil[2]. Bio-fuels are therefore a source of hope for the farmers in the tropics, many of whom live in poverty today. This hope is reinforced by the additional fact that the production of bio-fuels does not require high technology.

For the bio-fuel potential to be developed, governments in the SADC region have to create the correct pro-poor environment. If they do this, the wealth from biofuels will in the future benefit millions of countrymen and women. A truly democratic change!

Today, with upward pressure on the oil price due to increased demand and tougher environmental requirements and with improved production and transformation techniques of crops, the production of bio-fuel is becoming an increasingly viable alternative. As can be seen, crude oil became more expensive than some agricultural commodities[3]. As a result, the global production of fuel ethanol (to be blended with gasoline) and bio-diesel is starting to grow spectacularly. As global food markets are saturated, leaving little room for expansion to trade in food commodities, bio-fuels and other industrial crops might soon become the major commodities in agricultural trade.

The world oil market is currently worth Euro 1000 billion per year. So the possibility to occupy even a fraction of this market represents a major opportunity for agriculture. Potentially, bio-fuels can totally replace fossil fuels one day. Just ethanol from sugar cane grown in developing countries might provide 10% globally by 2020, probably at very low cost. The first target for bio-fuel producers in the OECD is to reach 5% of the fuel market, which is in line with most governments' commitments after the World Summit on Sustainable Development (WSSD)[4]. While the US and European governments have put in place financial incentives to run the bio-fuel schemes, indications are strong that their farming systems are not competitive vis-à-vis farming systems in the tropics. Hence there is little doubt that the bio-fuel revolution will particularly benefit developing countries (SADC region in particular), which can produce bio-fuel for own consumption as well as for export. From nowhere, bio-fuel will soon become the most important agricultural commodity in the world

Benefits

A principal finding is that, while bio-fuels production costs are fairly easy to measure, the benefits are difficult to quantify. But this does not necessarily mean that the potential benefits are not substantial.

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[2] Price per liter: Crude oil (Brent) US$ 0.30, Palm oil (Malaysia) US$ 0.30, Ethanol (Brazil) US$ 0.20

[3] Crude oil USD 280/m^3 (refined petrol-diesel USD 500-1000 / m^3): Maize USD 120/t; Sugar USD 140/ m^3 (ethanol from Brazil USD 200/ m^3); soya USD 190/t (soya oil USD 500/ m^3); Malaysian palm oil USD 290/ m^3….

[4] This 5% of the fuel market equals Euro 50 bn per year, which can be compared with the total ACP agricultural exports to the EU, currently standing at Euro 7 bn per year.

- The potential benefits of bio-fuels are immense, starting with their capacity to create rural employment,
- Market for small-scale farmers and can be used to regulate oil crop prices.
- Foreign exchange savings by governments (by reducing the volume of fossil fuel imports).
- Improved energy security, lower emissions of greenhouse gasses. Bio-fuel is simple to use, is biodegradable, non-toxic and it reduces air pollutants, like particulates, sulfur, carbon monoxide, hydrocarbons etc.
- It is sustainable and environment-friendly. Neat bio-diesel is as biodegradable as sugar and less toxic than salt.
- The SADC energy sector will be less dependent on external vagaries, exchange rates, and will produce clean energy, which in turn will yield Kyoto-bonuses.
- Most of the oil-bearing crops are nitrogen-fixing plants. Hence they enrich the soil. Moreover, the energy crops consist solely of the plants hydrocarbon. Nitrogen, phosphorus and mineral elements can return to the field.
- Bio-fuel programmes have all the potential to halt deforestation and desertification, as they can include the use of oilseed-bearing, drought-resistant trees like jatropha and pongamia.
- SPS barriers cannot hamper trade in bio-fuels, as the products are not intended for human consumption.
- Finally, in the event of a famine in the region, the crops initially earmarked for bio-fuel production can be reallocated for human consumption. Therefore, a better understanding of how bio-fuels production affects crop and food markets is needed.

Biofuels: Ethanol and Biodiesel

Nature has always produced man's energy. Wood has heated the homesteads for thousands of years. Unfortunately, wood is not adapted as a source of energy in densely populated regions typical of our modern economy. Deforestation is a major threat to our countries.

Since the onset of the industrial revolution, the control over energy sources has been one of the major keys to success. This source of energy came essentially from the earth's fossil reserves: coal, fossil oil and 'natural' gas. The fossil reserves are limited and will be exhausted in a few decennia. World reserves are currently 70 billions of barrels, the daily needs stand at 80 million barrels[5]. The reserves would suffice for the next thirty years[6]. Alternative and clean energy sources are being sought. The world's most powerful nations are in the final stage of building the world's first energy plant based on nuclear fusion, which, unlike the nuclear fission plants, will not produce dangerous waste. Other increasingly important energy sources are waterpower, wind power and direct solar power. However, studies on the use of biomass remained so far limited to its

[5] See the nation master website to find more stats www.nationmaster.com
[6] A recent assessment from BP puts the world's reserves at forty years.

gasification and related mostly to waste[7]. Work on bio-fuels, considered irrelevant for years, is also picking up.

Brazil was the first country to start a major bio-fuel programme in the 1970s. The basis was ethanol, produced from the country's massive cane-sugar programme. Conventional engines can use ethanol if blended with petrol up to a maximum of 25%. Even though the potential is there, the Brazilian ethanol-run vehicles did not yet conquer the world market. Meanwhile, car manufacturers have developed fuel flexible engines that can run on any mixture of petrol and ethanol. Brazil's policy on production of bio-fuel (ethanol in particular) deserves more attention. In SADC, the potential for increased ethanol production should be examined, especially for smallholders.

A second option is biodiesel. This is diesel obtained from organic oils, mostly vegetable. Modifying vegetable oils and reducing their viscosity by various methods produce biodiesel. The most widely used process is transesterification, in which alcohol from ester is replaced by another alcohol. It can be used in compression-ignition (diesel) engines with no or minimal modifications. Biodiesel can be blended with conventional diesel in any proportion. It is easy to make, and can even be made in your kitchen (see www.veggievan.org). The use of vegetable oils in diesel engines is not new. Rudolph Diesel himself used vegetable oils to propel his engine in 1900. Argentina had castor oil-fuelled diesel engines in 1916. In 1928, a French engineer published a paper stating that vegetable oils can be used as fuels in diesel engines[8].

Modern production of biodiesel started in 1990 and production capacity has now reached a volume of 1.8 billion liters per year, mostly in Germany, Europe (1% of the motor distillate use, IEA). Big oil companies and car manufacturers are giving up their resistance against biofuel. While its production (in the OECD at least) is still more expensive than that of conventional diesel, it can be sold at competitive prices if exempted from certain taxes. The cost/benefit impact is much better in biofuel produced in developing countries. South Africa, the organizer of WSSD in 2002, is taking a lead in biofuels in the SADC region, followed by Malawi.

Biodiesel is simple to use, is biodegradable, non-toxic and it reduces air pollutants, like particulates, sulfur, carbon monoxide, hydrocarbons etc. It is sustainable and environment-friendly. Neat biodiesel is as biodegradable as sugar and less toxic than salt. Biodiesel can be used to regulate oil crop prices. Other potential benefits are the improved energy security, lower emissions of greenhouse gasses and reduction in solid wastes. Biodiesel is also a job creator. While in many other countries it is expected that biodiesel will enter into strong competition with other crops for labour and land, the situation in SADC is such that this competition is not there. Labour and land are not limiting factors in the region with very few exceptions (in South Africa, Lesotho and Mauritius).

[7] Such as the use of bagasse (biomass refuse from the processing of sugar cane) for electricity generation
[8] Joseph Vackayil, Biodiesel can fuel economy, Engines (2001, The Financial Express, India)

Biofuels for transport, including ethanol and biodiesel have the potential to displace a substantial amount of petroleum around the world over the next few decades; a clear trend in that direction has begun.

The potential of biofuel in SADC agriculture

Millions of SADC smallholder farmers are living in extreme poverty as they have limited or no access to both inputs and markets. They cannot afford fertilizers, as these are very expensive in remote areas with small trading volumes. Even for those farmers that can afford to pay the inputs, there are little incentives to produce surpluses, as the markets for their products are remote. Huge transport costs make their competitiveness an illusion even on the assumption that policies on trade would be fair. For example, smallholder maize farmers in Zambia's Northern or Western province cannot compete on the Lusaka market with bulk imports from abroad. Fuel is expensive, and therefore, transport is expensive. As a result, rural SADC is being emptied of its labour force as people hope to make more money in the cities. What used to be the economic heart of the region got marginalized in recent years.

Biofuel can completely change the setting. If farmers can produce fuels themselves they strike two birds at one go: transport costs go down and they have a guaranteed market for their products. At macro-economic level, the production of biofuel could employ millions of rural labourers, thereby boosting economic growth. Moreover, most SADC Member States can make huge savings on foreign exchange. As the country's expenses for energy are immediately re-injected into the economy, biofuels will generate a sustainable growth of the latter. The SADC energy sector will be less dependent on external vagaries, and exchange rates, and will produce clean energy, which in turn will yield Kyoto-bonuses.

SADC governments will have to prepare policies that target the smallholders as major beneficiaries in the development of this new economic sub-sector. New plantations may change the face of SADC. By allowing the smallholders to increase their income from biofuel production, they will be in a position to ensure their household food security. By allowing farmers to invest in their land, governments will ensure better sustainability of agriculture and improved environmental protection.

Most of the oil-bearing crops are nitrogen-fixing plants. Hence they enrich the soil. Moreover, the biofuels consist solely of the plants hydrocarbon. Nitrogen, phosphorus and mineral elements can return to the field. Bio fuel-programmes have all the potential to halt deforestation and desertification, as they can include the use of oilseed-bearing, drought-resistant trees like jatropha and pongamia.

An important element in the whole issue is the potential use of the by-products of biofuel. These can serve as animal feed, as source for gasification plants, in fertilizer production etcetera. Agriculture can produce many of the basic products for the organic chemistry industry (soaps, cosmetics, adhesives, etc) as well as the conventional petrochemistry (plastics, pitch, etc). SPS barriers cannot hamper trade in biofuels, as the products are not intended for human consumption. Finally, in the event of a famine in the region, the crops initially earmarked for bio-fuel production can be reallocated for human consumption.

The need for a dynamic pro-poor policy

All this, however, can happen only if the national and regional leadership, planners and the people get serious about the bio-fuel revolution.

In the EU, the US and Canada, oil seed rape and soybean oils are converted to bio-diesel. The bio-diesel capacity grew from nothing in 1990s to 1,800,000 tones a year in 2004, mostly in Europe. The EU is targeting to use 5.75% of bio-fuels in motor vehicles by 2010. Malaysia has constructed a palm oil extractor with a capacity of 500,000 tones. In the US, some firms convert used restaurant oils into bio-diesel. Most oils can be used, so besides the above, research should be done on the potential of other oil seeds such as castor oil seeds, coconut, etcetera.

Bio-diesel is still more expensive than conventional diesel, but it can be produced and sold at competitive prices if governments refrain from taxing it. High benefit/low cost bio-fuels are already being produced in developing countries like Brazil and India.

The current petroleum consumption in Southern Africa is about 0.7 million barrels a day (IEA). After refinery this produces roughly 12 million tones of diesel a year. If all of this were biodiesel SADC needs could be met from 400 plants (factories) with a capacity of 30,000 tones a year each. The cost of such a plant is 40 to 50 million Euros[9]. The production of bio-diesel can be done anywhere, as there is no minimum limit for the production plant. This again favors the rural areas. The SADC oil seed production needed thereto would be 60 million tones (valued US 12 billion). A first bio-diesel plant proposed by SASOL in South Africa might create a market of 0.5 million tones of soya. The company's choice for soya is determined by the fact that the by-products of soya extraction (soya cake, organic manure, glycerin) are easily marketable. Other agro-ecological zones in SADC might opt for other oil-bearing crops. Palm oil for instance has a much higher production per hectare than soya and groundnut and is more pest resistant. As palm oil is a labour intensive crop, its use might have a large impact on employment. It is also cheaper than soya oil.

The land to be put under oilseed crops would be 40 million hectares, as compared to the current 47 million hectares under crops. It would create an extra income for millions of SADC farmers. Hence it will help the farmers to increase productivity on their food cropland.

Environmental point of view.

It is argued that the world is short of suitable land for bio-fuel production, and that the production of energy crops will cause irreparable environmental degradation. FAO studies suggest that this will not be the case. There is still potential agricultural land that

[9] From the article ' Biodiesel Build-up' (Julia Kupka, in Farmer's weekly 27 February 2004)

is as yet unused. At present some 1.5 billion ha of land is used for arable and permanent crops, around 11 percent of the world's surface area[10]. A recent assessment by FAO and the International Institute for Applied Systems Analysis (IIASA)[11] suggests that a further 2.8 billion ha are to some degree suitable for rain fed production, which is largely sufficient to satisfy the world's energy needs.

The pool of unused suitable cropland is very unevenly distributed. Sub-Saharan Africa and Latin America are still farming only around a fifth of their potentially suitable cropland. Five countries of the Southern African Development Community (SADC) have ample room for expansion. Table 1 in chapter two assesses their potential cropland. The last column gives the hectares needed to satisfy their national energy needs (if sugar cane or oil palms are used as energy crops). All figures are given in millions of hectares.

A major conclusion is that these countries can easily satisfy their current energy needs by allocating a part (< 10%) of their cropland to energy crops. The income generated by this would allow farmers to buy fertilizers and to increase food production on the remaining land. Farming for energy will thus contribute to the national food security. The five countries can also choose to increase their cropland up to 100 million hectares. This would allow these countries to produce sufficient bio-fuel for the entire SADC region, which would today require 11 million hectares of energy crops. It would even allow for exports abroad. Using the figures above, the SADC agriculture sector could provide ten percent of the entire world's oil supply, representing a market share of US$ 100 billion. This is equal to 50% of SADC GNP.

Farming for Energy is not a threat to the environment or to the society, as some claim. It is instead a huge opportunity for sustainable development, in particular for the SADC region. There are many unfounded apprehensions regarding biofuels some of which are listed below:

The general arguments on bio-fuels and their correct perception in the region

	Argument	**Real situation**
1	Cars must change their engines to fit bio-fuels.	Not true. Blending up to 20% will require no engine alterations.
2	It's too expensive to use bio-fuel.	In the tropics this is not true. Conventional diesel in Tanzania is imported CIF Dar es Salaam at US$ 0.52 per litre compared to locally made bio-diesel from palm oil costing US$ 0.45 per liter
3	It consumes more energy than it provides.	The energy balance (energy out/energy in) is more than one, and it is 8 in the case of bio-diesel from palm oil. The ratio is better in tropics than in colder regions.
		Not true (for Africa in particular). FAO study on gross extents of agricultural land found worldwide 3 billion

[10] In the SADC region only 5% of the land is used, while about 20% is suitable for rain fed agriculture.
[11] Global Agro-Ecological Assessment for Agriculture in the 21st Century: Methodology and Results (Günter Fisher *et al*., January 2002)

4	There is no land.	hectares with potential for rain-fed cultivation of which half is currently under crops. Africa and Latin America share most of the remaining potential land.
5	It competes with food production.	This is only correct in regions with high input level that cannot expand land under crops. In regions with expansion potential and /low input levels there is no immediate competition. On the contrary, the income generated by the bio-fuel will allow farmers to increase productivity on their food cropland. This could even lead to a decreased cropland area.
6	People cannot even grow enough for their own food.	This is the most vicious passion killer as it starts from the assumption that (subsistence) farmers produce so little food because they are technically not capable to do better. This is wrong assumption. Farmers know how to produce more, but they have no market incentives to do so. It is the economy and technology which pushes marginalized farmers to subsistence (survival)
7	It is environmental disaster.	It not true. The replacement of fossil fuels by bio-fuels limits dramatically the production of Green House Gases (GHG). More over energy-crops are perennial crops, which will stabilize the soils and protect them from erosion.
8	If it were OK the big seven would have done it.	The big seven (oil companies) could have done a lot in the past, but they didn’t because they do not know much about farming. But more important is that bio-fuels are more interesting to the social economy than the capitalistic economy.
9	The rich will leave nothing for the poor.	This is not true. The rich will pay (and thus get a bit poorer) but the poor will sell (and get bit richer). Venturing into bio-fuels cannot be done by/for the rich alone nor by/for the poor alone. Bio-fuels need both rich and poor and will bring them nearer to each other. Bio-fuels are therefore, a real democratic revolution.
10	These are alien crops.	Some call Jatropha an alien and invasive crop. The same can be said to other energy crops as they b have been introduced from other parts of the world. However, environmental impact assessment done so far suggests that the dangers to local environment are limited.

Chapter Three

Production Potential of Feedstocks for Biofuels in the SADC Region

Status of agricultural production in the SADC region

This chapter will cover basic agronomic data for the seven suggested crops in the region by crop and by country and economic indicators for the region, including relevant map and tables.

While the US and European governments have put in place financial incentives to operate their bio-fuel program, energy crops from the temperate regions can hardly compete with energy crops grown near the equator. The average temperature in Africa is higher than in the temperate zone, allowing for faster biomass production, and African perennial crops have the potential to transform solar energy into biomass the whole year round. Therefore, comparative advantage is greater in Africa. Hence there is little doubt that the bio-fuel revolution will particularly benefit developing countries, which can produce bio-fuel for their own consumption as well as for export.

Particularly several factors, namely variability of rainfall performance in different parts of the region; particularly the start and end of rains and length of the rain period hamper agricultural production in the SADC region. Other limitations include high prices of farm inputs (fertilizer and other agro chemicals). As a result most farmers get yields of various crops (Annex VIII) well below the recommended. Another factor is lack of reliable markets of farm produce. For instance in 1976, farmers in Tanzania had most of their maize harvest rotting, as they could not sell their surplus. Equally in Malawi the government introduced the sunflower crop and farmers did their best but when it came time for harvesting farmers had no market for sale of their crop. This resulted in farmers abandoning the production of sunflower. If market is there which will be an incentive to farmers; production potential of most of the suggested energy crops in the SADC region is very high, and if farmers can sell their crops; they can finally buy farm inputs which will end up improving their production per unit area and eventually reducing the area under crop, thereby leaving room for energy crops. Bio-fuel scheme is one of the best solutions to this, as it will assure market to farmers, which is a good incentive to them.

The production status for the suggested energy crops are shown in Annex 3a-g, and the rainfall pattern in the SADC region is shown on the map in (Annex IX; Fig. 1). From both the production data and the rainfall pattern, it is obvious that SADC countries have a very high potential of producing the suggested energy crops especially, Angola, DRC, Mozambique, Tanzania, Zambia and Zimbabwe.

Suggested feedstocks to be grown for biofuel production in the SADC region.

This section will analyze the production potential for the seven energy crops identified for this study - oil palm, sweet sorghum, sugar cane, sunflower seed, soybeans, jatropha and cassava-by country, thus providing a basis for biofuels. Table 1 below shows the estimated production in SADC countries based on 2004 figures. This Table confirms that if the full potential of the region is used, there will be enough feedstock.

Table 1: Production status of the seven suggested energy crops (Yields in 000mt) (Based on FAO, 2004 figures)

Country	CROP						
	Palm oil	**Sunflower**	**Soyabean**	**Maize**	**Sorghum**	**Sugar cane**	**Cassava**
Angola	280	11		510		360	5 ,600
Botswana		7		10	32		
DRC	1,150		14.6	1,155	54	1,787	14,951
Lesotho				150	46		
Madagascar	21		0.05	349.7	1	2,460	2,191
Malawi		3.7		1,733	45	2,100	2,559
Mauritius				0.19		5,200	0.13
Mozambique		6.3		1,248	314	400	6,150
Namibia		0.05		33	6		
South Africa		675.5	220	9,737	449	19,095	
Swaziland				70	0.6	4,500	
Tanzania	65	28	2.1	2,800	650	1,800	6,890
Zambia		10	15	1,161	19	1,800	950
Zimbabwe		8	84	1,000	80	4,100	190
TOTAL	**1,516**	**749.6**	**335.8**	**19,957**	**1,697**	**43,602**	**39,441**

Most of the SADC Member States can grow most of the suggested energy crops. The ecology of the region can accommodate most crops. Sugar cane for example can be grown in most Member States but suitably in Angola, Malawi, Mauritius, Mozambique, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe; (Annex 1and 3). Using information from both Fig.1 and Table 2 in Annex 3, Member States, which are listed as suitable, can choose which crop they want to grow for bio-fuel. In a liberalizing sugar market, and as sugar quota are being phased out under the Cotonou Agreement, ethanol production provides a viable alternative in these countries.

While the utilization of the blended ethanol-petrol is known, the use of organic oil to drive diesel engines may not be well known. Bio-diesels might be a new theme in the SADC region, but it is not completely out of the picture. South Africa is taking a lead in the SADC region and has put in place some incentives for biofuels.

