A ROADMAP FOR BIOFUELS IN KENYA
OPPORTUNITIES & OBSTACLES

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COMMISSIONED BY:

GESELLSCHAFT FÜR TECHNISCHE ZUSAMMENARBEIT (GERMAN TECHNICAL COOPERATION - GTZ) KENYA
&
MINISTRY OF AGRICULTURE, GOVERNMENT OF KENYA

THROUGH
PROMOTION OF PRIVATE SECTOR DEVELOPMENT IN AGRICULTURE PROGRAMME (PSDA)
GTZ-REGIONAL ENERGY ADVISORY PLATFORM EAST AFRICA (REAP EA)
GTZ Sector Project on Bioenergy in Eschborn, Germany

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&
ENERGY FOR SUSTAINABLE DEVELOPMENT AFRICA

PREFACE

The current debate on climate change and rising oil prices has greatly increased interest in renewable energy, such as biofuels. Many industrialized countries and more advanced developing countries are seeking to promote biofuels as a way of reducing fossil fuel consumption and mitigating the adverse effects of climate change.

Despite the myriad benefits of biofuels, it is important to note that they are not a panacea for climate change or the world's addiction to fossil fuels. As recent experience has shown, unsustainably produced biofuels can create more problems than they solve. For example, huge demands for corn-based ethanol in the United States and palm-based biodiesel in Europe have added pressure on already tight world food supplies and contributed to the clearing of virgin rainforests in Southeast Asia.

Policymakers and other stakeholders in Kenya must work to avoid replicating these unsustainable models of biofuels production. We must learn from the mistakes that have occurred elsewhere to ensure the use of environmentally and socially sound practices in domestic biofuels production. Kenya is seeking alternatives to its high dependence on imported fossil fuels and the concomitant outflow of foreign currency. Biofuels could provide many attractive opportunities to reduce this dependence while reinvesting in the country's sustainable development. But, as noted above and discussed in detail throughout this study, many challenges must first be addressed before a thriving industry can be established.

It is on this basis that the German Technical Cooperation (GTZ), on behalf of the German Government, has responded to a request from the Ministry of Agriculture, Government of Kenya, to commission this study, as well as a related study on biogas. In order to imbed the bioenergy study work in Kenya with similar questions regionally and globally, three projects have been cooperating and funding this effort:

- The Kenyan-German Private Sector Development in Agriculture (PSDA) Programme in Nairobi, Kenya
- The GTZ Regional Energy Advisory Platform East Africa (REAP EA) covering Ethiopia, Kenya, Rwanda, Tanzania and Uganda.
- The GTZ Sector Project on Bioenergy in Eschborn, Germany.

The following biofuels study provides a comprehensive overview of the national potential and challenges facing biofuels in Kenya. The goal is to elucidate benefits and analyze viability, while also assessing possible challenges, such as economic feasibility, fiscal and regulatory limitations, and environmental and social impacts, including competition with food. The study highlights the potential of establishing a biofuels industry and analyzes the political and legal environment that will be required to promote the sustainable development of biofuels in Kenya. The study also provides a history and current status of biofuels in Kenya and a critical appraisal of the policy framework within which this sector must develop.

Cover Photos - Top: Abandoned gas pump, Muhoroni; Middle Left: Jatropha plantation, Central Province; Middle Right: Croton seeds; Kerio Valley; Bottom Left: Sugarcane en route to factory, Muhoroni; Bottom Right: Spectre International ethanol plant, Kisumu. Credit: David Newman (2007).

We hope that this biofuels study contributes significantly to a well-informed and well-executed bioenergy strategy in Kenya.

Permanent Secretary	Permanent Secretary	Country Director
Kenya Ministry of Agriculture	Kenya Ministry of Energy	GTZ Kenya

Nairobi, 29 April 2008

1. INTRODUCTION & EXECUTIVE SUMMARY

Biofuels are liquid, solid or gaseous energy sources derived from renewable biomass.[i] They generally emit fewer toxic air pollutants and greenhouse gasses than petroleum-based fuels and can be produced anywhere sufficient biomass "feedstock" can be grown. At a time of record oil prices and growing concern over global warming, biofuels present a valuable opportunity to reduce dependence on volatile global oil markets, create local economic opportunities in agriculture and industry, and improve the environment.