The status of production of the seven suggested crops in the SADC region is shown in Annex 3**.** It can be seen from this Annex that with the exception of a few crops (such as palm oil which can do well in Angola, DRC, Madagascar; Tanzania and Zambia) most of crops suggested can be grown in the region.

In some Member States, a crop such as *Jatropha* is new and hence research is needed to get more information before the crop can be introduced. Otherwise, *Jatropha* can do well in most areas of the region although production data is not available as it has been grown as hedges and the tree had no economic value till recently.

As the region has high potential of producing the suggested energy crops, SADC can embark on biofuel production, as feedstocks could be made available to the bio-fuel industries. Table 2 shows potential of arable land for five selected SADC countries.

Table 2: Arable land potential for five selected SADC countries

Country	Land Area (mil ha)	Suitable Cropland (~ 20 %) (mil ha)	Area Under Crops Today (mil ha)	Area Required For Domestic Energy Supply (mil ha)
DRC	227	45	8	0.2
Angola	125	25	4	0.6
Tanzania	88	18	5	0.3
Zambia	74	15	5	0.2
Mozambique	78	16	3	0.2

Source: FAO-IIASA and own calculations

Role of agricultural research, seed sector and suppliers of agro processing machinery

A. Role of agricultural research.

Most of research stations in SADC countries have been concentrating their research mainly on increased yield per unit area, drought, disease and pest resistance. Very little has been done on increased oil or starch content in most of the energy crops. Bearing in mind that bio-fuel is becoming an important issue in the region; researchers should now reorient their programmes of breeding for increased oil and starch content in addition to their previous targets. For crops such as maize, sweet sorghum and cassava, researchers should gear their research towards increased starch content so that the crops can be used for ethanol production. In crops such as oil palm, soya beans, sunflower, etc, oil content of these seeds should be a major target in research. On the other hand the sugar cane research should also put emphasis on sugar content of given varieties.

Availability of varieties of different oil, starch and sugar crops, will give farmers a wide choice to decide which crop to cultivate in their area (according to their ecological suitability of the crop) for production of bio-fuels in the region.

More research is needed in the region so that different varieties of energy crops can be improved to coup with the bio-fuels revolutionary ideas. As mentioned before Jaropha is relatively a new crop for which a completely new research agenda is needed for its commercialization.

B. Role of seed sector.

In any agricultural production system, supply of good quality seeds and planting material is a prime factor. SADC should strengthen the seed sector to assure seed availability. Harmonization of seed laws, trade and property rights should be a priority in the region.

This will ease the seed movement in the region particularly at this period where the issue of production of bio-fuels in the region is gaining pace. Seed is a backbone of agricultural production systems; but it will be important if the seed sector will put emphasis in seeds which farmers are used to instead of importing GMO seeds which still need time for farmers to get used to.

C. Role of suppliers of agro processing machinery.

Suppliers of the agro processing machineries in the region will play an important role to supply machineries, which need simple technology and are affordable. This will create market for small-scale farmers and encourage them to produce more. Agro processing machineries should be located in rural areas in order to encourage farmers to produce feedstocks.

Rough Prioritization of Energy Crops in the SADC Region.

The ranking and comparison of the seven energy crops targeted for the production of biofuels in the SADC region is discussed below. The ranking is based on potential impact on biofuel production in volume terms, employment creation, energy balance (i.e. the quantity of inputs used to produce a liter of biofuel), yield per unit of land, and the effects on food security and foreign exchange savings. Other considerations include the ease with which member countries will be able to harness land, water, farming skills and farm inputs and capital investments needed to produce the required volumes of feedstock, and whether the crop can also be used for food. This is only a provisional ranking. Detailed economic analyses will be needed to come up with a scientific ranking.

There are both positive and negative factors affecting each crop's contribution to the major objectives for biofuels, namely employment creation, environment, foreign exchange savings, farm income and economic development. Some indicators can be measured and quantified such as yields and costs per liter of biofuel, number of jobs created and foreign exchange savings, while others are subjective, for example impact on environment and food security arguments.

Looking at the comparisons on a crop-by-crop basis the rankings can be justified as follows:

Sugar cane

Sugar cane tops the list because it is already being widely grown in the region and its production can easily be expanded wherever there is irrigation and water. Its impact on employment is high. Considering that ethanol is produced from a by-product of sugar, molasses, there is a double benefit in terms of income. Ethanol is already widely used as a petrol blend and the processing technology is known and available. Its direct benefit on foreign exchange savings are easy to calculate, depending on the blending rate adopted.

Soybeans

Soybean is ranked second because of the same reasons as above. It is already widely grown by both large and smallholder farmers as a food crop and an industrial crop. Soybean is used for vegetable oil and animal feed. Expanded use for biodiesel will create additional demand and stimulate production, and this can be achieved within one season by increasing the area under production.

Oil palm
Oil palm scores high for biodiesel in terms of oil yield and capacity to produce large volumes in those parts of the region with suitable climate. Factors not in its favour include the time lag to full production and the fact that most parts of the region do not have the right climate for palm oil production. It is ranked third place.

Sunflower seed
Sunflower seed is ranked fourth because compared to soybean its oilcake is not easily marketable for stock feed, but its production can be quickly expanded for biodiesel.

Sweet sorghum
Although not yet widely grown as a commercial crop, sweet sorghum can be grown in drier parts of the region with benefits for small-scale farmers. It can be used to complement sugar cane for the production of ethanol, while the by-products will be used for animal feed. It is ranked fifth place.

Jatropha
Jatropha is ranked in the sixth place because it has not yet been commercially grown in the region, although the potential is there. There is still a lot to be discovered in terms of its agronomic suitability to produce the required volumes for biodeisel.

Cassava
With the exception of Malawi, Zambia, and Mozambique, cassava is not considered a major crop in the region. A lot of work would still need to be done before it can be fully integrated into the production of ethanol. It is therefore ranked in seventh place.

The relationship between biofuels and food security

It should be noted that food security is 'ACCESS to nutritious food for ALL people at ALL times.' Therefore the main issue in food security is the ACCESS. People can access food by either concentrating on the production of food crops or by having a reliable source of income to access the food in the market. The introduction of biofuels programmes in SADC Member States will improve farmer's income by assuring the market for their crops. It is important to note that introduction of biofuel schemes will not necessarily make farmers stop production of food crops. Some of the energy crops are perennial (such as coconut, palm oil, etc) and this means that once farmers plant them, will never replant in their life time because these crops have a life span of 30-45 years.

In addition some of the energy crops such as soyabeans or sunflower are usually planted at the end of growing season (towards end of the rain season) or after harvesting the main food crops such as maize or rice. This implies that farmers will have their main food crop first and then plant their energy crops for extra income to improve their food security. Some energy crops such as cotton is grown mainly for its lint but cotton seeds can be used to produce oil for biofuel production. Such a situation can improve price of cotton hence giving farmers more income. The biofuel scheme will therefore, not prevent farmers from producing their food crops and instead will improve food security for the household. It has been shown that reliable market of a particular crop is a big incentive to farmers to produce surpluses. Biofuel will provide a reliable market to farmers and hence act as an incentive.

There are two arguments that have been put forward in regard to the relationship between biofuels and food security. The first argument, which is not in favor of biofuels, is that the increased production of energy crops for biofuel will lead to a substitution of agricultural resources (land, water, labor, fertilizer) away from food crops, thereby contributing to food insecurity. The second argument, which is in favor of energy crops, is that biofuels will stimulate production and economic activity and attract more resources into agriculture with positive effects on food security. To understand these points it is important to examine the major causes of food insecurity in the SADC region. Many papers have been published on this subject indicating that food insecurity is primarily caused by economic and weather-based production failures. The failure by farmers and consumers to gain access to adequate food through purchases and trade also lead to food insecurity both at the regional, national and household levels. Production failures arise mainly from droughts, excessive rainfall, floods, pests and diseases and other natural disasters. These are quite common in the region. Even in years of reasonable rainfall farmers may still fail to gain access to fertilizer and high yielding seed varieties resulting in low productivity and food shortages. At the production level food shortages have generally been attributed to inappropriate policies and economic constraints, which negatively affect agriculture. Poor market access and lack of incentive prices adversely affect the capacity of farmers to produce, while high food prices and transport costs limit the accessibility of food by poor urban households and those in remote rural areas. Lack of farm credit and high interest rates invariably work against the achievement of food security objectives.

Several strategies are and will continue to be needed to address food security issues. These include the provision of credit and input packs, incentive prices and farmer training, irrigation development and expanding arable land for crop production. However, the rate of capital formation in agriculture remains very low. Terms of trade are unfavorable due to volatile world markets for agricultural products. There is poor response to improved technology caused by lack of inputs and markets. To sum up biofuels will contribute positively to food security by helping to address some of the above constraints in the following ways:

- Biofuels will attract new investment into agriculture by companies that normally do not invest in the sector, such as petroleum and car manufacturing companies and other investors because of their relatively higher returns. For example ethanol production enhances the value of sugar cane and justifies more investment.
- Additional land will be opened and new roads constructed in the biofuels production areas, with spill over benefits on food crops.
- Water and irrigation facilities will be installed, which will also be available for food crops and for drought mitigation;
- Arable land that is currently under utilized due to lack of markets will be put to

the production of energy crops thereby enhancing productivity and credit-worthiness of producers and the value of that land;

- Seed and fertilizer companies will be motivated to increase the availability of their products in the energy crop producing areas thus assisting food production;
- The additional markets, employment and income generated by biofuels will improve the purchasing power of many households;
- At the macroeconomic level the foreign exchange savings arising from biofuels will release more resources for the importation of fertilizer, tractors and other imported raw materials. In the event that supplementary food is to be imported there will be less strain on the economy.

Chapter Four

Technological Aspects of Biofuels

Introduction to Liquid Biofuels Technology:

The major commercial liquid biofuels can be classified as:

- **Straight Vegetable Oil and Recycled Vegetable Oils**
- **Biodiesel**
- **Ethanol**

Vegetable oils

Straight Vegetable Oils (SVO) or Neat Vegetable Oils or Pure Plant Oils (PPO) or also referred to as Bio-oils are vegetable oils that used after extraction from oil bearing seeds followed by filtration with minimum processing.

Recycled Vegetable Oils (RVO) or Waste Vegetable Oils are oils from wastes of food processing industries such as fryers that are filtered and treated so that they can be used, if possible, in applications similar to SVOs, and especially in the production of biodiesel.

Straight Vegetable Oils in transport

SVO is used directly as a fuel as well as a raw material for manufacture of biodiesel. The concept of using SVO is as old as the invention of diesel engine itself as Rudolf diesel is reported to have used peanut oil for operating his engine in the Paris exhibition and also in the patent specifications of 1911 (1). Depending on the type of engine and viscosity and melting point of various SVOs, one of the following methods may be employed for their use:

- Direct application without any treatment
- Starting the engine with diesel either to heat the oil or start it and ending with diesel to flush it of any deposits.
- Heat the oil to + 60 deg C
- Blend with diesel
- Blend with Ethanol, Methanol or similar viscosity reducing substances
- Processing the SVO or RVO to produce biodiesel

Heating of SVO can be carried out in a number of methods. The most common of this is to start the engine on diesel or biodiesel and use the exhaust flue gas heat or the radiator coolant heat to heat the SVO by a heat exchanger and switch over to it as soon as desired temperature is attained. A battery-operated glow plug may suffice in some cases particularly locations where the ambient temperatures are high and if the SVO being used is not very viscous.

While vegetable oil has been commercially used to operate stationery engines for some time, the use of vegetable oils for engines in the transport sector has taken place on informal basis without backing from any known large commercial vehicle manufacturers. However, several small companies in USA and Europe are providing kits, which can be retrofitted in existing engines of many vehicles (1) (2) (3). The technical literature on long-term endurance trials is also not readily available on vehicular engines. However, a detailed experimental investigation was undertaken with some degree of success but did not involve endurance trails (4)

Straight Vegetable Oils for electricity generation

As stated earlier, it is technically feasible, with minor modifications if required, to use many varieties of SVO for operating power plants based on engines that are normally designed for residual fuels like furnace oil/heavy fuel oil as these engines are designed to handle difficult fuels. Extensive trials have already been undertaken by a well-known manufacturer (5) on vegetable oils (without trans-esterification). Pre-treatment of oil may be required in some cases in order to remove excess of acidity in the oil (high acid number) and maintenance schedules/protocols may be specifically designed for this quality of fuel. Such power plants can be constructed and commissioned in a relatively short gestation period (6- 8 months), which is an advantage. A fairly large sized plant of 16 MWe with relatively long hours of operations (5000hours) has reported a very high average plant availability of 95%. The consumption of vegetable oil is expected to be slightly higher (10%) than diesel as its calorific value is lower (6). The engine for this power plant offers flexibility in use of fuels, as it is also possible to operate the plant on heavy stocks such as furnace oil if the availability of bio oil is not adequate. If the need arises, the engine can also run partly on vegetable oil and partly on furnace oil. This offers an opportunity for growers of oil seeds to attain a degree of confidence on the long term assured market for their product and will motivate them to undertake cultivation. The engine will be able to switch to increasing quantity of vegetable oil as it becomes available. It is reported that in 2002 a total of 18 combined heat and power plants were operating with vegetable oil and another 13 were being built (1).

Engines of smaller sizes have also been successfully developed in some other countries. In Brazil a demonstration project that employed a 93 KW engine (7) using palm oil was successfully used to supply electricity for 6 hours every day to a remote village with a population of 700 in the Amazon region for more than 10 months in the year 2003 for a total of 2500 operating hours. This innovative project was called “Project Generation of Electricity in Small Community of Amazonia Using Vegetable Oils (PROVEGAM). The project used diesel at the start and end of each operation. The engine maintenance frequency was higher with palm oil but this was offset by the fact that large quantities of diesel did not have to be transported to this isolated location.

In India an initiative was taken by one of authors in Winrock International India (WII) to prepare a project report for Ministry of Non-conventional Energy Sources (MNES), Government of India, on remote village electrification using SVO from Jatropha curcas seeds, which are grown traditional by the villagers (8). Subsequently, a demonstration program has been started by the Ministry of Non-conventional Energy Sources, Government of India, to use non edible SVO, particularly form Jatropha carcus seed oil and from *Pongamia piñata*, to operate engines to produce electricity for remote village electrification and other applications such as to operate irrigation pumps. Slow speed small Lister engines up to 20 KW are being tested to evaluate the performance and endurance of the engine as also to determine the maintenance schedule and protocol.

Other applications of Straight Vegetable Oils

In Africa also Indian Lister type engines were used in countries like Mali (9) for operating multifunctional platforms in which locally produced filtered oil from Jatropha curcas was used in engines and is reported to have significantly eliminated use of diesel. These engines were used to operate oil extraction units, grinding mills, water pump, etc. It is reported that the Jatropha oil can also be used as a lubricant in these engines (10). It was reported that only 10% of the energy was required for extraction of oil. Since the oil was produced inexpensively it could be sold at prices lower than diesel and its availability was better as its supply was not hampered in the rainy season, as was the case with diesel.

Another method of application of SVOs is to use it in a boiler as a combustion fuel and employing the high-pressure steam for generation of electricity with a steam turbine. The low-pressure steam can be used for heating homes or for industrial applications or can be totally condensed to be recycled back for steam generation. This method of cogeneration or Combined Heat & Power (CHP) system has a very high efficiency and is desirable where heat such as low-pressure steam or hot water requirement is high. This application is also particularly favourable when the price of vegetable oil (recycled or straight) is comparable to that of petroleum fuels such as furnace oils, heavy oil etc. and where cogeneration system exists or is required.

Technical advantages and benefits of Straight Vegetable Oils

Operating data has demonstrated that the exhaust emissions are considerably lower than diesel/furnace oil especially with respect to carbon monoxide and total hydrocarbons (THC). Oxides of Nitrogen (NOx) emissions are slightly higher but can be controlled but on the other hand SOx emissions are almost eliminated. It has been reported that the use of SVOs offers an opportunity to generate electricity and heat with significant environmental benefits such as lower emissions including sulfur emissions (6) and use of renewable fuel (bioenergy) to reduce the effects of global warming as no fossil carbon dioxide is emitted.

Process for extraction of Straight Vegetable Oils

The extraction of vegetable oil consist of pretreatment of seeds, if required, such as steaming followed by crushing the seeds in various type of presses such as:

- Hand operated mechanical presses
- Hand operated hydraulic presses
- Animal operated grinding mills cum presses
- Electric powered grinding mills cum press
- Electrically powered oil expellers
- Solvent extraction plants

While the first three processes mentioned above are generally inefficient and can only be used when the requirement of SVO is very limited, the last is the most efficient but are viable only if substantially large production is envisaged.

Small-decentralized expellers typically have throughputs ranging from 30 to 50 kg/hr to 1000 kg/hr. In these expellers the oil is normally extracted by cold pressing, the maximum oil that can removed from the oil seeds by this process is about 90% of the total and balance of the oil is retained by the oil cake. For these types of expellers the reduction in oil output is partly offset by an enhanced cake value particularly if the oil is edible oil as it is sold as a protein rich animal feed. A principle of typical small-decentralized electric powered expeller is shown in Annex X**.**

In many developing countries where the seed production is highly decentralized and the quantity of oil seeds to be crushed relatively small such units with low capital investment may be a viable option. In case the need arises these extraction units can eventually become an ancillary to the larger solvent plants as suppliers of raw materials i.e. crushed cake. For large-scale and efficient extraction of oil from oilseeds solvent extraction is the most commonly used process. In the solvent extraction process a solvent such as hexane is used to extract oil efficiently, usually, attaining an extraction efficiency of about 98%. For relatively smaller oil extraction units batch process while for large scale units continuous solvent extraction unit is preferred option.

After oil has been expelled the minimum treatment it needs to undergo is the process of filtration. The filtration is typically carried out using filter presses. The expelled SVO is pumped at sufficient pressure to a filter press or a number of filter presses. In the filter press the filter cloth removes the suspended solid impurities. A filter aid may be used to facilitate the filtration of oil.

In case the oil has a high acid content, another processing step that may be need to be carried out is to neutralize the oil with an alkali such as sodium hydroxide (caustic lye). The soap formed in the reaction can be removed either by washing and settling or by continuous centrifuges.

In case the gum content of the oil is high it may have to be degummed using various technologies including water, acid, enzyme etc.

Biodiesel

Biodiesel is the common name of product that has properties that are somewhat similar to that of and are compatible with fossil diesel. The technical definition of biodiesel – "a fuel comprised of non-alkyl esters of chain fatty acids derived from vegetable oil or animal fats, designated as B100, and meeting the requirements of ASTM D 6751"(11). It is also referred to as Fatty Acid Methyl Ester (FAME**)** or Fatty Acid Ethyl Ester (FAEE) or in Europe Rape Methyl Ester (RME) when it is made from oil of rapeseed. Biodiesel can be used in neat (unblended) form in applications where diesel is used or blended with diesel by simple process of mixing in desirable ratios. A blend percentage of up to 20% is most common as various standards, oil companies and vehicle/engine and their component manufacturers accept it. Some of the major applications are in transport sector – vehicles such as trucks, buses, cars etc; marine –ships, motor boats etc; farm applications such as tractors, harvesters, irrigation pumps; mining – in operation of mining machinery, defense; railways; stationery diesel engines for applications such as generation of electricity; etc.

Technical advantages and benefits of biodiesel

Biodiesel has a high octane number that improves engine performance, high lubricity that reduces wear and tear, low content of sulfur, aromatics and other toxics. It reduces emissions of Carbon Monoxide, Hydrocarbons, Poly Aromatic Hydrocarbons (PAH), Particulate Matter, and Sulfur Dioxide etc. It mitigates the effects of climate change and green house gases (GHGs) by reducing the addition of Carbon Dioxides to the atmosphere thereby contributing to realization of goals of the Kyoto Protocol. Each tonne of biodiesel reduces Carbon Dioxide to the extent of 2.51 tonnes and thereby offering opportunity to trade in Carbon and earn foreign exchange (12).

Processes for the manufacture of biodiesel

There are a number of processes for undertaking transesterification of vegetable oil including:

- **Alkaline Process**
- **Acid Process**
- **Catalyst free supercritical Process**

The most popular commercial process followed at present is the alkaline process.

In case the plant size is small it may be advisable to produce batch wise, which is easier to operate and is less automated but has higher manpower requirement. For larger plants continuous production is recommended in which continuous reaction takes place when producing biodiesel.

Process description in brief

The process of production of biodiesel involves reaction of vegetable oil with methanol or ethanol employing a catalyst such as sodium or potassium hydroxide. In this process the reaction that takes place is called transesterification, which results in formation or biodiesel and glycerol (glycerin). The methanol present in the glycerin phase is removed by distillation and glycerin concentrated by removal of water. The biodiesel is separated from the glycerin of higher density by settling or centrifuging. The glycerin in crude form can be processed and distilled to make various grades of glycerin that can be sold to various consumers. A water wash may be given to biodiesel to remove impurities from it including methanol, catalyst and any remaining free glycerin. It is then distilled to remove the methanol and also to remove the water and final traces of glycerin. A simplified process flow diagram is given in Annex X.

Although it is possible to manufacture biodiesel at a very small scale including at home it is not recommended because Methanol, normally non-renewable petrochemicals, used is highly toxic and has an adverse effect on human health. The biodiesel produced at such a small scale may not recover methanol from either the biodiesel or the glycerin. Any ingestion through contamination of water stream or even by inhalation may have adverse impact on health. Methanol, like Ethanol, is classified as a highly inflammable chemical under various laws and special procedure has to be followed in handling, transport, storage and use. On the other hand ethanol, a renewable biofuel, is not toxic but the transesterfication reaction with it is slower, the properties of biodiesel produced from it are slightly different.

Specifications and Quality Standards

Fuel used in engines must meet quality norms so that the engine operates as per its rating, endurance and has expected life span. In order to achieve these goals, it is necessary to set Standards of quality with detailed specifications. Approved standards are also necessary for the evaluation of health, safety, risks and environmental protection. Standards are necessary for the approval and warrantee commitment for engine and vehicles by manufacturers and are, therefore, a pre-requisite for the market introduction and commercialization of biofuels.

In Europe biodiesel is predominantly made from rapeseed oil and most of the experience, information and data available are dealing with the rapeseed methyl ester (RME). EU has developed a common Standard for fatty acid methyl ester i.e. EN14214 that is more comprehensive than the ASTM standard. The EU and US standards are given in Annex.XI and XII**.**South Africa is reported to have developed its Biodiesel Standards. The EU standards for Diesel are also shown in Annex XIII

Storage, handling and transportation of biodiesel

It has been reported that Free Fatty Acid content as well as viscosity of biodiesel has a tendency to increase on prolonged storage but the value is quite low. It is recommended that biodiesel be stored in clean, dry and approved tanks. Although the flash point of biodiesel is high compared to fossil diesel it should be treated in the same way as other petroleum products. It is, therefore, necessary to follow all precautions for biodiesel and it blends related to avoiding fire hazards and other safety measure involved in handling and storage of fossil diesel. Biodiesel can be stored for long periods in closed tanks. Underground storage may be preferable for areas with cold climates but it can be stored over ground with proper insulation, heating and other equipment may also have to be installed. B20 fuel can be stored in tanks, above ground depending on the pour point of the blend and ambient minimum temperatures. There is a possibility of using additives to improve its flow characteristics in case of low temperature storage and pumping biodiesel

and its blends. Biocides (which kills microbes) may also be used, if and when necessary, for prevention of microbial attack on the biodiesel in fuel tanks. Since biodiesel is biodegradable it has been estimated that it can be stored for a period of six to twelve months. The use of some anti-oxidant additives may also be required for relatively long-term storage of biodiesel.
It is to be noted that biodiesel is more biodegradable than petro diesel. Large biodiesel spills may be harmful to some extent but they are safer and less harmful when compared to fossil diesel. However, all precautions and preventive measures taken in case of fossil diesel should be followed for biodiesel and its blends to avoid spills or leakage and containment of spills.
Transportation of biodiesel does not require any special precautions and can be transported by tankers with necessary safety features and warnings on the tanker, as is the case with fossil diesel.

Blending of biodiesel

Biodiesel blends readily with fossil diesel in any proportion. For blending of biodiesel with fossil diesel simple static mixers may be used or even pouring the two together in a tank (splash blending) would be adequate. Proper flow/volume measuring instruments will have to be installed. Requisite additives, if required, may also be added during this process. The blending operation requires the same precautions as in storage and handling of fossil diesel. However, the petroleum companies may install adequate testing facilities to test the quality of biodiesel, if necessary. Blending of biodiesel with fossil diesel can be undertaken at the petroleum refinery, storage depot/terminals or at the retail dispensing stations. However, in order to control the quality and the blend percentage, it may be advisable that it is done under the supervision of the petroleum companies.

Engine warranties for use of biodiesel

With rapid expansion of biodiesel capacity and production, the engine manufacturers in the passenger and goods transport sector are increasingly offering warranties for their engines for a blend up to 20% (B20). Biodiesel has wide acceptability in Europe where most of the transport vehicle manufacturers have offered warranty for their engine subject to the biodiesel being of the EN (European standards). The manufacturers have recommended some changes in material of construction of rubber parts including hoses, seals etc. in older engines but are incorporating these changes in their newer models. On the other hand, most of the manufacturers in USA are offering warranties for 20% blend that is made as per ASTM Standards.

Ethanol

Feedstocks for the production of ethanol

Ethanol can be and is produced either by synthetic process, as a petrochemical, or from energy crops (organic feedstocks). The Ethanol from energy crops is often referred to as bio ethanol to differentiate it from synthetic. However, for the purpose of this report any reference to Ethanol will mean that it is derived from energy crops.

Ethanol or Alcohol can be manufactured from a large number of raw materials (feedstocks or energy crops) that fall into three main categories:

Sugar-based
In this category the main crops are sugar cane (sugar cane juice and molasses), sugar beet (beet juice and molasses), sweet sorghum.

Starch-based
All types of grain including wheat, rice, maize (corn), barley, malt, millet etc. are included in this. In addition, tubers such as potatoes, cassava (tapioca) etc. are also starch based.

Cellulose-based
This category includes agro-waste, agro-residues, bagasse, rice husk, straw, and groundnut shells, wood chips, saw dust, organic municipal waste etc. This substrate is still being in the R and D phase of development as the cost of production from this source works out to be more expensive as the cost of raw material is the lowest but the cost of the processing and finance cost are exorbitant. It must be pointed out that since cellulose based ethanol will make available huge quantities of low priced biomass, extensive R and D is being undertaken in this sector to make it commercially viable.

Various feedstocks available in the region for manufacture of Ethanol have been discussed at some length in the feedstocks chapter. The technology for manufacture of ethanol from various feedstocks is readily available in the world and is well established.

However, newer innovations in this technology such as continuous fermentation technology and pressure vacuum distillation technology have developed over the past decade or so. These have been successfully incorporated in a number of plants.

Traditionally, the alcohol produced in many countries is based on molasses as a raw material, which is waste by-product of the sugar industry. In Europe sugar beet juice is most popular while in Brazil and USA sugar cane (juice) and corn (maize) respectively are the main feed stocks. Alcohol has also been made from malt and grains such as wheat, barley, sorghum and tuber such as potatoes and cassava. . The alcohol from these sources has been largely used for potable purposes. Another crop that is being examined closely as a feedstock is sweet sorghum.

Molasses is the most commercially popular raw material because its low cost of production as it is a waste by product of the sugar industry. The processing cost is also the low for this raw material as the number of steps involved in its processing is the minimum and so is the utility consumption. The pricing of Ethanol would depend on the cost of various raw materials (substrates). It may also be reiterated that sugarcane is one of the most efficient crop for converting solar energy to biomass and sugar. In addition, cost of production of Ethanol based on damaged grain is likely to be low in case it is available at throwaway prices. The feedstock selection should be made after undertaking comprehensive resource assessment and examining the past and future long-term scenario with respect to availability and prices of various feedstock proposed to be used for each location specifically. It would not be appropriate to frame a general rule for the selection of feedstock for all the countries of the region.

Technical advantages and benefits of ethanol

Ethanol is an excellent oxygenate and octane enhancer and is a good additive for phasing out lead and other toxic octane boosters like Benzene, Aromatics, MTBE etc. In addition to its high octane number that improves engine performance, low content of sulfur, aromatics and other toxics, it reduces emissions of Carbon Monoxide, Hydrocarbons, PAH, Particulate Matter, Sulphur Dioxide etc. It mitigates the effects of climate change and green house gases (GHGs) by reducing the addition of Carbon Dioxides to the atmosphere thereby contributing to realization of goals of the Kyoto Protocol (13).

Brief process description

In case of starch-based feedstock the steps involved for production of Ethanol are slightly different from those based on sugar-based feedstocks. These include drying/crushing/grinding of the feedstock, if required, and thereafter water is added and mixing done. This is then subjected to liquefaction and sacchrification to convert the starch into sugar (a process called mashing), which is achieved by using enzymes after heating wort. The process thereafter is same as the process from molasses as a feedstock, which is described below. In the case of ethanol from sugarcane and sugar beet additional processing is undertaken to extract the juice and pre-treat the sugarcane and sugar beet juice to clarify it and remove the suspended impurities and evaporate it, if required, to appropriate concentration for undertaking fermentation. Thereafter the essential process for all feedstocks is similar to that followed in case of molasses as a feedstock that is described in the process description section. (See Flow sheet in Annex X).

The process of manufacturing essentially consists of molasses storage and handling, fermentation, distillation and subsequent dehydration of alcohol to produce Ethanol. A brief description is given hereunder:

Molasses is a by-product of a sugar factory and is generally stored in steel tanks. The molasses is then pumped to the molasses weighing system located in the plant premises. After weighing the molasses, it is then pumped to the Molasses dilutor where it is mixed with requisite quantity of good quality water. It is fermented thereafter in fermenters to convert fermentable sugar to alcohol/ethanol using the yeast, which has been propagated in an earlier step. During this process considerable amount of carbon dioxide (CO2) is released. The fermentation temperature is maintained at desired levels by recirculation of cooling water through heat exchangers. The fermentation step can either be carried out as a batch process or as a continuous process. At the end of fermentation process the sludge from liquid (fermented wash) may be removed and send for distillation. The process of fermentation is a microbiological process and requires high level of cleanliness and other precautions to avoid infection and obtain high desired yields of alcohol.

The CO_2 obtained during fermentation can be purified and compressed and can be used as compressed carbon dioxide (or as 'dry ice') for industrial as well as food and beverage industry including the soft drink sector.

In order to concentrate the alcohol in the wash and remove all suspended and dissolved solids in the wash it distilled in distillation columns. The distillation system may have one or more distillation columns. However, in order to reduce down time due to maintenance and also reduce costs, energy efficient commercial distillation processes are being used that reduces steam consumption. The alcohol obtained has a concentration of around 95%, often called rectified spirit, is collected in a tank for further processing or directly pumped to the alcohol dehydration system for removing last traces of water.

The effluent is discharged from the wash column and is sent for effluent treatment, often with recovery of biogas using biomethanation plant. An efficient biomethanation plant can often supply enough biogas as a fuel to meet the requirement of steam and electricity of the alcohol plant and also produce surplus electricity for other units. A significant part of the water can be recovered and recycled back to the plant after reverse osmosis. The effluent can further treated in effluent treatment plant or mixed with biomass and/or press mud from the sugar mill to make bio compost, which is sold to the farmers as manure.

The rectified spirit is thereafter dehydrated to obtain Ethanol of desired quality. There are three types of commercially used technologies available for dehydration:

- Molecular sieve technology
- Azeotropic distillation technology
- Membrane technology

Vapour phase Molecular Sieve technology is the most commercially popular, financially viable and environmentally friendly technology, which has emerged in the late 1980s. In this process special beads, referred to as molecular sieves, are used to remove water and to obtain Ethanol of + 99.5% concentration.

Membrane Technology is an emerging technology, not widely used commercially, which employs a membrane that allows smaller molecules to pass through while the larger ones cannot pass through. In this process membrane is acts as a filter to remove remaining water from the mixture of alcohol and water.

Azeotropic Distillation Technology was the most popular commercial technology but now has become outdated with the advent of MS technology. It employs another chemical, called entrainer, in order to remove the final water content in distillation column. A number of such entrainers are commercially used including cyclohexane, benzene etc. The entrainer is recovered and is recycled for reuse. However, small quantities are not recovered and since entrainers like benzene are highly carcinogenic their use should be avoided. This process also consumes higher energy (steam) consumption and therefore is no longer as efficient as MS process. It is essential to reiterate that the third component may cause air pollution as well as water pollution especially components such as benzene are known to be highly carcinogenic and therefore use of this technology should be avoided.

In conclusion, since the biofuels programme in the SADC region is in its inception stage, only the latest, best, most energy efficient, cost effective and environmentally friendly technology should be adopted. At present molecular sieve appears to be the most appropriate technology for manufacture of ethanol. Azeotropic distillation technology, especially the one using benzene as third component, therefore, needs to be discouraged so that it does not become a major health hazard in the years ahead.

Specifications and Quality Standards for ethanol:

It has been pointed out earlier that it is essential to adopt Standards of quality with detailed specifications. Many countries have adopted Standards for Ethanol for blending with petrol such as Brazil, USA, India, and EU etc. Since Malawi has been commercially blending 20% Ethanol in petrol for many years, it may be necessary to study the standards adopted by them Ethanol. Ethanol can be blended with petrol in any ratio. The petrol Standards for EU are given in Annex XIV. While Brazil blends ethanol to a maximum extent of 25% and uses 100% Ethanol (hydrous) (14), in USA the most common ratio is 10% (**13**) while India has adopted for 5% ethanol blend in petrol because of limitation in availability of Ethanol (15). All these countries have adopted their own Standards. The ASTM Standards of USA are attached as Annex XV

Storage, storability, handling and transportation of ethanol and its blends

Storage of Ethanol posses no major problems. However, long-term storage may lead to moisture (water) content in Ethanol increasing and result in some evaporation losses. Also since Ethanol readily mixes with water, precautions have to be taken that all tanks, pipe lines and other equipment handling ethanol are proper cleaned and water removed. In the storage dehydrating agents such as silica gel can be used to prevent uptake of moisture from the atmosphere by Ethanol. It is necessary to follow all precautions for ethanol and it blends related to avoiding fire hazards and other safety measure involved in handling and storage of petrol. It is to be noted that Ethanol is more biodegradable than petro diesel and spills of ethanol are safer and less harmful when compared to petrol. However, all precautions and preventive measures taken in case of petrol should be followed for Ethanol and its blends to avoid spills or leakage and containment of spills.
Transportation of Ethanol does not require any special precautions, except to ensure that the container is clean and does not contain water and is able to prevent ingress of water. It can be transported by tankers with necessary safety features and warnings on the tanker similar to that of petrol.

Blending of ethanol

Ethanol blends readily with petrol in any proportion. With few exceptions, the features of blending Ethanol with petrol and biodiesel with diesel are similar and have been covered earlier in this chapter.

Engine warranties for use of ethanol

Engine manufacturers in the passenger cars and other vehicles operating on Ethanol petrol blends have been offering warranties for their engines for a blend up to 25% (E25) in Brazil, while in USA and many other countries most vehicle manufacturers limit the warranty up to10% (E10), except in case of Flexible Fuel Vehicles (FFVs) in which case the warranties extent to any ratio. At times, the manufacturers may have to undertake minor changes in material of construction of some parts such as rubber parts including hoses, seals etc.

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Chapter Five

Location and Size of Biofuel Plant

Major factors and criteria for location of plant

Feedstocks

Price, availability, accessibility and proximity of raw materials/feedstocks have been considered to be the most important criteria for the location of a plant. Energy crops that are feedstocks for the production of biofuels can only be grown with high yields if the land is fertile and agro-climatic conditions of the area are optimum to the particular crop(s). Feedstock(s) should be competitively priced, be available in adequate quantities and, at the same time, be easily accessible in close proximity to the biofuels manufacturing unit. This reduces the transportation cost, which in turn, has a direct relation to the cost of manufacture. It should be noted that the feedstocks for biofuels are normally voluminous as they have low bulk density and, the same time, the starch/sugar/oil content is relatively low i.e. typically from 10% to 40%. Therefore, the transportation costs of biofuel feedstocks are relatively high. In order to be economically viable it is important that biofuels plants be set up in close proximity to the source of feedstocks. At the time of resource assessment, if the present and potential availability of feedstocks were found to be low it would lead to selecting a biofuels plant of sub-optimal capacity, which may render it unviable and therefore is one of the most critical criteria in selection of a biofuel plant.

In case of biodiesel, at least the oil extraction plant, be set up as close to the source of feedstocks as possible while the biodiesel plant may be some distance away. In exceptional cases, this may be an alternative as the vegetable oil is relatively high priced and contains about the same energy content as biodiesel. However, even in this case, handling and storage at two different sites are involved – one at oil extraction and other at production of biodiesel. This will, inevitably, increase its cost of production. In case ethanol is to be made from molasses it is important that such a production unit is located in close proximity to a large-sized sugar mill and, if possible, next to it so that surplus molasses is available at competitive prices by at very low transportation costs by pumping it to the ethanol plant.

Infrastructure

Availability of adequate infrastructure is required in order to transport feedstocks, raw materials, consumables, spares, products etc. Thus not only the road infrastructure may be required but also transportation system suitable for efficient movement of personnel and material is essential. Often when competition is intense and most efficient infrastructure gives a crucial competitive advantage. At times, efficient railway system is most cost competitive in transportation of large quantities of feedstocks and products over long distances in a land locked country. In case of other countries, proximity to an efficient port for long distance transportation of cargo, especially for export, may be another commercially attractive alternative which may add to cost advantage while selecting a location. For emergency spares and high value and low shelf life items, efficient and easily accessible air transport may be required. This is also a factor that may be considered. In efficient and competitive operation of biofuels plants adequate quantity of good quality of water and low cost and reliable electricity supply is essential. In addition, if landed costs of fuels of requisite quality are very high, it may be adversely effect the viability of plant and may have to be taken into consideration in selection of location. For maintaining the supply chain, it is essential that the locations selected have an efficient and reliable communication network that includes telephones, mobiles (cells), faxes, and emails, Internet etc. This is also an important factor in location of a plant.

Other infrastructure such as hospitals, schools, shopping center and recreational facilities is often essential to attract highly educated, trained and skilled manpower to manage the enterprise at optimum parameters in a highly competitive environment. Another factor that is taken into account while selecting a location is the availability of developed and efficient banking and commercial infrastructure. This is also essential to the success of any enterprise as often banking transactions have to be undertaken within the country and outside and dealings in foreign exchange may be involved.

Educated, trained and skilled Manpower

Availability of trained and skilled manpower is often a critical factor in selection of location for a plant or enterprise. If educated and skilled manpower at comparatively low cost is readily available it contributes to successful and efficient operation of the enterprise and, at the same time, ensures that manpower costs are competitive on a long-term basis.

Markets

Proximity to markets is an essential pre-requisite for deciding on the location of a unit for the manufacture of biofuels. Without easy accessibility to markets of adequate size the product would accumulate leading to temporary shutting down manufacturing plant and operating it below its optimum capacity. The proximity of the markets also cuts down the transportation costs and makes the product more competitive and may improve its commercial viability. Selecting a location with only a small market in close proximity may involve transporting biofuels over long distances, which will add cost in transportation and may result in its inability to effectively compete with other suppliers of biofuels or petroleum product.

Environmental Factors

Environmental factors are often key to location of plants. These process plants such as biofuel plants should not be located in the city or town but at an appropriate distance so as to avoid environmental and safety (fire) hazards. The plants should meet the environmental and air and effluent pollution norms of the country.

Political and economic stability

Political and economic stability is also an important factor in selection of location of an enterprise. Corporations, multinationals, entrepreneurs, funding agencies, banks and other such bodies are encouraged to invest at locations where long-term political and economic stability exist along with track record of investor friendly transparent policies. These include a reasonable law and order situation where safety of the employees and the management can be assured. Persistent unrest in any form is often perceived as a factor not conducive to location of the unit and the business.

Industry and farmer friendly policies

Industry and farmer friendly policies are also a very important factor. There are many countries that lack resources like feedstocks but have emerged as manufacturing or service industry hubs because of their industry friendly policies and high scores in other factors listed above. This factor is often considered critical by management of reputed companies while selecting a location, especially for a plant involving emerging technology or product as risk factors are higher and responsive policies and government machinery provides due comfort. The issue of granting reasonably long term land rights also becomes important for organization investing and undertaking plantation of energy crops and may be a significant factor in selecting location of a biofuels plant.

Plant Size

Major Factors and Criteria in determining Capacity or Size of Processing Plant

Availability of feedstock

Since biofuels are emerging commodity products the size of the plants is limited by the availability of feedstocks. These feedstocks are agricultural products, which have to be planted after acquiring and developing the land and procuring acceptable quality of seeds or planting material, nurtured, harvested and transported. The availability of fertile land with conducive agro-climatic conditions may also limit the size of the plant as the production of feedstocks depends also on the area of plantation. As plantation is a time consuming and, often, seasonal (once a year) exercise with limitations such as availability of planting material or irrigation facility, it may take a few years before optimum quantities of feedstocks can be assured. However, in the beginning, in most cases where feedstock production has not been established, either a biofuel plant operates on low capacity utilization or a smaller capacity plant may have to be set up initially. In exceptional cases only a small capacity plant will operate on a commercially viable basis on a long-term basis. Therefore, present and potential availability of feedstocks of desired quality are a major factor in selecting the plant capacity of biodiesel.

Market size and accessibility

Land-locked countries with relatively low consumption of petroleum products and with a weak infrastructure may have limited market for biofuels within the country. In such a case the size of the domestic market becomes a critical constraint in determining the size of the unit. The alternative may be to export biofuels in order to achieve economies of scale. However, because of poor infrastructure, and/or cost of transportation and /or government policies of the importing country including tariff and non-tariff barriers it may not be attractive proposition to export of the biofuels. In such a situation it would either import biofuels or may be constraint to set up smaller sized biofuel plant(s).