Global oil consumption is projected to increase by about 36% by 2030.[ii] In Africa, oil consumption could nearly double in that time.[iii] As more countries scramble for an increasingly limited supply of oil, the price and availability of fuel will become ever more challenging issues. Many countries see biofuels as part of the solution to these problems, which has led to explosive growth in global production. From 2000 to 2006, global fuel ethanol production nearly tripled to 40 billion liters, while biodiesel production grew from one to six billion liters.[iv]

As the thirst for biofuels has expanded, so too has the recognition that not all biofuels are created equal in terms of environmental and social sustainability. From the destruction of rainforests for palm oil plantations to the use of staple food crops like maize for ethanol, the impacts on ecosystems and food supplies have grown. This has led some to question the overall value of biofuels as a solution to global warming and tight oil supplies. Unfortunately, the debate over the sustainability of biofuels has evolved in a way that generally has created two rather inflexible and absolute schools of thought: one in favor and the other against. A more nuanced approach, however, shows that biofuels *can* be produced in an environmentally- and socially-beneficial way if the right crops and models of production are prioritized.

Countries like Kenya, with no proven oil reserves but suitable climatic conditions for growing biofuels, could limit the shock of high oil prices by developing its own supply of domestically produced biofuels. Although Kenya has yet to participate in the biofuels boom, it is beginning to lay the groundwork for significant progress in the years to come. The government recently enacted a policy (Sessional Paper, No. 4 of 2004) and legislation (the Energy Act, No. 12 of 2006) that favors the development of ethanol and biodiesel, and the Ministry of Energy has developed a biodiesel strategy through its National Biofuels Committee. In addition, a Kenya Biodiesel Association is being formed with support from all sectors of the biofuels industry. The Ministry intends to turn its attention to ethanol once the biodiesel program is established.

This study is intended to support these efforts with a detailed analysis of the latest information on the agronomy, economics, law and policy, and environmental and social impacts of biofuels in Kenya. The overriding objective is to transcend the standard rhetoric with an informed discussion of the true opportunities and obstacles. The following is a brief summary.

Overview of Ethanol & Biodiesel

Section 2 provides a detailed overview of ethanol and biodiesel, the two main sources of biofuels considered in this study. Ethanol, also known as ethyl alcohol or grain alcohol, is a liquid fuel that can be produced from a variety of sugars and starch containing crops, such as grains. Ethanol was first used as an automotive fuel starting in 1908 with the Model T Ford and has been used as an additive in petrol fuel for over 30 years. Kenya has produced ethanol from sugarcane since the early 1980s and for a time even blended it with petrol as part of its now-defunct gasohol program.

Ethanol can be blended with petrol in any ratio, or used straight, but requires the use of specially designed flex fuel vehicles in blends above 10%, referred to as E10. The energy content of ethanol is about two-thirds that of the equivalent amount of petrol, so an E10 blend will have about 93% of the fuel economy of straight petrol. International and Kenyan fuel quality and blending standards exist to ensure standardized quality and to protect consumers from potentially harmful fuel. The Kenyan standards are a vestige of its earlier gasohol program and need updating.

Ethanol can be produced from sugar crops, such as sugarcane and sweet sorghum; grains, such as corn and wheat; and cellulostic crops, such as switchgrass, although the latter is not yet economically viable for commercial production. The basic production process involves extracting sugars from the biomass, which is much easier and cheaper for sugar crops than grains, and then fermenting the sugar in the presence of yeast. The resulting product is distilled to remove water, leaving alcohol that is concentrated to 200 proof. Methanol, or some other denaturant, is then mixed with the pure ethanol to make it unsuitable for potable consumption.