Economies of scale

Biofuels may have to commercially compete, not only with other producers of the same product but also with producers of petroleum products which are well established, are very efficient and are produced in refineries of extremely large capacity. In the case of commodity products every penny per liter saved through any technique may often make a difference between profit and loss. Thus all things being equal a large capacity plant is likely to be more commercially viable than a lower capacity plants. Therefore, economies of scale are very important for such products. Large capacity plants are often more automated and have better technologies, give better yields and efficiencies, recover by-products more efficiently and have the ability to convert them to value added products and diversify, if and when the opportunity arises. It is also to be noted that large capacity plants require substantial investment, which becomes attractive for large business house or multinational to invest in. Such organizations are very strong and have financial and marketing muscle, which ensures long-term sustained viability of a larger capacity plant. Often, such organizations enter the business when its success is assured and acquire smaller units as an entrance strategy into the market. As stated earlier, in view of the likely limited availability of feedstock smaller capacity plants may have to be set up initially. In exceptional cases, a small capacity plant will operate on a commercially viable basis on a long-term basis for a niche market.

Other factors

Often larger capacity plants require substantial investments not only in the processing plant but also in long-term investment in undertaking large-scale plantation of energy crops for biofuels feedstocks. Countries with political instability, policies that are not friendly to the industry, unfavourable law and order situation, unstable economies, low investor base and such factors are, generally, not attractive to entrepreneurs or commercial financial institutions for investing large amounts of capital. In some cases this may become a critical factor in inhibiting the setting up of a large capacity biofuels plant although potential may exist.

Since biofuels may not be established in a country or a region, another factor limiting the capacity of production plant may be that the Financial Institutions may shy away from making heavy investments in projects involving high capital costs in emerging technologies till a viable project of similar size has been set up and has been proven to be a success. Thus they may opt for financing smaller capacity projects if they appear to be viable. The uncertainty in the crude oil market is another risk factor that limits large-scale finance for such projects, as there may be reduction in crude oil price, which may render a biofuel project unviable. Thus such factors may also become a barrier in setting up of a large capacity plant

Technology constraints in determining the plant size

Often there are technical constraints in determining the size of the processing plants. While bench scale units, often made of glass, can produce a few liter per batch mainly in laboratories, large scale plants such as petroleum refineries can process as much as 30 billion liters per year processing almost 100 mill liters per day. In the case of biofuels, the size is restricted by the fact that the technology on a commercial scale is relatively new and it is still in the phase of development. Also the availability of feedstocks is another major constraint.

At the start of a biofuels program in a country plants are often of relatively low capacity. For example, in the case of Ethanol plants the average plant size in India is around 10 mill liters per year as the industry is in its infancy. On the other hand, the average plant size is more than ten times this size in Brazil where the ethanol program is well established since its inception three decades ago.

In SADC region, Malawi already has two Ethanol plants of capacity of 20 million liters per year each based on sugarcane molasses. The capacity of Ethanol plants in this region has to be decided on present and potential availability of feedstocks, potential to sell the product and on detailed analysis of financial viability of individual projects. In some countries using cheap molasses, 10 million liters per day plant may be viable while entrepreneurs in other countries may opt for larger plants using feedstocks such as sugarcane, cassava, and sweet sorghum.

In case of biodiesel, commercial units with a capacity of a less than a few thousand liters per year and upwards are available. Normally the new biodiesel plants being set up in Europe are of capacity in the range of 100 million liters per year. One of the largest plants being set in UK is reported to be of capacity 350 million liters per year **(1).** It is reported that a plant with a capacity of double this size is proposed to be set up in Malaysia (3&4).

As in the case of Ethanol, the size Biodiesel plant in SADC region would depend on the present and potential availability of feedstocks, access to markets and detailed analysis of financial viability of individual projects. A number of small plants of even 0.3 mill liters per year to around 25 times this size may come because of limitations already listed above. These plants may play a crucial and significant role in the initial stages of biodiesel program, as is the case in India. Some relatively small demonstration plants of biodiesel may also be set up, with government assistance, in order to start the blending program in some cities or a province(s). However, ultimately, over a long period, with a few exceptions of niche players, they would be constraint by a number of factors such as a lack of on-line process control and quality monitoring systems; efficient recovery of by-products; lower yields; not utilizing the economies of scale etc. Once the biodiesel program gets established and matures in SADC region, medium to large plants will play a significant role on a long-term basis.

(2) Biofuels Corporation Ltd., UK, Plant News Reports on fresh public issue of equity2005
(3) Sudhir Nathak, Energy & Power, Dhaka
(4) Ir. Chee Meng Sang & Soeren Varming - CDM Potential in Malaysia

Chapter Six

Important Issues for the Success of Biofuels Program

Since biofuels involve a large number of stakeholders from various sectors including agriculture, industry, energy, transportation, finance, environment, and consumers, it leads to a large number of important issues for successfully implementing the biofuels program. Some of major issues are listed below:

Awareness and capacity building issues

- Sensitizing political and administrative leaderships in the SADC region on the benefits and spin offs of a large-scale Biofuels Program and building consensus on the urgent need for starting such a program.
- Creating widespread awareness about various liquid biofuels, their wide range of applications, benefits and advantages in the major stakeholders including:
    - Relevant departments of Governments including finance, commerce, energy, agriculture, forestry, environment, industry etc.
    - Farmers and related personnel involved in agro/social forestry
    - Funding and financial institutions, development and commercial banks
    - Various stakeholders including industry, sugar mills, vegetable oil processing companies, petroleum companies, vehicle manufacturers, technology and plant suppliers, Industry Associations, consultants, academic and R and D institutions etc
    - Electronic and print media and through the media public in general who need to be informed about the role of biofuels in rural employment, energy security, environment etc.
- Undertake capacity building so that adequate skilled and trained manpower is available including training where ever required of relevant personnel involved in:
    - Relevant Government departments such as Energy and Agriculture
    - Financing and funding of such projects
    - Farmers on agro-technology and practices for plantation of energy crops for biofuels feedstocks
    - Technicians, engineers, managerial and other personnel involved in operating biofuels plants, blending, quality control, applications including use of vegetable oil in stationery engines

- Create awareness of the applications of straight vegetable oil (SVOs) in the energy sector and their uses needs to be promoted. Existing potential local users and entrepreneurs need to be educated of their vast potential in stationery engines.
- Create a focal organization, such as the Biofuels Development Board, that continuously collects and collates world and regional information, knowledge, experience and lessons learnt thereof on biofuels and their feedstocks and disseminates it effectively and promptly within the SADC region to all stakeholders including interested individuals and organizations.

Policy and workable implementation strategy

- It is essential that a holistic and well thought through, stable and long-term, enterprise friendly ‘Biofuels Policy’ is formulated and is in place at the earliest and is integrated in the energy and transport policy in the region. Such a policy should incorporate the most appropriate policies, workable strategies and advanced practices being followed in countries with most successful Biofuels Programs and modifying them, if necessary, so that it is suitable to the SADC region. The introduction of unleaded petrol in the region provides a unique opportunity to introduce Ethanol as a blend and an oxygenate and is better than Methyl Tertiary Butyl Ether (MTBE), Benzene, Aromatics, Methylcyclopetadienyl Manganese Tricarbonyl (MMT) etc. as an octane booster.
- The Biofuel Policy should ensure that procedures are simple, and controls and tariff and non-tariff barriers are minimum within the SADC region.
- A high-powered ministerial task force of the SADC region is set up to monitor the implementation of biofuels program in the region.
- Creating a Vision with long term goals, a Mission with a road map and a comprehensively thought through and a well defined strategy that includes setting up of annual blending targets for the next 10 years with detailed action plans.
- Treating biofuels as a priority sector and putting in place farmer and investor friendly policies by providing activities related to it all benefits and incentives that are normally offered to agriculture, industry, renewable energy and environmentally friendly technologies, and other such priority sectors
- There also needs to be a high-powered nodal ministry to coordinate the program in each country.
- Creating a permanent Institutional framework, a regional nodal agency, such as Biofuels Development Board having Biofuels Development Fund in the SADC Secretariat and in each of the Member States. In addition, it is important that the Board, in turn, sets up a committee consisting of all stakeholder including nodal ministries and representatives of the farmers, biofuels manufacturing industry, petroleum industry, vehicle manufacturers, NGOs etc who meet regularly to sort out problems, barriers and to undertake planning for the future including deciding on the blend composition. .
- Impose a small ‘cess’ or nominal ‘levy’ on all petroleum products to finance the Biofuels Development Fund
- Tax breaks for green fuels (biofuels) should be given in the beginning to encourage investments into this sector. ‘De-taxation’ of green biofuels is being widely adopted in all leading countries to spur growth of biofuels and to reduce vehicular pollution and green house gases to comply with the Kyoto Protocol.
- Along with encouragement of entrepreneurs and private sector try to incubate new organizational models including ‘out grower schemes’ and co-operative sector in which the farmers have a stake in the production of biofuels.
- Use poverty alleviation funds and other funds such as ‘food for work’ to foster cultivation of biofuels in arable land and forests.

- Commit on high priority basis to assist in all ways, including financial, to set up first demonstration biofuels projects in the region as these would show case technology and the viability of such projects
- Assure the farmers of reasonable prices for their biofuels crops until the production of biofuels stabilizes in the region. Stability of prices of feedstock is essential for the success of this program as farmers need assurance so that they continue in the biofuels crops business before it stabilizes
- Prepare a contingency plan to effectively undertake risk management of any temporary downside of biofuels if any, such as by mitigating the effects of unanticipated decline in petroleum prices, by-products, draught, environmental, socio-political issues. Since long-term upward trend in petroleum products appears to be inevitable, adequate provision (financial) must be made for short-term downward fluctuations, if and when they take place.
- Ensure fair purchase price of biofuels that leads to adequate return on capital and other acceptable financial parameters so that it encourages bankers, financial institutions and shareholders to invest in biofuels projects. Long-term viability of a project is important for its sustained growth.
- The Policy should encourage not only production of Biofuels but also that of electricity for internal consumption as well, wherever possible, for supply to the national grid.
- Ultimately, the policies and awareness should light up the spirit of enterprise in the region.

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Legislative, legal and regulatory framework

- Enacting legislations or amending Acts, rules and regulations to enable blending of biofuels and use of neat biofuels. Ensure all laws, rules and regulations are in place to permit and encourage blending but at the same time provide flexibility in variation of blend percentage. Formulating and enacting legislation mandating the use of biofuels to the extent possible
- Develop National and Regional Standards and ensure that harmonized quality standards are adopted in the region that are simple, practical and workable but adequate in consultation with major stakeholders including manufacturers of biofuels, petroleum companies and the vehicle manufacturers.
- Putting in place farmer and investor friendly legislations, regulations and rules and placing it in the high priority list and providing all benefits that are accorded to such sectors including government grants and investment as equity etc.
- Taxation issues – exemption of taxation on biofuels and protection to oil companies from double taxation
- Introduce mandatory provision for blending of biofuels to the extent available
- Address issues of regulations including Amendment in various Acts, rules and regulation such as ‘Petroleum Act, Standards, Adulteration Act, Weights and Measure Act’ etc
- Sort out issues of land rights so that long term land lease can be given for plantation of biofuels

- Simplify the rules and regulations and treat Ethanol as a chemical once it has been denatured.

Investment, capital, finance and commercial issues

- In order to compete with petroleum products take steps to bring down cost of production of biofuels by investing in most suitable energy crops in regions that produce them most efficiently, achieving the requisite economies of scale, subject to availability of adequate feedstocks, and increasing efficiency in the complete supply, manufacturing and distribution chain over a period of time.
- Putting in place farmer and investor friendly environment by placing it in the high priority list and providing, through agriculture and industrial development banks, benefits such as facilitating in the availability of soft loans - high Debt to Equity (DE) ratio, low interest rate, venture capital, government grants, government investment as equity, long moratorium period etc.
- Encourage commercial Financial Institutions (FIs) and Banks to give soft loans with lower rate of interest and higher DE ratio and with a longer moratorium period for, at least a few demonstration projects .by providing adequate security/comfort to bankers.
- Ensure fair purchase prices of biofuels such that it leads to adequate return on capital and other acceptable financial parameters so that it encourages bankers, financial institutions and shareholders to invest in biofuels project.
- Utilize resources of Biofuels Development Fund from levy, already suggested earlier, for risk management including hedging against any temporary fall in price of crude.
- Access to biofuels and by-product market with total purchase of production by buyer (petroleum companies and other users) at viable prices
- Regular and timely payment by the buyer (oil companies) to the producers of biofuels who in turn ensure same to the farmers

Agricultural and farmers issues

- Depending on agro-climatic conditions, selection of appropriate oil seed crops that are likely to be feasible, economically/commercially viable, quality wise suitable for manufacture of biofuels and will have a benign or positive impact for each region
- Use of best agriculture practices and agro technology in regions with optimum agro-climatic conditions employing high yielding seeds or planting material for plantation
- Make available optimum inputs of proper quality – fertilizer, manure, natural and chemical insecticides and pesticides
- Minimum economic size of plantation must be undertaken in regions selected for plantation of biofuels crops.
- Timely, efficient and cost effective harvesting, collection and transportation of oilseeds to oil extraction units by providing access to requisite machinery, trained & reliable manpower, transportation infrastructure and transport vehicles within

requisite time so that feedstock is transported promptly without deterioration that adversely affects the yield

- Government must create and provide adequate infrastructure in areas where biofuels energy crops plantation is undertaken
- Ensure that adequate minimum price of feedstock is paid so that it is economically viable and financially attractive for farmers and those involved in agro-forestry to grow the crop on a long-term basis.
- Where ever possible promote multiple feedstocks for biofuels production so that total reliance on one crop is avoided as a risk management strategy
- Selection of biofuels feedstock crops for plantation that are as draught resistant as possible
- Initially to provide grants, incentives and facilitate plantation of biofuels feedstocks to small and marginal farmers and out growers.
- Promote crops such as maize, cassava, soya, and palm oil, sunflower that can also be used for edible purposes in case of food shortages.

Biofuels technology and production

- Ensure adequate availability of acceptable quality of feedstocks and raw materials at viable landed prices are available in proximity to the plant so as to avoid deterioration and high cost of transportation. Selecting the appropriate location for the biofuels plant is critical to its long-term success.
- Adopt clean, latest and up-to-date technologies that are most appropriate to the region and are able to operate on multiple feedstocks so as to provide flexibility. Technology, plant and machinery selected should be reliable and efficient and should be at competitive prices with ready availability of spares and after sales service.
- Install plants that are expandable and assist in utilizing economies of scale at a later date, if the need arises.
- In order to operate at high capacity utilization and throughout the year set up a multi/flexi feed plant that can use wide varieties of feedstocks, if necessary.
- Provide adequate availability of basic infrastructure at the site of proposed unit – Electricity, fuel, water, roads, hospitals, schools, accommodation etc. Cost of transportation and feasibility of transportation of feedstock's and raw material from source and product to the buyers.
- Ensure that the product (biofuels) produced is as per quality standard and that total quality management takes place at all stages of production.
- Negotiating with Oil companies to take their consent in blending of biofuels in petroleum products and arriving at road map regarding the extent of blending
- Negotiating with vehicle manufacturers on providing warranties for the vehicles using biofuels blends.
- Purchase of power at economical rates from power generation units operating by Ethanol, Vegetable Oils –straight (SVO) or recycled (RVO) or Biodiesel or from its by-products such as cake, fruit shell, hull, waste etc. and permitting 'wheeling' of power.

- Efficiently utilize by-products including cake, glycerol, effluents
- Creation of adequate storage facility by biofuels manufacturers as well as the buyers
- Installation of adequate testing facility with biodiesel manufacturers & the buyers
- Establish a full-proof system that ensures that adequate measures are in force so as not to mix non edible and edible oils or potable alcohol and denatured ethanol, if both edible/potable and biofuels markets are to be served.

Supply and distribution chain and market development

- In a highly competitive environment, adequate infrastructure, including roads, ports, airports, railways, and supply chain needs to be in place in order to transport feedstocks, raw materials, consumables, spares, products, by-products etc. efficiently and cost effectively as it is critical to the success of a biofuels production enterprise.
- Availability of railway or/and a port in close proximity of a biofuels plant may be essential for long distance transportation of products or feedstocks or intermediates.
- Ensuring adequate availability of good quality water, low priced and reliable supply of electricity and fuels.
- Efficient and reliable communication network including telephones, mobiles (cells), faxes, emails, internet etc, is essential for the long-term sustainability of any industrial activity including biofuels plants
- A formal, efficient and vibrant supply and distribution/supply chain for all feedstocks and products needs to be established in order to be commercially sustainable.
- Availability of banking infrastructure near the location of biofuels plants is essential for maintaining operation of the unit and also the supply and marketing chain.
- Since the major consumer of biofuels is likely to be a petroleum company that is normally a very large multinational while the producer may be a smaller enterprise it is essential that fair play be ensured on both sides by constituting a committee to sort out problems of marketing and commercial issues, if any.
- The Governments need to keep the option open of export of any surplus SVO, biodiesel, glycerine, oil cake, biomass in the national and international markets if the prices are attractive

Research and development

- For long term-success of the biofuels program it is essential that the prices of feedstocks as well as biofuels manufacturing cost be reduced significantly over a long-term. To achieve this objective there should be a sustained increase in productive, yields and cost effectiveness of agriculture and biofuels manufacturing process. In this context, it is critical to adequately invest in and, undertake sustained and focused R and D in agriculture and manufacturing process by manufacturers, academic institutions and research centres, at appropriate time in areas such as:

- Identifying feedstock crops that are most suitable to the particular country or region
- Development of disease resistant crops with higher yield and oil/sugar/starch content and requiring lower inputs
- Developing package of agricultural practices that will enable farmers to obtain high yields most efficiently and result in high profits to the farmers
- Improve yields, quality and energy efficiency of biofuels manufacturing units
- Collection and dissemination of information on developments in other major biofuels countries in the area of biofuels crops/feedstocks and technology for its manufacture.
- Applications of biofuels in various areas such as SVOs in stationery and vehicle engines for agriculture applications.
- Develop diverse uses for by-products and effluents of biofuels production including its uses as nutrients, glycerol etc

Environment and ecology

- Examine if the energy crops being selected have any significant detrimental effect on the environment and ecology of the region.
- Provide for adequate effluent treatment measures at the time biofuels manufacturing are being set up.
- Chose locations which are most appropriate from environment and ecological angle
- Use effluents to derive value added products and make zero effluent discharge as long-term goal

Chapter Seven

Policy implications for biofuels

The challenge for biofuels policy is the need to create a viable policy and market environment at the national and regional levels, which is conducive to the implementation of bio-energy programs. The global environment is on one hand, now characterized by high and fluctuating crude oil prices, declining demand and low farm gate prices for agricultural products, while on the other hand there are rapid advancements in scientific research and crop productivity, and well-developed manufacturing technologies. This calls for the need to develop (and redraft) energy policies and strategies so that they incorporate and clearly define the biofuels sector. The response of agriculture in the provision of feedstock for biofuels is a second policy priority. Suitable trade, industrial and financial measures for promoting investments and cross-border movements in biofuels, raw materials and technologies will also be required. Environmental policies that govern carbon emissions, deforestation and industrial waste; will be needed for promoting biofuels.

There are three basic observations that should guide any new policy on biofuels:

- Biofuels are not an entirely new technology, but represent an industry which is already internationally established and recognized in which the SADC region should fully participate using its collective comparative advantage to produce, manufacture and consume its own energy resources;
- The private sector is already actively involved in the energy sector and policy for biofuels should aim to build upon the existing partnerships, bearing in mind that biofuels offer a great opportunity for the direct involvement of farmers and small to medium enterprises in economic development; and
- Biofuels lend themselves to a multi-sectoral approach, but requiring efficient coordination, with the energy and agricultural sectors playing leading roles, as illustrated below:

Institutional framework for biofuels policy development

Public Sector	Quasi-Government	Private Sector
Energy, Agriculture, Environment Science and Technology, Natural Resources, Forestry and Water, Industry and Trade, Finance	Industrial Development Corporations, National Investment Centers, Research Councils, Licensing Authorities, Academic Institutions, Agro-Industrial Parastatals, Cooperative sectors	Petroleum Companies, Car Manufacturers, Seed Companies, Automobile Associations, Petroleum Councils, Engineering Companies Farmers' Unions Biofuel Producers/ Association

Redefining the vision for the energy sector

The vision for the energy sector in relation to biofuels should be to have efficient and economic production, conversion, blending, transportation, storage, distribution and retailing of biofuels in complementarity with the distribution structure for existing forms of liquid fuels in relation to quality standards, environmental and occupational safety and pricing structures. Policy should ensure favourable conditions for and promote empowerment of the indigenous sector at competitive prices and guide investment decisions at all levels.