The following ethanol feedstocks are considered in the study: cassava, sugarcane and sweet sorghum. Other crops, including corn and sugar beet, were discounted from consideration due to potential conflicts with food or incompatible agro-ecological conditions. Detailed information on agronomy, uses, environmental pros and cons, and pests and diseases are included. Working with the World Agroforestry Centre's (ICRAF's) GIS laboratory, we have designed suitability maps for each feedstock that show where they can grow and where they would be competing with existing food and cash crops.

Biodiesel is a liquid substitute for petroleum-based diesel fuel made with vegetable oil derived from a wide variety of oil-bearing plants such as castor, coconut, cottonseed, croton, jatropha, rapeseed (canola) and sunflower. Biodiesel has been around since the beginning of the 20^{th} century, but has only recently been produced in large, commercial quantities. No vehicle modifications are required to use biodiesel blends of up to 20% (B20), although auto manufacturers have varying biodiesel warranty policies on what level of blend is permitted without voiding the warranty. Blends above 20% all the way up to pure biodiesel (B100) can be used in ordinary diesel engines, but may require slight modification of older fuel lines and hoses that are less compatible with pure biodiesel.

International fuel quality and blending standards for biodiesel ensure that the fuel does not harm consumers. Biodiesel contains about 93% of the energy content of petroleum diesel, so B5 will achieve about 0.5% less fuel economy than ordinary diesel. The production of biodiesel involves mixing pure vegetable oil with alcohol and caustic soda, which produces ethyl or methyl esters (biodiesel) and glycerin. This study takes a detailed look at the following biodiesel feedstocks: castor, coconut, cotton, croton, jatropha, rapeseed and sunflower.

History & Current Status of Biofuels in Kenya and Around the World

Section 3 of the study provides a detailed history and current status of ethanol and biodiesel in Kenya, as well as in select countries globally and regionally. Kenya was ahead of its time in producing and using ethanol for fuel, but abandoned its gasohol program over 15 years ago. Kenya's present-day ethanol industry, which includes Agro-Chemical and newcomer Spectre International, is marked by tremendous opportunities and significant challenges. These two companies have a combined production capacity of 125,000 liters per day, although current supplies of molasses – the only ethanol feedstock being used in Kenya – mean that only about half of capacity is being used, for a total production of about 60,000 liters per day. Fulfilling the full production capacity at the two ethanol plants would require almost the entire supply of molasses from Kenyan sugar companies, which is not feasible given the alternative markets for molasses and the current low productivity of sugarcane in Kenya.

Poor planning and a crumbling infrastructure are also limiting the competitiveness of sugar and ethanol in Kenya. Thriving in an increasingly competitive global commodities market will require the Kenyan sugar and ethanol industries to innovate and diversify, as well as to invest in more efficient methods of production. The integrated production of sugar, ethanol and power that Mumias Sugar Company is planning is a more efficient and sustainable model of production. Undeterred by these developments, Spectre is moving ahead with a major expansion that will increase its production capacity from its current 65,000 liters per day to 230,000 liters per day.

However, limitations on available land and competition with food production is almost certain to preclude all planned ethanol production to be supplied by sugarcane, meaning that alternative feedstocks, such as sweet sorghum, will be required. One of the greatest potential benefits of sweet sorghum is the fact that it can thrive in drier, more marginal agricultural areas than sugarcane, however more practical research needs to be done to maximize its economic potential in Kenya.

At the current rate of growth of petrol consumption of about 2.8% per year, Kenya is projected to consume about 618 million liters of petrol by 2013. A national 10% ethanol blend would require about 93 million liters, up from the 20 million liters Kenya currently produces. Revival of ethanol fuel production in Kenya has widespread support from the stakeholders who were interviewed for this study.