The biofuel strategy for the region should also be guided by the raw material production capacity and comparative advantages for each country and crop, technical capacity to efficiently produce a tradable commodity of international quality standards, processing and distribution models which take into account economies of scale and regional and international trade opportunities.

The collective goal for the region should be say within a period of ten years, to produce twenty percent of the region's total energy requirements from biofuels, for both ethanol and diesel, and to achieve a maximum ethanol to petrol blending rate of ten percent, and diesel to biodiesel blending rate of ten percent.

Biofuel quality standards

There should be mandatory blending of available biofuels, and a stipulated date of compliance, so that cars in the region use blended fuels. SADC standards for biodeisel and all blended fuels should be designed and adopted by all member states and should conform to international standards.

Legal framework

There must be a regulatory framework backed by appropriate legislation and a regulatory authority appointed in each member state to set biofuel operational standards and enforce compliance.

Objectives of the biofuels sector

The major policy objectives for the biofuels sub-sector are as follows:

a) To supply at least twenty percent of the total liquid fuel needs of the SADC region from local production of agro-based bio fuels and thereby enhance national and regional energy security;
b) To open new markets and value addition opportunities for agriculture in line with the region's comparative advantage for tropical crops as energy crops;
c) To reduce the dependence of national economies on imported fuels thereby saving foreign exchange, while taking advantage of available processing technologies on the international market;
d) To create employment opportunities for small holder farmers through increased demand and production of agricultural raw materials for the local manufacture of biofuels and by-products; and

e) To have an integrated industry that contributes to a cleaner environment, reduction of GHG emissions and intra-regional trade of biofuels, feedstock and technology transfer within the region.

Impact of biofuels on agriculture

Irrespective of the technology used and the type of crop used for the manufacture of bio-diesel and ethanol, clearly the largest share of investment cost in biofuels is the cost and availability of feedstock, and this impacts directly on the agricultural sector. It has been argued that the production of energy crops might be so attractive in terms of price ratios and income that it may lead to rapid diversification of resources away from food crops, thus threatening food security. This study has, however, shown that it is quite possible for the SADC region to produce sufficient volumes of raw materials needed for biofuels without in any way adversely affecting the existing biodiversity, food security and the traditional strategic industrial crops. Increased incomes and markets for energy crops will in fact lead to positive benefits on food security. There will, however, be need for the following deliberate actions and policy interventions to be taken for agriculture to benefit from the demand created by biofuels and at the same time guarantee the sustainable growth of the biofuel sector:

Crop production and food security targets

New crop targets need to be set to accommodate the expected demand for feedstock created by the biofuels industry. Some countries have started to put in place sectoral working groups and commodity associations, which periodically review production and marketing targets. Food security involves both producing enough food for direct consumption, and producing to sell on the market in order to have cash to buy food produced by others. The full implementation of the SADC strategic food reserve facility for instance would greatly assist the region to manage food security and allow maize, the staple food security crop, to move freely between countries thus stabilizing fluctuations between surplus and deficit seasons and countries. A properly managed food reserve can help to commercialize this crop without jeopardizing national and regional food security and create room for the production of a wide range of commodities. However, more policy dialogue and analysis of this strategic commodity is recommended before long-term investment decisions are made. In other countries selective input and financial incentives, and granting of special land rights are some of the measures being provided to encourage the production of food crops and producing cash crops.

Crop diversification strategies

The decision by any farmer to venture into a new and alternative crop enterprise is dependent on cost and availability of farm inputs (seed, fertilizer, chemicals, land, labour, machinery, finance) expected price and return on investment and information pertaining to markets, technology, and environmental regulations. Policy can significantly influence such decisions. The biofuels initiative offers major opportunities for farmers not only for the primary production of feedstock, but also semi-processing of crude oil. Contract farming and out grower schemes, backed by government and farmer associations are recommended in order to ensure that farmers benefit directly from biofuels in terms of price and employment. Out growers can also be encouraged to become shareholders in biofuel processing companies.

Biofuels trade policy

Trade options and opportunities for the biofuels sector will be at six levels, namely cross-border movement of planting seed for the energy crops; trade in feedstock to guarantee all-year-round processing in countries with bigger capacity; movement of biofuels to countries with bigger processing capacity; trade in the finished product biodiesel and ethanol to high consumption countries; trade in finished and semi-finished bio fuel by-products; and trade in machinery and processing equipment. This has implications on the harmonisation of seed standards and removal of cross-border trade barriers and strengthening of information systems, which will accelerate free trade. International trade in biofuels and feedstock should be encouraged so that the region takes full advantage of its favourable agro-climate, and also benefit from new technologies available on the international market.

Policy on processing technologies

Biofuel production systems can range from small technologies to high tech facilities and this gives a choice on whether to focus on a large number of economically viable small-scale decentralised plants, or a few large scale centralised facilities, both at the national and the regional levels. By focussing on small-scale technologies it is possible that employment and other socio-economic benefits from production are spread widely. However control of quality standards for the end product and blending can become more difficult with a large number of small-scale scattered plants. Inconsistency on the quality of biodiesel apart from adversely affecting car engines can render the product less attractive for trade and work against the gaol of achieving regional self-sufficiency. This also has implications on the types of technology to be imported and licensed, and the size and location of plants within countries and in the region.

Other policy considerations

Other issues to be considered in developing a biofuels policy strategy for the region include the analysis of the size and composition of the vehicle fleet and petroleum distribution facilities, and the need to agree with the oil and motor industries on the suitable timing, quality standards and logistics for blending. There is need to review the fuel price structure to reflect cost of imports, blending levels and environmental and economic benefits of bio fuels. Soft financing packages and tax incentives for bio diesel factories, and for opening new land for the production of energy crops are a major policy requirement. Pricing structures for by-products and livestock have an impact on bio fuel prices. Policy decisions are needed on the choice of feedstock to focus on. Presently jatropha is viewed as a wild plant but policy is necessary to declare it an “agricultural crop" so that it can receive full attention in terms of research, extension, plant breeder's rights, marketing and other resources. The same applies to sweet sorghum, palm oil and cassava, which in most countries are currently still treated as minor crops.

Public and private sector partnerships.

The biofuels policy should indicate a clear division of labour between national governments, SADC and the private sector as shown in the table below.

National Governments	SADC	Private Sector
National energy policy and regulatory framework, Tax incentives and concessionary loans, Duty waiver on renewable energy capital equipment, Stipulating Blending levels and quality standards, Research and development, Information dissemination	Regional Policy Framework for biofuels, Facilitating cross-border trade, Harmonization of biofuel standards, Resource mobilisation for joint projects, Information dissemination, Linkages with other projects	Production of feedstock, Processing and blending of biofuels, Distribution and marketing of biofuels, Making capital investments, Research and development, Partnerships and out grower schemes

Chapter Eight

Conclusion and Recommendations

Conclusions

Development of National and Regional policy and strategies on biofuels.

The policy implications for the biofuels sector complement the energy sector which sets the national priorities for energy distribution, blending and consumption, and cut across the financial, industrial and environmental sectors which impact on the size and location of processing plants and types of technologies to be used. The major driving factor in biofuels is the ability of the agricultural sector to provide the required feedstock and adopt policies that will ensure continuity of supply, including cross-border movement of seed, farm inputs and raw materials. Another critical factor is the ever-increasing prices of petroleum products and their vulnerability. Agricultural research and seed production must be re-oriented to meet the challenge.

Biofuel holds enormous potential for the SADC agriculture and for its economies in general. The authorities should treat it as a high priority.

However, before the launch of any major biofuel programme, policy decisions and plans on several issues need to be finalized. Identification and development of high-yielding varieties of crops, involvement of the private sector in sugar and oilseed production, ensuring remunerative price for the farmers on a long-term basis, setting up processing plants in major sugar and oilseeds growing areas, promotion of the use of vegetable oils for rural electrification and exercitation of water pumps, tractors and farm implements etc are some issues that need be resolved.

In SADC the potential of the different agro-ecological zones and different crops for the production of vegetable oils should be evaluated, as well as the potential role of agro-forestry. Agricultural research has to be reoriented to the issue.

It has been possible through this regional feasibility study to confirm and reach a conclusion that biofuels are a necessary and viable development strategy for the SADC region, with immense benefits. However, in order to come up with a concrete strategy and action plan, member countries should be assisted to host consultative meetings involving all the key players in the area of biofuels from agricultural producers, processors and distributors, car manufacturers and policy makers. It was noted that some countries have started the process of reviewing their renewable energy policies to incorporate bio fuels using task forces, expert working groups and joint implementation committees, but the countries visited admitted that they did not have sufficient resources, capacity and technical knowledge on bio fuels. UNCTAD, EU and other organizations that have shown an interest to support bio fuels in developing countries should work with the SADC Secretariat to coordinate the process. Output from the country level consultations would then feed into the regional strategy, using this report as background.

Increasing public awareness and consensus building on biofuels.

A major striking observation made during the study visit is the apparent lack of awareness and knowledge about biofuels by many people in both the public and private sectors, and lack of information about bio fuel projects existing within the same country. It will therefore be necessary to launch a big awareness campaign through country level stakeholder workshops and a regional conference on biofuels, and the distribution of pamphlets, newsletters and publications as an ongoing programme. In the long term this should be followed by exchange visits to countries with established projects in and out of the region, as well as promotions through schools, farming associations and departments of extension.

Biofuels development and project support funds

Biofuels are a new initiative in the region. There is vast technical knowledge and technology internationally. The study has shown that the region has vast potential for production, but limited capacity to harness it. A consolidated fund should be created and managed by the Secretariat, working with partners such as African Development Bank, Development Bank of Southern Africa, African Capacity Building Foundation etc to support cross-cutting activities such as research and development, training, development of regional standards, and the funding of pilot projects. While member countries may source internal and bilateral funding arrangements, most projects and programmes will be of a regional nature and must be funded accordingly. For example the negotiation of Clean Development Mechanisms and rebates for carbon reduction can best be done as a regional initiative.

Financing the biofuel revolution should not be an insurmountable challenge. The Global Environmental Facility (GEF), the European Union, the Renewable Energy and Energy Efficiency Partnership (REEEP), the Global Renewable Energy Fund of Funds (GREFF), Carbon Fund, the United Nations Environment Programme (UNEP), and other funds are amenable for funding such proposals.

Clean Development Mechanism (CDM) Projects

The region should move quickly to take advantage of CDM in accordance with the Kyoto Protocol, by putting together a team of experts knowledgeable about the subject. CDM is a tool adopted by the protocol that allows a country or a group of countries on behalf of their industries to buy or sell carbon emission reduction certificates for activities that cut down on the greenhouse gases responsible for climate change, calculated on the basis of carbon dioxide equivalent emissions.

Capacity Building and Research and Development Grants.

The study revealed that there is an urgent need to support technical, economic, business and agronomic research to enable the region to adapt and keep pace with global developments on bio fuels. It was also noted that a number of universities and research centers have embarked on research programmes and trials to test various bio fuels. Through a competitive grant system it should be possible for SADC to facilitate funding of technical and economic research projects, results of which can be shared regionally, and to support private research projects, and establish centers of excellence on basis of identified specialization. Major areas identified for which in-depth research on bio fuels is needed include the following:

- Supply-side constraints on expansion of energy crops;
- Detailed production and marketing chain analysis for each of the energy crops identified for the region;
- Research into the agronomic characteristics of new plants like jatropha carcus, which have not yet been grown on a large scale but have great potential as a smallholder farmer tree crop in the production of bio fuels and by-products;
- Impact of biofuels on food security and poverty reduction;
- Evaluation of food and non-food crops, and the pricing of feedstocks, by-products and ethanol or biodiesel and blending prices;
- Development of technologies for biofuel production suitable for the region.
- Technical composition of blends and effects on car engines under local climatic and transport conditions;
- Analysis of emerging trade and investment opportunities in the region, and competitiveness and market entry issues in industrialized countries.

National and Regional Biofuel Associations

In line with the need to facilitate public-private sector partnership in the biofuels strategy, Member States are encouraged to promote interactive biofuels associations. These will help to foster dialogue among affected parties on all issues regarding the biofuels programme including standards, policies, regulations and technologies governing the industry. A Southern Africa Biofuels Association (SABA) has been formed and there is need for formal interaction between SABA and SADC to ensure that the objectives and composition of the association are in conformity with the biofuels strategy of the region.

SADC Biofuels Advisory Panel

The biofuels initiative is still in its infancy in the region but gathering momentum. A biofuels technical advisory panel of experts would greatly assist member states with relevant information, design of bankable projects, feasibility studies, financial proposals, and research funding and resource mobilization. The ultimate goal is to assign regional centers of excellence to deal with specific technical issues such as research on quality standards of biofuels, economic and price analysis, and impact on car engines. The implementation of the biofuels programme will be monitored and evaluated for impact on the region.

Recommendations

- Set up an institutional framework to promote biofuels by establishing a Biofuels Development Board or a similar autonomous organization to coordinate all aspects of biofuel programme in the region.
- Study the extensive experience of world in all aspects of biofuels including policies, feedstocks, technologies and business models.
- Each Member State should come up with a vision and mission on biofuels, which will be harmonized to create a regional programme.
- Formulate and adopt holistic and biofuels friendly policies and a workable and practical strategy.
- Assure farmers of procurement of biofuels feedstocks at a minimum support price, in case of temporary surpluses.
- SADC region should formulate practical and simple standards as soon as possible.
- Showcase pilot projects at the earliest to demonstrate technology and the workability of the biofuel programme.

Way Forward

As an immediate way forward the report contains an indicative work plan to facilitate implementation of some of the recommendations listed above. The work plan, shown in a matrix below, is based on five expected outcomes which include the following: increased awareness of the potential for the production of biofuels in the SADC region; effective national and regional structures for executing the SADC biofuels programme; national and regional policies and strategies for the production and marketing of biofuels; regional biofuels training and research and development programme; and budget and financing plan for the SAD biofuels programme.

INDICATIVE IMPLMENTATION PLAN FOR THE SADC BIOFULES PROGRAMME

Expected Outcome 1: Increased Awareness of the Potential for the Production of Biofuels in the SADC region				
ACTIVITIES	**LEAD ACTOR (S)**	**PARTNER (S)**	**TIMING**	**REMARKS**
1.1 Disseminate SADC Biofuels Feasibility Study Report and the Brochure	SADC Secretariat	Member states	Sept 2005	To obtain comments on way forward. Produce SADC Biofuels Newsletter.
1.2 Meeting of SADC Technical Experts on Biofuels	SADC Secretariat consultants	Ministries of Energy, Agriculture, Science and Technology	October 2005	To agree on implementation plan, and legislation for blending.
1.3 SADC Regional stakeholder workshop on Biofuels	SADC Secretariat consultants, farmers, NGOs	Government, Private sector stakeholders, Oil companies, Southern African Biofuels Association, Donors	Nov 2005	To identify key players in the region. Detailed costing of biofuels to be undertaken in each country, and work relevant out incentives.
1.4 Participate in international Biofuels Conferences and Study Visits	SADC experts and officials	Private Sector	On going, as they arise.	e.g. Biofuels International Conference, China, 2006. Study visits to Brazil, USA, Germany, India etc.

Expected Outcome 2: Effective National and Regional Structures for Executing the SADC Biofuels Programme				
Activities	**Lead Actors (S)**	**Partner(s)**	**Timing**	**Remarks**
2.1 Appoint SADC Biofuels Development Board with Advisory Committees.	SADC Secretariat	Regional Experts, private sector, petroleum companies and motor traders	After October 2005	To advise SADC and member states on biofuel programmes
2.2 Assist member countries to have biofuels working groups or task force	Member countries, SADC Secretariat	Relevant stakeholders	October 2005	Some countries already have inter-ministerial working groups on biofuels
2.3 Support the establishment of national and regional biofuel associations and networks	Private Sectors, SADC secretariat	Universities Research Organizations	November 2005	To facilitate maximum stakeholder involvement
2.4 Nominate national focal points and a SADC biofuels technical advisor/Programme Coordinator	SADC Secretariat	Member states	October 2005	To ensure proper and consistent coordination

Expected Outcome 3: National and Regional Policies and Strategies for the Production and Marketing of Biofuels				
Activities	**Lead Actor(s)**	**Partner(s)**	**Timing**	**Remarks**
3.1 National Processes and workshops to draft biofuels policies and strategies	Members states	SADC secretariat, Donors, Private Sector\, Technical Partners	By January 2006	Some countries have already begun to draft policies. Format and guidelines to be distributed

3.2 Consolidate National Polices into a Draft Regional Policy Paper on Biofuels	SADC Secretariat	Member states, Regional Advisory Board	By April 2006	To ensure uniform regional quality standards and common vision.
3.3 Action Plan and bankable biofuels investment projects	Member countries	SADC Secretariat, Project Promoter and Donors	By April 2006	Prioritise national and regional project proposals for funding Joint approach to financing partners has an advantage.
3.4 Design a database and mechanism to monitor progress in the implementation of the biofuels programme.	SADC Secretariat, Advisory Board	Member states	On-going	Monitor in terms of number of new projects, feedstock production, quantity of biofuels produced, impact on employment, foreign exchange savings etc.

Expected Outcome 4: Regional Biofuels Training and Research and Development Programme				
Activities	**Lead Actors (S)**	**Partner(s)**	**Timing**	**Remarks**
4.1 Identify training areas and lead institutions and design a training programme for biofuels	SADC secretariat	Member states, Universities	On-going	To enhance capacity building and expertise on biofuels in the region

4.2 Identify research themes and research topics, and lead research centers in the region.	SADC Secretariat, Member states	Research Institutions, Private Companies	On-going	Regional center of excellence to deal with specific research topics e.g. feedstock production, quality standards, trade and the economics of biofuel production.
4.3 Regularly disseminate information and research results	SADC Biofuels Advisory Board, Research Institutes	Biofuel stakeholders, Member states	On-going	Publication of the research papers and Biofuels Newsletter Regular Technical Workshops and Conferences.

Expected Outcome 5: Budget and Financing Plan for the SADC Biofuels Programme				
Activities	**Lead Actors (S)**	**Partner(s)**	**Timing**	**Remarks**
5.1 Detailed 12 month budget for co-coordinating the SADC biofuels programme	SADC Secretariat, Member states	SADC Biofuels Advisory Board, Potential Technical Partners	By October 2005	Budget items to include, conferences and workshops, travel, per diem, co-ordination, study visits, communication, publications, stationery
5.2 Create a Biofuels Development Fund	SADC Secretariat, Member states	Financing Partners	By December 2005	Identify a consortium of donors Facilitate privet sector funding

5.3 Participate in Clean Developme nt Mechanism	SADC Biofuels Advisory Board	Technical Experts, Donors	On-going	CDM is a major potential source of funds for biofuels projects
5.4 Cost and consolidate national and regional biofuels projects for funding.	Member states, SADC Secretariat	Advisory Board, Private Sector, Technical Partners, International and Regional financiers	On-going	Ensure that viable bankable projects are funded and implemented. Monitoring and evaluation of the program.

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Annex 1: A Draft Regional Policy Paper (RPP)
Background

A holistic, well thought through, stable and long-term enterprise friendly policy is essential for the success of the biofuel programme. Most Member States currently do not have a biofuel policy. In order to formulate such a policy in depth interaction is required between Member States of the SADC region so as to reach a consensus on the most appropriate and suitable policy guidelines for the region. Such policy guidelines should be integrated into the policies of Member States and the region.

Outlines of the policy guidelines

- Establish Ministerial task force on biofuels
- Formulate Vision and Mission on biofuels.
- Undertake awareness
- Identify suitable lead institutions for coordination of the biofuel programme within the region.
- Set long-term annual targets for production of energy crops and biofuels.
- Set long-term annual targets for the mandatory blending of biofuels with petroleum products.
- Identify and appoint a nodal Ministry in each Member State for coordination within the country as well as regionally.
- Capacity building.
- Institute requisite legislative, legal and regulatory framework for biofuels.
- Identify financial and funding mechanisms.
- Introduce various incentives for the production and use of biofuels including tax benefits.
- Put in place measures that encourage production of feedstocks such as land rights, out growers' schemes and technical support.
- Adopt clean and up to date technologies that are appropriate to the region.
- Create infrastructure for setting up biofuel production units and blending it by petroleum companies.
- Encourage research and development in most important technical and scientific issues.
- Ensure that the programme is environmentally friendly and ecologically suitable.

Annex II: SADC Brochure on Biofuels

The brochure will contain the following information:

- Front page will have a SADC logo
- Definition of biofuel, this will appear in front page with pictures of selected energy crops.

    - **What is Biofuel?**

    Biofuel is liquid fuel produced from plant origin. It can either be biodiesel or ethanol. Biodiesel is diesel obtained from organic oils, mostly vegetable. Modifying vegetable oils and reducing their viscosity using various methods produces biodiesel. The most widely used process is transesterification, in which another replaces an alcohol from an ester. Ethanol is produced from sugar based crops such as sugar cane, sweet sorghum, and starch based crops such as maize, cassava, or any type of grain or tuber.).

- The benefits of biofuels with pictures of farmers working in the field.