Compared with ethanol, biodiesel production in Kenya is in its nascent stage. However, a flurry of activities among government agencies, NGOs and the private sector indicate great potential. The vast majority of biodiesel projects currently underway or being planned involve jatropha as the main feedstock, although projects involving other feedstocks, including castor, croton and coconut, are also being discussed. The study provides an overview of the activities of various governmental, non-governmental, research and private sector organizations.

Many of these projects and organizations are beginning their own research and development activities to identify superior planting material and best practices for jatropha. Others have expressed interest in doing so. However, these efforts should be better coordinated among participants, donors and investors to avoid overlap and to take advantage of the relative strengths of the various projects.

The role of certain government ministries is key. The Ministry of Agriculture, through the Kenya Agricultural Research Institute (KARI), the Kenya Plant Health Inspectorate Service (KEPHIS) and the Kenya Sugar Board, perhaps has the most critical role in supporting the agricultural development of superior planting materials, silvicultural practices and models for production. The Ministry of Agriculture should also take the lead in promoting particular biofuels crops and growing regions to minimize the conflict with food.

The Ministry of Environment and Natural Resources, through the Kenya Forest Research Institute (KEFRI), the Kenya Forest Service and the National Environmental Management Authority (NEMA) should take the lead in research for tree crops, like jatropha and croton, as well as overall environmental and public health protection along the biofuels value chain. On the policy front, the Ministry of Energy has convened a National Biofuels Committee, which recently released a national strategy on biodiesel, which it is working to implement. The strategy promotes jatropha, with little mention of other potential crops, but demonstrates strong support for biodiesel development, including recommendations for policy and coordination of government and the private sector.

More than 30 countries around the world have launched ethanol fuel programs, with Brazil and the United States leading the way. The European Union is the top producer of biodiesel, with about 4.5 billion liters, or about 72% of global production, in 2006. This section of the study provides an overview of biofuels programs and policies from the following leading biofuels producers from around the world: Brazil, Germany, India, Thailand and the United States. This section also includes descriptions of regional biofuels activities from the following countries: Ethiopia, Malawi, Mali, Nigeria, Senegal, South Africa, Sudan, Tanzania and Uganda.

Economic Analysis of Biofuels in Kenya

Section 4 analyzes the economics of biofuels in Kenya. In general, the economic case for biofuels in Kenya is quite strong. Kenya currently spends about $1 billion per year in foreign currency on imported oil. Since the early 1990s, the Kenyan Government has spent over $169 million exploring for oil and gas, with over 30 wells drilled but no discoveries. To appreciate the potential value of biofuels, one only needs to consider the fact that many African countries currently spend many times more for imported petroleum than they do on health care and poverty alleviation programs. Even if only a portion of this money were redirected towards domestic bioenergy programs, the social and economic benefits would be substantial.

Biofuels feedstock is the primary and most expensive ingredient for biofuels production. Land availability and agricultural practices are the main factors that determine the supply and price of biofuels feedstock. The Study includes three feedstock production scenarios to determine potential availability. The first considered the status quo production of feedstocks and found that enough sugarcane is currently produced for 49 million liters of ethanol if only molasses is used and 345 million liters if all cane went into ethanol instead of sugar. The existing production of castor is enough to produce about 1.3 million liters of biodiesel. Underexploited coconuts and croton seeds, if linked to biofuels processors, likely could produce millions more, although detailed quantities are not available.

The second feedstock production scenario calculates the amount of each crop that could be grown at current yields if half of all suitable areas (according to the suitability maps) were planted. Excluding land that is currently being used to grow other crops, enough new sugarcane could be grown to produce between 30 and 210 million liters (depending on whether molasses or cane juice was used). Alternatively, over 8 billion liters of ethanol could potentially be produced from sweet sorghum and over 3 billion from cassava. Depending on which biodiesel feedstock is used, between 18 million to over 5 billion liters could be produced.

Of course, even 50% of suitable lands would not be possible to plant with a single crop, so these figures would have to be further reduced to come up with a more realistic estimate of what is possible in the real world. The point is that enough suitable land outside of existing agricultural production is available to produce at least tens, if not hundreds of millions of liters of ethanol and biodiesel.

The final scenario calculates production if half of suitable lands were used, but at optimal yields for each crop. Not surprisingly, the numbers are significantly higher than in the second scenario. The lesson is that both available land and increased yield are important factors in producing adequate supplies of biofuels feedstock to support a domestic industry.

The next part of the analysis describes the economic feasibility of producing ethanol and biodiesel in Kenya. Ethanol has been produced in Kenya for many years from the molasses residue of sugar production. Despite Kenya's relatively low molasses prices, the overall cost of ethanol production remains higher than in the other five sugarcane-based ethanol producing countries or regions considered in this study. The current average cost of production at the two ethanol plants in Kenya is approximately Ksh 36.5, or $0.56, per liter. The main reasons for the higher operating costs in Kenya are poor infrastructure and the relative inefficiency of the Kenyan ethanol model.

Another factor to consider is the impact of fuel taxes on economic feasibility. There is a roughly Ksh 30 ($0.46) per liter tax on petrol. For ethanol to be feasible in the market without any help from the government in terms of tax reductions or subsidies, the pre-tax price of each liter of ethanol must be less than roughly Ksh 40 ($0.61) per liter (assuming a retail pump price of ~Ksh 90 per liter and that one liter of ethanol contains about two-thirds of the energy of a liter of petrol). The current average production cost of Ksh 36.5, or $0.56, per liter of sugarcane ethanol is barely economically feasible as a substitute for petrol, assuming the Ksh 3.5 per liter difference between the cost of production and the pump price is sufficient to cover the cost of transport, blending, marketing and profits. Considering that ethanol sold as potable alcohol currently fetches at least Ksh 50 per liter, some sort of incentive will likely be needed to encourage ethanol producers to begin selling their product for gasohol at a cheaper price.

Little information is available on the cost of production for ethanol produced from sweet sorghum and cassava. Using what information is available on current and projected prices, it appears that both cassava and sweet sorghum would be too expensive to be used economically for ethanol absent any support from the government in the form of tax exemptions or subsidies.

We have evaluated three different scales of production for biodiesel: farm scale (~180,000 liters per year), small commercial scale (~2 million liters per year), and large commercial scale (~12 million liters per year, which is not actually large-scale by international standards). The cost of biofuels feedstock is a factor of the price per tonne of the oilseed, the percentage of oil that can be extracted from the seed (known as "oil content"), and the revenue that can be collected from the seedcake that is leftover after the oil has been extracted. Croton and jatropha appear to be the cheapest feedstocks, although farmers have very little, if any, experience growing these two trees as plantation crops and thus the economic assumptions regarding the price of seed and the yield per hectare are much less certain than for the other crops considered. The next two cheapest feedstocks are coconut and castor.

To determine overall feasibility, the cost of production (which includes feedstock, operations and capital costs) plus taxes must be compared to the current pump price for petroleum diesel, which is about Ksh 80 per liter at the time of this publication. However, discounting for the lower energy value in biodiesel, we can reduce the comparative price of petroleum diesel by 7% to Ksh 74.4 per liter. Thus, at current retail prices, biodiesel production is not economically feasible at any scale of production unless the tax burden is reduced or eliminated. At these levels and with the price of diesel likely to fluctuate below its current retail price, investing in a new biodiesel venture in Kenya seems extremely risky without some governmental support.

Markets for ethanol include alcoholic beverages, pharmaceutical and industrial applications, and fuel. Current ethanol production in Kenya amounts to about 20 million liters per year, the vast majority of which is exported to Uganda and the Democratic Republic of Congo for beverage use. A ten percent ethanol blend (E10) in Kenya would require approximately 93 million liters a year by 2013. In 2006, European countries imported 2.36 billion liters of ethanol. Closer to home, African nations imported about 154 million liters of ethanol in 2006, with a demand that is surely to rise in the coming years. Another potential local market is the use of ethanol in cook stoves and lamps.