    Benefits

    - The potential benefits of biofuels are immense, starting with their capacity to create rural employment,
    - Market for small-scale farmers and can be used to regulate oil crop prices.
    - Foreign exchange savings by governments (by reducing the volume of fossil fuel imports).
    - Improved energy security, lower emissions of greenhouse gasses. Biofuel is simple to use, is biodegradable, non-toxic and it reduces air pollutants, like particulates, sulfur, carbon monoxide, hydrocarbons etc.
    - It is sustainable and environment-friendly. Neat biodiesel is as biodegradable as sugar and less toxic than salt.
    - The SADC energy sector will be less dependent on external vagaries, exchange rates, and will produce clean energy, which in turn will yield Kyoto-bonuses.
    - Most of the oil-bearing crops are nitrogen-fixing plants. Hence they enrich the soil. Moreover, the energy crops consist solely of the plants hydrocarbon. Nitrogen, phosphorus and mineral elements can return to the field.
    - Biofuel programs have all the potential to halt deforestation and desertification, as they can include the use of oilseed-bearing, drought-resistant trees like jatropha and pongamia.
    - SPS barriers cannot hamper trade in biofuels, as the products are not intended for human consumption.
    - Finally, in the event of a famine in the region, the crops initially earmarked for biofuel production can be reallocated for human

consumption. Therefore, a better understanding of how biofuels production affects crop and food markets is needed

- The key factors for successes of biofuels programme will also contain some pictures of processing plants.
- Potential of production of feedstocks of biofuels in the region.
- SADC map showing rainfall pattern.

- Key factors for success of biofuels programmes, a picture of a processing plant will accompany this.
  - Appropriate location of processing plant.
  - Availability of feedstocks.
  - Blending policy and standards.
  - Supportive government policies.
  - Remunerative prices for farmers.
  - Legislative and regulatory framework.
  - Institutional framework
- Potential for the production of feedstocks for the biofuels.
  The map of SADC showing the rainfall pattern and a table showing selected Member States with ample arable land.

Annex III: Field Visits to South Africa, Malawi and Zambia, 10-24 July 2005

The study involved consultants visiting three countries in the region to interview public and private sector institutions dealing with biofuels and assess the situation on the ground .The countries visited are South Africa (10-14 July), Malawi (14-19 July) and Zambia (20-24 July). Meetings with relevant authorities were also held in Botswana. The full list of institutions visited and people met in each country is shown in Annex IV.The main highlights of each visit are shown below by country.

South Africa

1.German Chamber of Commerce and Southern African Biofuels Association

- Issues included general introduction on biofuel initiatives in South Africa, the recently launched Southern African Biofuels Association (SABA), its link with SACAU for farmers, interest in biofuels support for compulsory blending, taxation policies, European energy market, and need for a joint SABA-SADC regional workshop on biofuels in October possibly;
- Meeting also included Andrew Makaneta from a commercial bank (ABSA), which is interested in biofuels and SABA. SABA will look at research and development, technology and engineering, equipment, farming issues, infrastructure and marketing, sales and distribution;
- Structure to be replicated in all member countries and membership open to individuals and companies and affiliate members e.g. SADC Secretariat, SADC Business Forum. Purpose is to create business opportunities and interaction between members;
- Banks concerned with maize surpluses in SA from a financial point of view. Biofuels would create stability in agriculture and opportunities for growth. Regionally its an opportunity for trade, potential to develop agriculture, create jobs and get carbon credits, and cross-border funding of projects;
- SADC governments encouraged to have legislating and provide incentives and enlighten the public. Finalization of blending ratios would stimulate those countries with greater biomass opportunity to produce.
- Critical success factors are; minimum rate of return, security of supply, mandatory blending targets, legislation which guarantees a market, special incentives for production, marketing and consumption and duty free imports, training and information. SABA creates a forum for a consolidated viewpoint on biofuels in the region.

2. Climate Change Corporation (C3), Adam Simcock.

- Main issues discussed were on jatropha oil including initiatives by the company in Malawi, Zambia and Madagascar. Proprietor was before working for D1.Model applied involves a management contract with a local NGO which will identify out growers, plant nurseries, train farmers, supervise trees, collect seed and crush into oil-C3 buys the crude oil to make biodiesel.

- Out growers to be selected around tobacco farms and along lake Malawi. The model does not involve buying seed but a long-term management contract with grower who is paid for his labor.
- In Madagascar jatropha being used to protect vanilla plants from insects and animals. Mining industry also keen on biodiesel to save on transport costs.

3. Praj Industries Limited
    - Praj Industries is an Indian based company that provides technology, plants and equipment as a technical package for ethanol production. Have worked in many countries in region where sugar is produced-South Africa, Tanzania, Malawi, Zambia, Zimbabwe, Mozambique, Swaziland and Mauritius;
    - ACP Sugar Protocol which provides concessionary price support and duty free entry into the EU has greatly assisted the sugar industry;
    - Cassava another potential source of ethanol is grown in Mozambique, Zambia and Malawi. Sweet sorghum is found in Zambia, Zimbabwe, South Africa, Malawi, Tanzania and Swaziland, but not fully developed as a commercial crop;
    - South Africa looking at the possibility of using surplus maize for ethanol and yields have benefited from GMO;
    - Critical success factors for ethanol production are: blending must be mandatory, clear energy security policy and strategy in place, carbon credits accessed, incentives to end-users, assured raw material supply, return on investment, suitable legislation and social benefits;
    - Diversification of the energy portfolio and increased dependence on renewable energy sources based on farming creates employment. Information exchange and prices and availability of fossil fuels are the other critical factors.
4. Departments of Agriculture, Mines and Energy nescience and Technology
    - Meeting held jointly with the three departments. Renewable energy policy document prepared in 2003.No specific bio fuels blending policy as yet. Science and Technology has mandate to reduce dependence on electrical energy which is mainly from coal;
    - Transport fuels imported with 30% locally produced from coal. Bio-ethanol to substitute paraffin for blending is currently under discussion. Joint Implementation Committee (JIC) on Bio fuels now in place involving Departments of Science and Technology, Agriculture, Environment, Energy, Science Councils, Organized Agriculture, Water Affairs, Forestry, Industry, Consumer Associations and Development Finance Institutions;
    - JIC has working Groups dealing with legislation and policy, alternative crops, beneficiation of by-products, involvement of new farmers and technical issues (car engines, oil companies, equipment);
    - In regard to agriculture focus for bio fuels is on multi-purpose, i.e. those that can be used as food crops and whether virgin land can be used for new crops. Farmers to decide on basis of business plan e.g. maize for ethanol. Jatropha tests being done in confined areas.

- Key success factors for bio fuels are: constant supply of raw materials, quality of end product, risk management, profit margins, policy environment, market opportunities in Europe, production efficiency and job opportunities;
- Potential threats are trade relations, sustainability, environmental issues, externally driven strategies, information generation and uncontrolled exploitation of resources.

5. SASOL

- Sasol deals with all types of renewable fuels. Main focus is on bio diesel using soyabeans, which can create huge demand for the crop in the region. SADC has great potential but much will depend on the economics, transport costs, government taxes and relative cost of electricity.
- More opportunities are in landlocked countries. Central processing plant more cost effective than small plants.

Malawi

1. Department of Energy
    - Malawi already in the process of revising energy policy to incorporate bio fuels. Has been producing ethanol from sugar for past twenty years and blending at twenty percent to save on forex. Biofuel being promoted because of Malawi's huge agricultural potential and impact on GDP;
    - Task force of all major stakeholders in liquid fuels in place. Reforms include licensing and divesting management through franchises as part of economic empowerment;
    - University of Malawi Chemistry Department doing research on adaptability of car engines. UNEP to assist on public awareness. SADC provides an opportunity for countries to combine efforts and produce in large quantities, political awareness, and regional programme of investment;
    - Department pf Energy is one that creates an enabling environment in terms of policy and creates demand, strategies, timetable and law, then feeds into Agriculture, Environment, Industry, Trade, Finance;
    - SADC to support commissioning of papers by people already doing work on biofuels, country position papers and regional policy guidelines, and an expert group on biofuels.
2. Director of Science and Technology
    - Recommends that there should be research grants for Universities and short-term training on biofuels. Science creates demand for agriculture. For example efficiency of production of raw material and oil itself is very low making it cheaper to import
    - Research also needed on pricing, incentive structures, impact on foreign exchange savings, economic value of tree crops compared with field crops;
    - Role of DST is to disseminate new technologies and guide research;
    - Development of the biofuels industry should not be based on subsidies as we have no capacity to subsidize;
    - Environment Department to ensure compliance with local standards and conformity to international agreements.
3. Ministry of Agriculture

- New policy for agriculture emphasizes value addition for a landlocked country which cannot be competitive in exports, access to inputs to encourage production, commercialization of the staple food crop maize through contract farming, irrigation, and encouragement of foreign investment on underutilized land;
- Biofuels fits in well with the crop diversification strategy. Farmers very responsive to market incentives. Need small scale processing technology owned by farmers and central collection points, then link up with industry;
- Maize production is very unpredictable: biofuels could help to even out surpluses without being afraid of overproduction and depressing prices-link up with food reserve facility;
- Policy on biofuels requires collective responsibility and effective coordination, with government setting policy and private sector implementing;
- SADC role should be exchange of information on comparative crop yields, production systems, technologies used, seed availability, global policy framework showing shortcomings, resource mobilization, documenting best practices in the region, facilitation of project preparation processes, research grants and policy dialogue.

4. Gel Factory
   - A brief visit was made to the Kanengo industrial area in Lilongwe to see an NGO that produces gel fuel as ethanol by-product for use in cooking in place of firewood and electricity. They also distribute cooking stoves. Production had stopped due to rise in price of ethanol.
5. C3 Jatropha Biodiesel Association
   - Visited an NGO in Kanengo that has a factory to crush jatropha seed and works under C3, a private company based in SA.A processing plant was being installed and women were dehulling seed in preparation for test run;
   - Site visit made to nurseries and plantations in Salima along the lakeside. GO gave some material including copy of out grower contract, pictures of jatropha and their business plan.
6. ETHCO Ethanol Sugar Company, Duangwa Valley
   - In production since 1982 and source of Malawi ethanol. Malawi is among some 50 countries in the world producing and using fuel ethanol, and one of the first to achieve a national blend up to 20% ethanol in its petrol;
   - Produced from molasses a by-product of sugar production. Other by-products include rectified alcohol, potable alcohol and carbon dioxide for fizzy drinks;
   - Advantages of using ethanol conversion of a ‘waste’ product molasses into a value added product, enhancing market for sugar production, foreign exchange savings, enhance of octane in fuel and energy security. Employment and provision of social amenities in the sugar growing areas, and technical advice to out growers;
   - Challenges include exploration of new export markets, legislation of ethanol production, research to maintain standards, and cooperation with oil companies. Company produces 18million liters per annum with 150 employees;

- Sweet sorghum and maize can complement sugar. Mandatory blending is necessary. SADC can assist with market opportunities, coordination of the many activities taking place, creating a Regional Bio Fuels Research and Development Center, building of testing stations for cars, and developing partnerships.

7. Farming Organizations
    - Meetings were held with NASFAM and the Malawi Farmers Union, who are members of the Southern African Confederation of Agricultural Unions (SACAU). They indicated that at the moment farmers are totally unaware of what are bio fuels and what is happening in this field, which at the end of the day is a farmers' project.

Zambia

1. Acting Director for the Department of Energy
    - Zambia is in the process reviewing the National Energy Policy of 1994 to ensure that the bio fuels sector is specifically mentioned in the new policy;
    - Petroleum Act will also be amended;
    - Three sugar estates but not yet producing ethanol. Draft policy paper proposing 10% blending. Exchange visits made to Malawi and Zimbabwe to see ethanol plants;
    - Bio diesel trials done on a small scale using jatropha while awaiting policy position of government;
    - Working group drawn from stakeholders already working on national bio fuel strategy. Need for awareness campaign highlighted;
    - Regional initiative would help to share experiences, access resources beyond national capacity, training and demonstrating successful projects. Private sector need to be linked with international financiers;
    - Project identification can be done at national level but collectively submit to SADC simultaneously with bilateral requests. SADC to assist in sourcing technical experts, technology advice, short term training, visits and meetings;
    - Supports harmonization of bio fuel standards since market is beyond one country. Oil companies are fully supportive. Zambia has one central refinery which makes blending easy; and
    - Key guiding factors for befouls policy are: price of fossil fuel, political will and awareness, international developments, financial, technical and raw material capacity, regulatory framework. Even if oil prices were to go down need long-term policy to influence capital investment decisions and offer alternative markets for agriculture.

2. Principal Agricultural Economist, Ministry of Agriculture
    - Zambia has rich soils, abundant water resources, good climate and surplus land (about 80%of arable land is still unexploited) for the production of all the seven energy crops;
    - Cassava is being grown commercially. Sweet sorghum trials done. Marketing is biggest threat to farming as farmers are highly sensitive to past experiences of

instability. Fully support bio fuels as alternative market for crops. Additional sugar mill planned to make them four. Molasses used mainly for livestock.

- Political commitment necessary for success. Lead Ministries on bio fuels are Energy, Agriculture, Finance, Commerce and Natural Resources. Energy department should have more technical capacity to drive the programme.
- Seed industry is strong and will benefit from bio fuels. Will also stimulate investment in irrigation.
- SADC to assist in sensitizing governments and coordination of policy to minimize duplication, and capacity building through refresher courses.

3. CEEZ

- Apart from oil palm Zambia can produce all the energy crops identified. Research trials on sweet sorghum must be intensified for its dual use of stem and grain, and suitability for smallholder farmers in drier areas. Possible to achieve two crops a year and complement sugar cane;
- Advocacy on bio fuels a necessity. Policy needed to support out grower schemes and empower them through contracts and farmer associations, especially for jatropha to have proper management as a new crop;
- SADC to work on eligibility of region for carbon credits and bundling up projects and link with Kyoto, UNEP, World Bank etc;
- Universities like Zambia and Kwazulu Natal offer courses on alternative energy sources. Region must identify and link up on where and what training is available;
- For more information see wwww.carienza.net;www.partners for Africa.org.

4.Department of Environment

- Environment is mainly concerned about issues of deforestation induced by high demand for fuel wood and charcoal and low connectivity of households;
- Environment Council of Zambia still to do more work on policy and implications of the bio fuels sector.

5. Marli Investments, Kabwe

- Met with project directors and visited four out growers who have planted jatropha. Company plans to have 200 000 trees and 4000 out growers (at 1100 trees/ha). Each household has about 5 ha;
- Farmers will operate as a grower association and company plans to plough 5%of profits for community projects. There are contracts signed between each grower and the sponsoring company, which provides seed and training in tree management;
- Consultants met with District Commissioner for the area, which together with local chiefs have supported the provision of land and agricultural extension workers for the project. Traditional land is not under title;
- Critical issues for the success of the project are: more research on varieties and yields, funding to extend to other districts, technical know how needed at the processing stage. Project must have quick impact on poverty alleviation; land rights to minimize potential conflicts as project expands and for collateral and insurance for the trees.
- Banks not well informed about bio fuels and not keen to fund the sector. SADC and governments need to sponsor pilot projects for people to see, and mobilize international support.

6. Assistant Executive Secretary, COMESA

- Indicated that COMESA now have a programmed for diversification of energy portfolio and first meeting of the Committee on Energy was to take place in Lusaka25-26 July 2005;
- Due to current underutilization of agricultural land and labor under dry land production, bio fuels and in particular sugar cane under irrigation has great impact on employment and development;
- Need to promote co-ownership by giving shares to out growers in processing plants and lock them in the value chain to secure feedstock, and not just as producers of raw materials;
- Implications of Kyoto Protocol on carbon credits and technology transfer to be looked at quickly and develop bankable projects;
- Critical issues for bio fuels are: new crops to consistent with agronomic conditions, early impact needed, there must be minimum impact with existing land use patterns; examine use of by-products to enhance returns; guaranteed ownership by beneficiaries, use of fertilizer and chemicals energy balance; and aim to achieve critical size of plants-if too small then no immediate impact, if too large then high management risk.

7. Marketing Director, Zambia Sugar

- There are three sugar milling companies in Zambia and Zambia Sugar jointly owned with ILLOVO, SA is the biggest and oldest mill. Main product is sugar for export to EU, SA and local market and molasses for livestock sector.
- Studies have been done on ethanol production and blending but no firm decision as yet. Company also looking at impact of EU reforms;
- Company directly employs about 2000 people plus 4000 seasonal and supports 17000 people on the estate, which provides schools, clinic community hall etc. There are 161 out growers, 8 ha average producing 35%. Individuals can buy shares in the company which is listed (but small farmers need education)
- Crushing season is April to Nov.High yields achieved due to soil, climate and availability of irrigation water. Main cost items are fuel and power for pumping, spares, chemicals and fertilizer which are imported;
- Critical success factors are: finance for expansion, supportive government policy and price structures. Technology, market and expertise not a limiting factor.

8. Ministry of Transport

- Main concern of Ministry is in provision of road and rail infrastructure. Would recommend use of biodeisel to start with tractors for agriculture, followed by long distance buses and lorries, then private cars as a phased approach;
- Source and supply of bio fuels has to be guaranteed first before long-term investment decisions are made e.g. if car industry is to adjust engines. Need for public awareness emphasized;
- Ministry keen on development of transport corridors to Durban, Walvis Bay, Dar es Salaam and Beira

9. Jatropha expert, Godfrey Chungu

- Has worked on jatropha and other trees like moringa at Golden Valley Trust, but for products like lighting oil, soap, and candles. Planting of jatropha should be

1100 trees/ha spaced 3 by 3 meters, or 25 meters apart if grown for hedge. Minimum rainfall required is 500mm;

- Golden beetles and red spider mite have been observed on small trees. Expected yield in year one is 0.7 kgs per tree, going up to 3,5 kgs at 3 to 5 years. Tree can produce for up to 30 years;
- Tree can be grown from cuttings but best is seedlings in plastic sheaves to allow development of tap root (cuttings produce fruit early but at lower yields than seedlings. Yield on hedges is 4kg/ha;
- Expects to plant 40 000 ha for D1 in the Chisamba area in central Zambia.Motorised expeller can produce 1 liter from 3,5 kgs depending on quality of seed (60:40 oil to cake). Trials being done on cake for livestock feed and fertilizer.

Botswana

1. Department of Energy Affairs
    - Consultancy took advantage of their presence in Botswana at SADC to meet with the Department of Energy Affairs and explain to them the purpose and of the study on bio fuels;
    - Questions raised during discussions are what will be the implications of bio fuels on food production given that some countries still face shortages? What will be the comparative price ratios between bio fuels and fossil fuels? What is the reaction of oil companies? What is the experience with bio fuels in the region and other parts of the world and what are the risks involved? What should be done to promote bio fuels in terms of policy, awareness and incentives? And what is the expected output and way forward on the issue;
    - SADC expected to assist in identifying soil conditions and areas suitable for different crops, what types of policies on bio fuels developed in other countries, and information on minimum sizes of plants and feedstock needed, and on feasibility studies;
    - Director of Energy invited the team to attend a SADC Clean Fuel Workshop, which was to take place at the Gaborone International Conference Center, and to make a presentation to delegates on the bio fuels study.
2. SADC Chief Director
    - Meeting was held to brief the Chief Director and FANR Director on the country visits made and share ideas on the study. Issues on viability, economies of scale, intensity of production, impact on food security, single standard which is comparable internationally were discussed;
    - Efforts to deal with energy costs such as collective procurement, increasing investment in fossil fuel exploration, and investment in technologies to reduce energy intensity or conserve energy are to be complemented by new and renewable energy sources such as bio fuels. A one-page memorandum on bio fuels was to be prepared.

Annex IV: List of Stakeholders Contacted

Name	Position	Organization	Country	Contact details
Dr Sizwe Mkhize	Assistant Director-General, SRM	Department of Agriculture	South Africa	ADGSRMU@nda.agric.za +27 12 319 6446/6521 Cell: 082 218 1725
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Mr. Nyongo		Department of Energy Affairs	Malawi	
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Henry F. Mbeza	Director of Science & Technology	Ministry of Industry, Science &Technology	Malawi	hmbeza@yahoo.co.uk +265 01 776 077 +265 01 776 075 Cell: 08 345 913
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Keza Ngoma	Administrative Assistant	Bio-Diesel Agriculture Association	Malawi	
Paul Webb	Head of Operations	Climate Change Corporation	Malawi	+265 8915016
Timothy Mahoney	Agronomist	Climate Change Corporation	Malawi	+265 8834292
	Nursery Farmer, Extension Worker and Villagers	Jatropha Carcus Plantations in Salima near Lake Malawi	Malawi	
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Susan Nyirenda		Ethanol Company Limited, ETHCO	Malawi Dwangwa	susannyirenda@ethanolmw.com
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Mr. Shitima		Department of Environment	Zambia	
Hekkie Grobler	Managing Director	Marli Investment, Biofuel Company	Zambia Kabwe	marlinvestment@yahoo.com +260 097 460 099/847 874
Mr. Desai	Partner	Marli Investments	Zambia	+260-05-224620

Mr. Komaki Mr. Arituri Mr. Mingishi Joseph Zulu	Out grower Farmers	Jatropha plantations, Kabwe	Zambia	Marli Investment
Edward Mulenga	Project Coordinator	Marli Investment	Zambia	
Mr. Mulando	District Commissioner	Chimbombo District, Central Province	Zambia	
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Annex V: Terms of Reference for the Feasibility Study for the Production and Use of Biofuel in the SADC Region.

The consultants will evaluate the potential of biofuel production and use in SADC, and the bottlenecks that need to be addressed. The consultants will compare the potential of the following energy-crops that grow in the region:

- Oil palm;
- Sunflower;
- Soyabeans
- Jatropha curcas;
- Sugar cane;
- Sweet sorghum; and
- Cassava.

The consultants will make policy proposals for SADC and its Member States, and bundle these in a Regional Policy Paper (RPP). The RPP should clearly indicate its links with the RISDP. The consultants will also prepare the outlines of a SADC-brochure on biofuels to the attention of the broad public.

The exercise is a desktop study. Nevertheless, the consultants will visit South Africa and Malawi as these countries have recent experiences with biofuel. They will also visit Zambia, which represents SADC's landlocked areas with assumed biofuel potential.

The study will start from the assumptions that crude oil prices are at $40 per barrel (NYSE), that SADC Member States are not in a position to subsidize befoul production and that they instead use the conventional fuels to earn income through duties and taxes;

The study will make an impact assessment of the production/use of biofuels, with specific emphasis on employment, environment, trade and economic growth.

The consultants will give particular attention to the following technical issues:

- The agro-ecological zones in the region;
- The spatial distribution of fuel production plants;
- The potential for small to medium agro-industries;
- The existence of SADC Development Corridors;
- The required quality and standards;
- The role of governments and private sector;
- The role of Agricultural Research, the SADC seed sector, the suppliers of agro-processing machinery and other stakeholders.

Profile of the Consultants

The team will consist of a development economist (team leader), a fuel expert and an agronomist:

1. The Team Leader: He/She will be a development economist (MSc or higher) with at least 15 years of relevant work experience. He/She will have demonstrated capability in feasibility studies in the field of agriculture. The candidate should have field experience in Southern Africa, and good knowledge of the biofuel initiatives undertaken, especially in Brazil, India or Malaysia.
2. A fuel expert: He/She will be a plant design engineer /fuel expert (MSc or higher) with at least ten years relevant experience preferably in Southern Africa or developing countries. He/She will have a good knowledge of fuel plant design.
3. An agronomist: He/She will be an agronomist (MSc or higher) with at least ten years relevant experience with sugar and /or oilseed production, preferably in Southern Africa, Brazil, India or Malaysia.

The consultants should be fluent in English. Knowledge of French or Portuguese will be an added advantage.

Timetable

The assignment will be carried out in five weeks.

During the first week the consultants will be briefed at the SADC Secretariat. At the end of the week they will present an Inception Report and provide a brief presentation to the Secretariat. The Inception Report should be detailed, indicating how the Team will meet the objectives of the project within the agreed time of the study period. On day 5 the consultants will leave Gaborone for a field trip that will start with the relevant South African and Malawi authorities and end in Zambia. During the rest of the assignment, the consultants will operate from the SADC Secretariat in Gaborone. The consultants will work and report in close collaboration with the different Directorates of the SADC Secretariat.

The report will be handed over to SADC on day 35.

Reporting

The report should be produced in English, using Word and Excel format. Fifteen hard copies of the final report must be prepared for distribution. The reports must also be submitted in electronic format. SADC Secretariat reserves the right to have the reports re-drafted as many times as necessary to bring them to the required standards.

Reports will have a maximum of 50 pages, including the executive summary of no more than four pages, outlining major findings and recommendations of the project. The cover will carry the date of submission of the report, and in brackets the mission dates. The first page will carry the following disclaimer “The authors accept sole responsibility for this report drawn on behalf of the SADC Secretariat. The report does not necessarily reflect the views of the SADC Secretariat”. Repetitions will be avoided and replaced by a reference to the relevant section(s).

The report will include at least the following annexes:

- Feasibility report of the production and use of biofuels in the SADC region;
- A draft Regional Policy Paper (RPP);
- Outlines of a SADC brochure on biofuels;
- Terms of Reference of the mission, and comments on the latter (if any);
- Methodology applied by the consultants;
- List of Persons/organizations consulted and detailed schedule of the mission;
- Literature and documents consulted (with precise references);
- Brief CV of the Consultants (max 1 page for both);
- Technical annexes as necessary.

Bearing in mind that liquid biofuels are largely unknown in the region, the study report should sufficiently dwell on the history of biofuel use, the global environmental context, and current initiatives worldwide.

Annex VI. Profiles of the Consultants for the SADC Biofuels Study

Dr Tobias Takavarasha (age 51 yr): A Zimbabwean national, Dr Tobias Takavarasha, the team leader is an agricultural and development economist with twenty-two years of practical experience working in the Ministry of Agriculture in Zimbabwe (1980 – 2002), including as the Ministry's Permanent Secretary (1996 – 2002). From 2002 -2004 worked as Chief Executive Officer of the Food, Agriculture and Natural Resources Policy Analysis Network for Southern Africa (FANRPAN), and later as FAO Agriculture Advisor to NEPAD for four months from May to September 2004. Dr Takavarasha served as a member of the Presidential Land Review Committee of the Government of Zimbabwe, and Technical Advisor from May 2004 to April 2005.He sits on a number of Boards including Seed Co Zimbabwe, Zimbabwe Show Society and Southern African Regional Poverty Network (SARPAN), and has participated in a number of consultancy studies in agriculture in the Southern African region. Dr Takavarasha holds a Doctorate in Agricultural Policy (University of Zimbabwe, 1996), MA Agricultural Economics (Leeds University, 1978), and BA Honours Economics (Birmingham University, 1977).

Dr Hamimu Hongo (age 50 yr): A Tanzanian national is an Agronomist. Holds **PhD** in Agronomy (University of Reading, UK, 1995), **MSc** Agricultural Meteorology (University of Reading, UK 1986), **BSc** Agriculture (University of Dar es Salaam, Tanzania 1983) and **Diploma** in Crop Husbandry (Ukiriguru Agricultural Institute, Mwanza, Tanzania 1979). In addition, Dr Hongo also holds diploma in Computer Science (University of London Wye College UK 1989/90). He also attended several short courses in Agro-meteorology (Turin, Italy 1988), Food Security (FAO, Italy, Rome 1987), Wetland Management (Naivasha, Kenya 2003), Trainer's Training (STA Colleges Letchworth UK -City and Guilds of London Institute). Worked with Ministry Agriculture and Food Security Tanzania (in various posts) from 1979 to date. Between 2003 and March 2005 worked with SADC Secretariat in Gaborone, Botswana as Senior Crop Expert. Dr Hongo presented and published several papers on agriculture, and has participated in several consultancies. **Mr. Jai Uppal (age 57 yr):** Mr. Uppal has wide and varied experience of about 35 years as a company executive, project manager, business and technical consultant, and in Non Governmental sector (NGO). He has worked in the areas of Process Industry, Alcohol, Ethanol, Bio-diesel, Renewable Energy, Bio-energy/Biomass, Alternate Fuels (& Hydrogen), Energy Conservation, Environment, Biogas, Effluent treatment & diverse other fields. At present, Mr. Uppal is Advisor Renewable Energy to Winrock International India and also consultant to a number of reputed companies and organizations. He has been in the forefront of promotion of biofuels in India, which culminated in India's adoption of the Ethanol Program in 2003. He has been active in the area of project design, formulation & planning, setting up & managing of projects, operations, general management and monitoring and evaluation. He has been Chairman of various Technical Committees. His Indian University has conferred Mr. Uppal with the distinguished Alumni Award. He is a Fellow of the Institution of Engineers & Past Chairman of Indian Institute of Chemical Engineers (NRC). He has traveled extensively to many countries on assignments, written extensively presented papers in India and abroad and organized conferences. Mr. Uppal completed Bachelors in Chemical Engineering (1970), and Masters in Chemical Engineering from University Michigan (1971).

Annex VI1: Technical briefs of the seven suggested energy crops for SADC:

1. OIL PALM
Its scientific name is ***Elaeis guineensis*** Jacq.

Origin:
Oil palm is originated in West Africa and was introduced to South America during migratory movements of African slaves.

Description:
Oil palm has dense mat of adventitious roots, it can grow to a height of 30 m and have inflorescence, which is unisexual, and it bears male and female inflorescence simultaneously. There are three types namely Dura, Pisifera and Tenera. The later is a hybrid of the first two types and is a higher yielding than the rest of the two. It is rich in oil content ranging from 47 to 52 %.

Climate:
It is cultivated throughout equatorial Africa where the altitude is below 700m and rainfall is high (up to an annual rainfall of 1,700 mm). Planted in the field at a spacing of 9m sides giving 143 plants per ha with potential yield of 18 to 20 tons of bunches per ha per year. But in equatorial Africa the yield ranges from 12 to 13 bunches per ha per year.

2. SOYA BEAN
Its scientific name is ***Glycine max*** (L;) Merrill;

Origin:
Its origin is said to be northeast China

Description:
There is *Glycine soja* (wild forms) and *Glycine max (L.)* Merrill. (cultivated forms). Soya beans cultivars are either determinate or indeterminate. Determinate soya bean cultivars stop growing in height at flowering while the indeterminate cultivars continue to grow in height throughout the flowering and pod development stages. Under favourable growing condition soya bean can develop a tape root up to 2m. Its yield ranges from 550 to 2,200 kg/ha although yield of up to 3 to 4 tons/ha has been recorded in Zambia and Zimbabwe. Oil content is about 20%.

Climate:
Soya bean is usually refereed to as a short-day plant although daylight insensitive cultivars have been developed. Soya beans grow well under a wide range of temperatures, but prefer a mean monthly maximum temperature above 20°C. Growth is slow or nil at 10°C and its optimum is 30°C. It grows in a wide range of soils ranging from loamy sands to clay loams, provided they are deep and well drained.

3. SUNFLOWER
Its scientific name is *Helianthus annuus* L.

Origin:
It originates from Mexico

Description:
Is an annual herb with normally no branch hairy stem ranging from 0.5 to 4m in height. Tap root can go up to 2.5m deep and its surface roots can go up to 3m away from the plant, hence pronounced drought tolerant. Oil content ranges from 40 to 50% depending on the variety. Yield ranges from 0.5 to 1.5t/ha.

Climate:
It can grow from seal level up to 2,500m. Sunflower prefers temperature ranging from 18 to 27°C. Maturation is favoured by dry and warm weather. Although it can grow in wide range of soils, sunflower does well in deep, well drained, fairy light sand soils.

4. JATROPHA OR PHYSIC NUT
Its scientific name is *Jatropha curcas* from the family *Euphorbiaceae*

Origin:
Originates from Central America

Description:
Is shrub or tree growing up to 6m tall with spreading branches and stubby twigs and has milky exudates. The seeds contain 35 to 40% oil, while the kernels have 55 to 60%. The oil is used as; skin care and cosmetics, pesticide, fuel oil for lighting and cooking, soap making, lubricate machinery and also can be used to produce bio-diesel. It is an attractive species for resource-poor farmers since it will survive in drought and with little or no fertilizer input. Yields ranges from 2.5 to 4.5 tones per ha.

Climate:
Although not native to Africa, Jatropha is fairly well established in several parts of the continent. Is drought resistant tree that can grow in areas where annual rainfall is as low as 500 mm. It can grow very well in soils that are quite infertile. Usually found at lower elevations (below 500m).

5. SUGAR CANE
Its scientific name is *Saccharum officinarum* L.

Origin:
Its origin is said to be New Guinea

Description:
Sugar cane is a perennial plant and can be cut up to 10 times in succession depending on the fertility of the land and care. It can grow as high as 2 to 4m and leaves are 1 to 2m long and 5 to 7cm wide. When matured it stores its sugar in a form of sucrose. Yields vary, depending on type of soils and climate, but at the age of 12 months, it can give 80

to 100 tones of cane per ha. The total sugar content in the cane can be as high as 14 to 15% but on average the sugar content rarely exceeds 8 to 9%

Climate:
Sugar cane can be grown in tropical and sub tropical regions. It can tolerate high temperatures but cannot abide the cold. It needs at least 1,200 sunshine hours per year but best is 2,000 hours per year.

6. CASSAVA
Its scientific name is *Manihot esculenta* Crantz

Origin:
Its origin is north South America (Brazil, Peru, Guyana and Mexico).

Description:
Is a shrubby, semi-woody plant, can grow to a height of 2 to 3m. It is grown as annual or biennial crop. Stem is filled with pith hence very fragile. The root system is well developed and this gives the crop a good drought resistant. Yields of 20 to 25 tones per ha of fresh roots have been recorded, but average yields in tropical regions are 10 tones per ha. It contains 33.6% starch (hence used in production of ethanol due to high starch content).

Climate:
Cassava grows well in sunny, wet climate, but it can do well in relatively dry regions. (It needs a minimum of 500mm of rainfall per annum). For optimal growth it requires temperatures between 25 to 30°C and its growth stops at temperatures below 10°C.

7. SWEET SORGHUM
Its scientific name is *Sorghum bicolor* (L.) Moench

Origin:
Its origin is in dry lands of Sudan.

Description:
It can grow up to 5 m high, and have roots well developed and takes 120 150 days from sowing to harvesting hence it's possible to have two crops in one year in some regions. Sweet sorghum is an extraordinarily promising crop not only for its high economic value (due to its high sustainable productivity ranging from 20 to 50 tones per ha) but also for its capacity to grow in all continents (in tropical, sub-tropical, temperate (grown in summer) regions as well as in poor quality soils and semi-arid regions. In Africa grain yield is always ranges from 0.5 to 1 tones per ha, although yield of up to 7 tones per ha has been reported in Zambia. It contains 70 to 90% starch.

Climate
Sweet sorghum can be grown in wide range of temperatures, from tropical to temperate and even in dry lands with average rainfall from 500 to 600 mm. Sorghum is uniquely

adapted to adverse growing conditions such as drought, poor fertility, water logging, high altitudes and salinity. However, it generally grows on sandy loams and pH ranging from 4.5 to 8.5. Study on bio ethanol by World Bank show that sweet sorghum is more promising crop in comparison with sugar cane for bio ethanol production especially where there is water scarcity and poor soils.

Annex VIII. Cropland potential and yields of oil per ha of the oil seed crops and plants.

Table 1: Cropland potential for five selected SADC countries

Country	Land Area (mil ha)	Suitable Cropland (~ 20 %) (mil ha)	Area Under Crops Today (mil ha)	Area Required For Domestic Energy Supply (mil ha)
DRC	227	45	8	0.2
Angola	125	25	4	0.6
Tanzania	88	18	5	0.3
Zambia	74	15	5	0.2
Mozambique	78	16	3	0.2

Source: FAO-IIASA and own calculations

Table 2. Yields, (of oil) by crop and suitable countries for production in SADC region.

Crop	Yield (kg oil/ha)	Liters of oil/ha	Favourable country In SADC
Palm oil	5,ooo	5,950	Angola, DRC, Tanz, Zam
Coconut	2260	2689	Moza, Tanz
Cashew nut	148	176	Angola, Moza, Tanz
Sunflower	800	952	Angola, Bots, DRC, Malawi, Moza, Nam, SA, Tanz, Zam, Zim
Sesame	585	696	Angola, DRC, Moza, SA, Tanz, Zam, Zim
Soyabean	375	446	DRC, Malawi Moza, SA, Tanz, Zam, Zim
Cotton seed	273	325	Angola, Malawi, Moza, SA, Tanz, Zam, Zim
Peanut	890	1059	Angola, DRC, Malawi, Moza, Tanz, Zam, Zim
Castor beans	1188	1413	Angola, DRC, Moza, SA, Tanz
Avocado	2217	2638	DRC, SA, Tanz
Jatropha	1590	1892	All countries

Source:

1) **Crop production in tropical Africa, Ed. Romain H. Raemaekers, 2001**
2) **Report of the Committee on Development of Bio-fuel, by Government of India, New Delhi, 2003.**

ANNEX VIII. Production of suggested energy crops in the SADC region.

Table 3a. Annual Production of Palm Oil in the SADC Region 1961- 1999 (Area is in 000 ha and production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2004	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola		38.1		37.6		39.6	23	280
Botswana								
DRC		213.8		184.7		163.3	250	1,150
Lesotho								
Madagascar#		_		1.4		3.0	1.8	21
Malawi								
Mauritius								
Mozambique								
Namibia								
South Africa								
Swaziland								
Tanzania		0.991		2.5		4.4	4.5	65
Zambia								
Zimbabwe								
AFRICA		**1,149.95**		**1,272.32**		**1,520.1**	**4,333**	**15,823**
WORLD		**1,683.98**		**3,436.67**		**8,133.96**	**12,115**	**162,249**

Source: FAO Rome 2004

Table 3b. Annual Production of Sunflower in the SADC Region 1961- 1999 (Area is in 000 ha and production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2004	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola	7.0	7.0	14.0	12.0	12.0	8.0	15	11
Botswana	1.0	0	3.0	1.0	1.0	0	6.2	7
DRC								
Lesotho								
Madagascar*								
Malawi	1.0	1.0	6.0	4.0	6.0	4.0	6.3	3.7
Mauritius								
Mozambique	5.0	3.0	21.0	12.0	32.0	18.0	22	6.3
Namibia	_	_	_	_	1.0	1.0	0.13	0.05
South Africa	166.0	97.0	312.0	288.0	374.0	350.0	630	675.5
Swaziland								
Tanzania	33.0	11.0	62.0	30.0	79.0	38.0	82	28
Zambia	2.0	0	18.0	11.0	48.0	27.0	18	10
Zimbabwe	4.0	2.0	15.0	12.0	53.0	29.0	26	8
AFRICA	**235.0**	**132.0**	**499.0**	**408.0**	**739.0**	**584.0**	**982**	**889.5**
WORLD	**7,554**	**8,623**	**10,274**	**11,822**	**14,529**	**18,787**	**21,436**	**26,108**

Source: FAO Rome 2004.

Table 3c. Annual Production of Soya beans in the SADC Region 1961-1999 (Area is in 000 ha & production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2004	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola								
Botswana								
DRC	3.0	2.0	5.0	4.0	10.0	8.0	30	14.6
Lesotho								
Madagascar*							0.05	0.05
Malawi								
Mauritius								
Mozambique								
Namibia								
South Africa	9.0	4.0	19.0	21.0	34.0	51.0	135	220
Swaziland								
Tanzania	5.0	1.0	5.0	1.0	4.0	1.0	5.6	2.1
Zambia	_	_	1.0	1.0	14.0	15.0	15	15
Zimbabwe	1.0	1.0	22.0	44.0	50.0	97.0	58	84
AFRICA	**206.0**	**82.0**	**283.0**	**188.0**	**395.0**	**422.0**	**1,117**	**1,054**
WORLD	**26,526**	**34,433**	**40,204**	**64,531**	**53,126**	**95,543**	**91,443**	**204,266**

Source: FAO Rome 2004.

Table 3d. Annual Production of Maize in the SADC Region 1961- 1999 (Area is in 000 ha and production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2004	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola	518	432	584	394	707	252	980	510
Botswana	18	6	45	24	24	9	84	10
DRC	532	368	676	501	967	796	1,450	1,155
Lesotho	142	105	108	98	128	109	180	150
Madagascar*	116	126	115	118	139	143	195.5	349.7
Malawi	926	946	1,069	1,253	1,199	1,356	1,550	1,733.1
Mauritius							0.055	0.19
Mozambique	420	396	583	407	902	364	1,300	1,248
Namibia	18	22	22	27	20	24	23	33
South Africa	4,368	5,824	4,347	8,626	3,946	8,394	3,204	9,737
Swaziland	85	43	67	95	74	109	60	70
Tanzania	957	682	1,179	1,238	1,589	2,165	1,580	2,800
Zambia	913	764	906	1,202	629	1,186	750	1,161
Zimbabwe	808	1,022	959	1,673	1,295	1,952	1,400	1,000
AFRICA	**16,734**	**18,585**	**17,885**	**25,638**	**19,846**	**30,010**	**27,178**	**43,390**
WORLD	**109,181**	**238,178**	**121,138**	**352,044**	**126,858**	**445,146**	**147,022**	**721,379**

Source: FAO Rome 2004.

Table 3e. Annual Production of Sorghum in the SADC Region 1961- 1999 (Area is in 000 ha and production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2004	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola								
Botswana	85	23	91	40	111	28	95	32
DRC	36	24	32	28	56	39	85	54
Lesotho	67	54	63	59	56	38	53	46
Madagascar*	5	3	3	1	2	1	2	1
Malawi	86	58	94	77	29	17	60	45
Mauritius								
Mozambique	229	184	256	205	356	201	515	314
Namibia	8	3	12	5	15	7	20	6
South Africa	389	328	266	479	261	452	130	449.1
Swaziland	12	5	3	2	1	2	1	0.6
Tanzania	246	160	516	327	531	518	620	650
Zambia	71	45	65	36	36	24	22	19
Zimbabwe	155	84	184	100	197	97	140	80
AFRICA	**14219**	**10806**	**14001**	**11261**	**15761**	**13688**	**25,012**	**21,001**
WORLD	**48158**	**49481**	**46934**	**62074**	**45433**	**66613**	**43,727**	**58,884**

Source: FAO Rome 2004.

Table 3f. Annual Production of Sugar cane in the SADC Region 1961- 1999 (Area is in 000 ha and production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2004	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola	14.0	688.0	15.0	592.0	15.0	283.0	9.5	360
Botswana								
DRC	9.0	529.0	13.0	760.0	27.0	1,172.0	43	1,787.3
Lesotho								
Madagascar*	19.0	996.0	33.0	1,316.0	57.0	1,776.0	68.7	2,459.7
Malawi	1.0	102.0	7.0	781.0	15.0	1,679.0	20	2,100
Mauritius							72	5,200
Mozambique	38.0	1,836.0	55.0	2,495	27.0	636	30	400
Namibia								
South Africa	150	11,894	198	17,239	262	18,926	305	19,095
Swaziland	11.0	1,093.0	18.0	1,939.0	35.0	3,655.0	48.3	4,500
Tanzania	29.0	822.0	31.0	1,299.0	12.0	1,315.0	17	1,800
Zambia	1.0	76.0	6.0	661.0	11.0	1,138.0	17	1,800
Zimbabwe	13.0	1,270.0	23.0	2,309.0	33.0	3,495.0	39	4,100
AFRICA	**598**	**37,198**	**857**	**54,617**	**1,184**	**69,555**	**1,423**	**84,564**
WORLD	**9,781**	**504,296**	**12,388**	**675,796**	**15,865**	**945,582**	**20,287**	**1,323951**

Source: FAO Rome 2004.

Table 3g. Annual Production of Cassava in the SADC Region 1961- 1999 (Area is in 000 ha and production is in 000 tones)

	1961 - 1970		1971 - 1980		1981 - 1990		2002	
Countries	Area	P´ction	Area	P´ction	Area	P´ction	Area	P´ction
Angola	422.0	1,431.0	387.0	1,400.0	393.0	1,507.0	640	5,600
Botswana								
DRC	1,404.0	9,495.0	1,697.0	11,670.0	2,081.0	15,993.0	1,850	14,951
Lesotho								
Madagascar*	171.0	1,070.0	222.0	1,382.0	331.0	2,110.0	352.8	2,191.4
Malawi	19.0	129.0	39.0	240.0	66.0	203.0	150	2,559.3
Mauritius							0.014	0.13
Mozambique	770.0	2,720.0	814.0	3,280.0	901.0	3,691.0	1,050	6,150
Namibia								
South Africa								
Swaziland								
Tanzania	627.0	3,233.0	609.0	4,570.0	655.0	7,270.0	660	6,890
Zambia	34.0	149.0	44.0	212.0	72.0	359.0	165	950
Zimbabwe	15.0	44.0	17.0	51.0	21.0	79.0	44	190
AFRICA	**6,009**	**35,097**	**6,930**	**44,910**	**7,831**	**59,293**	**12,253**	**108,110**
WORLD	**10,700**	**85,247**	**12,870**	**111,586**	**14,303**	**138,013**	**18,512**	**202,648**

Source: FAO Rome 2004;

ANNEX IX

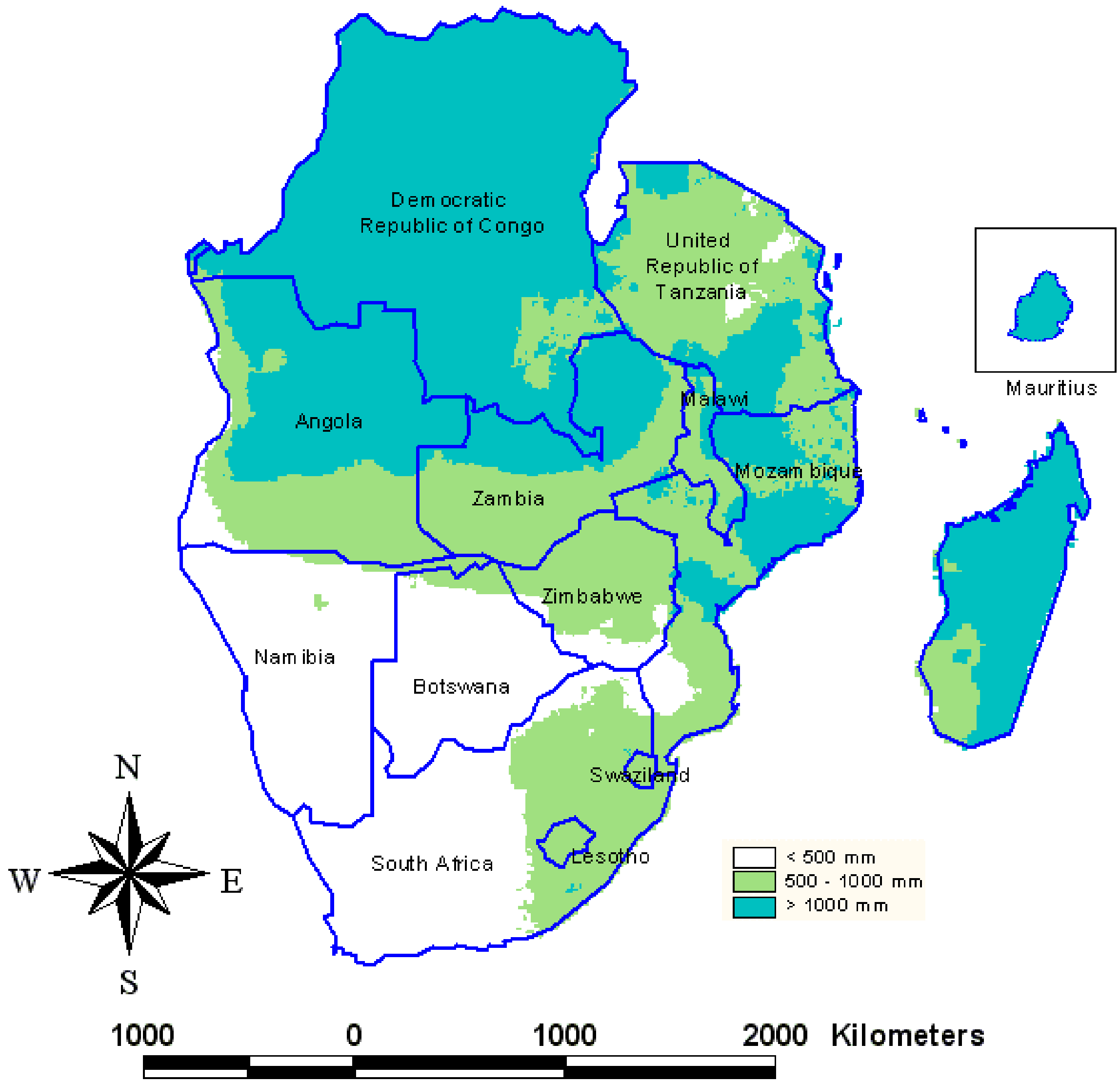

Figure 1. Rainfall Pattern for the SADC Region.
Source: Regional remote sensing FANR

Annex X

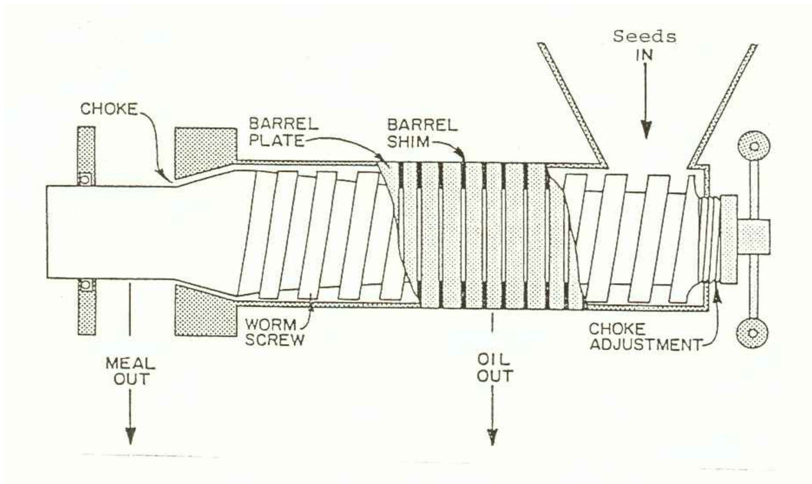

Fig.10.1 Principle of Oil Expeller Operation

Annex X

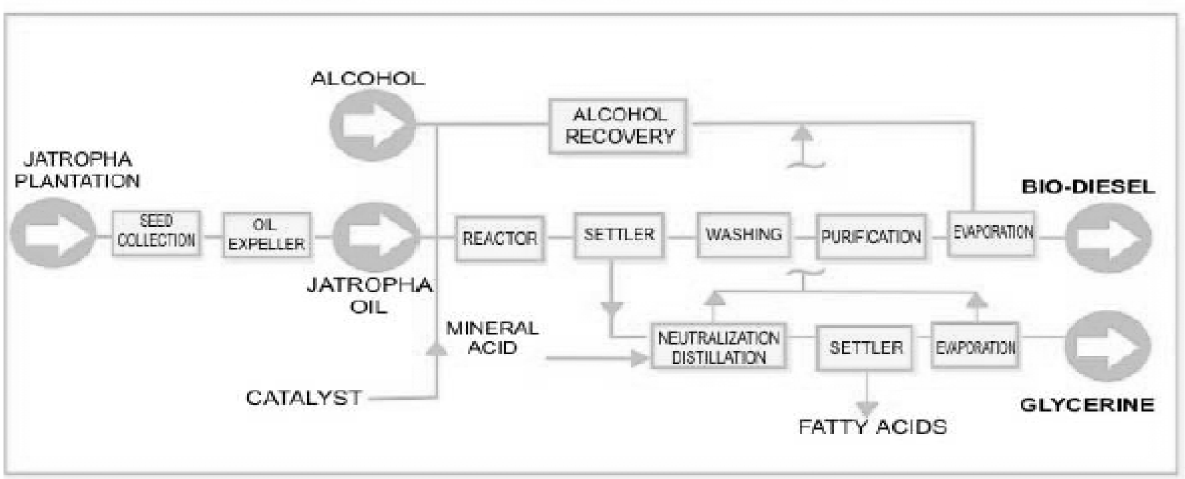

Fig. 10.2 Simplified Process Flow sheet for Production of Biodiesel

Annex X

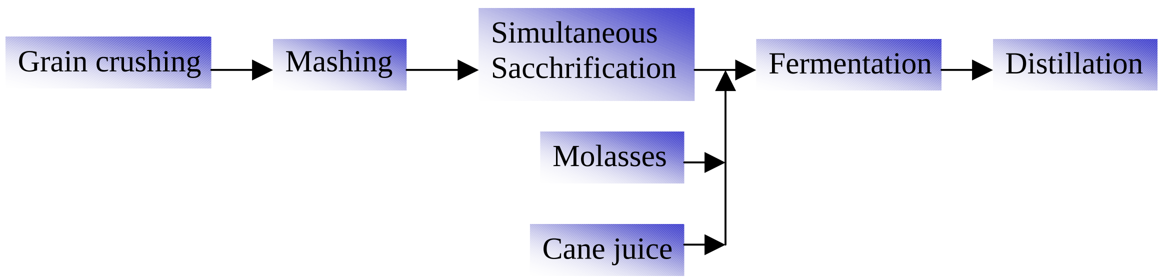

Fig. 10.3 Simplified Process Flow sheet for Production of Ethanol

Annex XI

Biodiesel, B100, Specification

Property	ASTM Method	Limits	Units
Flash Point	D93	130 min.	Degrees C
Water & Sediment	D2709	0.050 max.	% vol.
Kinematic Viscosity, 40 C	D445	1.9 - 6.0	mm^2/sec.
Sulfated Ash	D874	0.020 max.	% mass
Sulfur	D5453	0.05 max.	% mass
Copper Strip Corrosion	D130	No. 3 max.	
Cetane	D613	47 min.	
Cloud Point	D2500	Report	Degrees C
Carbon Residue 100% sample	D4530**	0.050 max.	% mass
Acid Number	D664	0.80 max.	mg KOH/gm
Free Glycerin	D6584	0.020 max.	% mass
Total Glycerin	D6584	0.240 max.	% mass
Phosphorus Content	D 4951	0.001 max.	% mass
Distillation Temp, Atmospheric Equivalent Temperature, 90% Recovered	D 1160	360 max.	Degrees C

* To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller and manufacturer.

** The carbon residue shall be run on the 100% sample.

\# A considerable amount of experience exists in the US with a 20% blend of biodiesel with 80% diesel fuel (B20). Although biodiesel (B100) can be used, blends of over 20% biodiesel with diesel fuel should be evaluated on a case-by-case basis until further experience is available.

Annex XII

European and Australian Standards for Biodiesel

			EU	Australia
Standard/Specification		Unit	EN 14214	
Date			July 2003	September 03
Application			FAME automotive	FAME
Density	15°C	kg/m³	860-900	860-890
Kinematic	20°C	mm²/s	-	-
Viscosity	40°C	mm²/s	3.50-5.00[16]	3.5-5.0
	I.B.P.	°C	-	-
Distillation	5%	°C	-	-
	95%	°C	-	≤ 360 / 90%
	250°C	%	-	-
Distillation	350°C	%	-	-
	370°C	%	-	-
Flashpoint		°C	≥ 120	≥ 120
CFPP		°C	[22]	TBA[16]
Pourpoint	sum/winter	°C	-	-
Cloud point		°C	-	-
Total Sulfur		% mass	≤ 0.0010	≤ 0.005/0.001[23]
CCR	100%	% mass	-	≤ 0.050
	10%	% mass	≤ 0.30[17]	or ≤ 0.30
Sulfated ash		% mass	≤ 0.02	≤ 0.020
(Oxid) Ash		% mass	-	-
Water cont.		mg/kg	≤ 500	-
Total contamination		mg/kg	≤ 24[18]	≤ 24
Water & Sediments		% vol.	-	≤ 0.050
Cu-Corrosion	3h/50°C		class 1	≤ No. 3
Cetane No.		-	≥ 51	≥ 51
Acid value		mgKOH/g	≤ 0.50	≤ 0.80
Oxidation	IP 306	g/cm²	-	-
Stability	ISO12205	g/cm²	-	-
	EN 14112	h	≥ 6.0	≥ 6
Thermal stability			-	-
Storage stability			-	-
Methanol content		% mass	≤ 0.20	≤ 0.20
Saponification		mgKOH/g	-	-
Ester content		% mass	≥ 96.5	≥ 96.5
Monoglycides		% mass	≤ 0.80	-
Diglyceride		% mass	≤ 0.20	-
Triglyceride		% mass	≤ 0.20	-
Free glycerol		% mass	≤ 0.020	≤ 0.020
Total glycerol		% mass	≤ 0.25	≤ 0.250
Iodine No.			≤ 120	-
Linolenic methyl ester		% m/m	≤ 12.0	-
Polyunsaturated	≤4 doub.b.	% m/m	1[19]	-
Phosphorus content		mg/kg	≤ 10.0	≤ 10.0
Alcaline metals	Na + K	mg/kg	≤ 5.0	≤ 5.0
Alcaline metals	Ca + P	mg/kg	≤ 5.0	≤ 5.0
Net calorific value		MJ/kg	-	-

[16] If CFPP is -20°C or lower, the viscosity measured at -20°C shall not exceed 48 mm²/s
[17] ASTM D 1160 shall be used to obtain the 10% distillation residue
[18] Pending development of a suitable method, EN 12662 shall be used
[19] Suitable test method to be developed
[22] like diesel fuel
[23] Beginning with 1 Feb 2006
[24] Alcohol
[25] Only for FAME as heating fuel solely, same limit as for mineral oil according to national regulations
[26] Free for additives for cold flow improvement or cloud point depressing; only for blending purposes

Annex XIII

ENVIRONMENTAL SPECIFICATIONS FOR MARKET FUELS TO BE USED FOR VEHICLES EQUIPPED WITH COMPRESSION IGNITION ENGINES

Type: **Diesel fuel**

Parameter (1)	Unit	Limits (2)	
		Minimum	Maximum
Cetane number		51,0	—
Density at 15 °C	kg/m3	—	845
Distillation:			
— 95% (v/v) recovered at	°C	—	360
Polycyclic aromatic hydrocarbons	% m/m	—	11
Sulphur content	mg/kg	—	350

(1) Test methods shall be those specified in EN 590:1999. Member States may adopt the analytical method specified in replacement EN 590:1999 standard if it can be shown to give at least the same accuracy and at least the same level of precision as the analytical method it replaces.

(2) The values quoted in the specification are "true values". In the establishment of their limit values, the terms of ISO 4259 "Petroleum products - Determination and application of precision data in relation to methods of test" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account (R = reproducibility). The results of individual measurements shall be interpreted on the basis of the criteria described in ISO 4259 (published in 1995).

Annex XIV

ENVIRONMENTAL SPECIFICATIONS FOR MARKET FUELS TO BE USED FOR VEHICLES EQUIPPED WITH POSITIVE-IGNITION ENGINES

Type: **Petrol**

Parameter (1)	Unit	Limits (2)	
		Minimum	Maximum
Research octane number		95 (3)	—
Motor octane number		85	—
Vapour pressure, summer period (4)	kPa	—	60,0 (5)
Distillation:			
— percentage evaporated at 100 °C	% v/v	46,0	—
— percentage evaporated at 150 °C	% v/v	75,0	—
Hydrocarbon analysis:			
— olefins	% v/v	—	18,0 (6)
— aromatics	% v/v	—	42,0
— benzene	% v/v	—	1,0
Oxygen content	% m/m	—	2,7
Oxygenates			
— Methanol (stabilising agents must be added)	% v/v	—	3
— Ethanol (stabilising agents may be necessary)	% v/v	—	5
— Iso-propyl alcohol	% v/v	—	10
— Tert-butyl alcohol	% v/v	—	7
— Iso-butyl alcohol	% v/v	—	10
— Ethers containing five or more carbon atoms per molecule	% v/v	—	15
— Other oxygenates (7)	% v/v	—	10
Sulphur content	mg/kg	—	150
Lead content	g/l	—	0,005

(1) Test methods shall be those specified in EN 228:1999. Member States may adopt the analytical method specified in replacement EN 228:1999 standard if it can be shown to give at least the same accuracy and at least the same level of precision as the analytical method it replaces.

(2) The values quoted in the specification are "true values". In the establishment of their limit values, the terms of ISO 4259 "Petroleum products - Determination and application of precision data in relation to methods of test" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account (R = reproducibility). The results of individual measurements shall be interpreted on the basis of the criteria described in ISO 4259 (published in 1995).

(3) Unleaded regular grade petrol may be marketed with a minimum motor octane number (MON) of 81 and a minimum research octane number (RON) of 91.

(4) The summer period shall begin no later than 1 May and shall not end before 30 September. For Member States with arctic or severe winter conditions, the summer period shall begin no later than 1 June and shall not end before 31 August.

(5) For Member States with arctic or severe winter conditions the vapour pressure shall not exceed 70 kPa during the summer period.

(6) Unleaded regular grade petrol may be marketed with a maximum olefin content of 21 % v/v.

(7) Other mono-alcohols and ethers with a final boiling point no higher than that stated in EN 228:1999.

Annex XV

Fuel Ethanol Specifications
United States of America

The American Society for Testing and Materials (A.S.T.M.) Standard D4806-98 for "Denatured fuel ethanol for blending with gasoline, for use as automotive spark-ignition engine fuel"

1.	Ethanol, %v/v:	92.1 min.
2.	Methanol, %v/v:	0.5 max. (5,000 ppm)
3.	Water, % v/v:	1.0 max. (10,000 ppm)
4	Solvent-washed gum, mg/100ml:	5 max. (50 ppm)
5.	Chloride ion, mg/L:	40 max. (40 ppm)
6.	Copper content, mg/kg:	0.1 max. (0.1 ppm)
7.	Acidity, as acetic acid, %w/w: *	0.007 max. (70 ppm)
8.	Appearance:	Visibly free of suspended or precipitated contaminants (clear and bright).
9.	Denaturant:	A minimum of 1.96% v/v, and a maximum of 4.76% v/v of natural gasoline, gasoline components or unleaded gasoline.

- Note: There was an error in the original standard. It stated, "mass % (mg/Liter)" which are not the same units, whereas the relevant analytical method specifies "%w/w."
- For full details and test procedures, reference should be made to the standard, which is available from A.S.T.M.