Biodiesel is used for transport fuel, stationary power, farm equipment use and marine power. A two percent blend of biodiesel (B2) into the local transport market would require about 32 million liters of biodiesel by 2013. Biodiesel could complement, or completely displace, the use of petroleum diesel for many stationary applications. Straight vegetable oil (SVO) that has not been processed into biodiesel could potentially be used in some applications, such as for transport with specially modified vehicles or for farm equipment. SVO and/or biodiesel could potentially be used as a replacement for kerosene as the main source of light and cooking fuel in many parts of Kenya. As indicated above, rapidly expanding markets for export of ethanol and biodiesel provide tremendous growth opportunities for countries like Kenya, although trade restrictions, such as import tariffs, could impede these markets.

The potential employment and income benefits of biofuels in Kenya are enormous. An additional 93 million liters of ethanol (enough for a national E10 blend by 2013) could yield about Ksh 4.65 billion ($72 million) per year to the economy and produce thousands of new farm jobs and between 500 to 1,000 new non-farm jobs. About 229 new non-farm jobs and thousands more farm-related ones would be created if Kenya adopted a B2 policy requiring the production of roughly 32 million liters of biodiesel by 2013.

To be sustainable and to benefit the largest number of Kenyans, any future biofuels industry should maximize smallholder farm income by selecting feedstocks that will yield the highest return on investment. The availability of oilseeds in large enough quantities for commercial biodiesel production will depend on which crops farmers see as the most beneficial. Although revenues can be calculated for each crop, based on yield per hectare and the current market price of each feedstock, net income is more challenging. Information on the cost of production is not readily available for all crops and will require further research. The Kenya Agricultural Research Institute (KARI) has the capacity and the interest in conducting such important work and should be engaged to do so as soon as possible.

Due to the overwhelming focus on jatropha by the Ministry of Energy, private farmers, investors and NGOs, we have analyzed the potential farm income for a theoretical 50-hectare plantation. The plantation is designed to minimize the up-front establishment costs by planting 10 hectares per year over the first five years. This approach would require about 12 years before the entire plantation is fully matured. Based on projected yield and prices, it will take more than five years before the plantation turns an annual operating profit and more than ten years before such an investment produces a cumulative net income. However, over the long-term, such an investment would achieve an internal rate of return of nearly 15%.

Jatropha is similar to other crops like coffee and tea that take years to mature. However, unlike coffee and tea, that are well-understood crops with established yields and production costs, jatropha plantation farming is still in its infancy and many questions remain. Many of the assumptions we have relied upon, such as un-irrigated yield, could vary significantly from the experiences in India we have borrowed from. Nonetheless, it seems nearly certain that farmers will require significant long-term financing to develop commercial jatropha plantations. Smallholders, who do not have such large land areas, and can provide much of the labor themselves, may begin planting on boundaries and unused land, but may also require significant economic support to develop smaller jatropha plantations.

Kenya spent $983 million, or 5.6% of gross domestic product, importing petrol and automotive diesel in 2006. If Kenya offset 10% of petrol imports and 2% of diesel imports with locally produced biofuels by 2013, it would keep a total of $71 million per year from flowing overseas (at current consumption levels, assuming an average price of $90 per barrel of oil).

The potential reduction in greenhouse gas emissions from biofuels could theoretically provide an additional revenue stream for some projects. There are two distinctive markets for carbon credits: the mandatory market created through the Kyoto Protocol of the United Nations Convention on Climate Change (UNFCCC), and market for voluntary credits. The former is more stringent and restrictive, but generally yields a higher price per tonne of carbon. Conversely, the latter is more flexible and easier to gain compliance with, but fetches a lower price, (though the price has increased steadily due to the value placed on the livelihood aspect of voluntary carbon trade). The only type of biofuels project that has been approved for carbon credits within the CDM is for biodiesel made from waste vegetable oil. Thus, income from carbon credits is unlikely to provide much, if any, added incentive for project developers and investors.

Regulatory & Fiscal Analysis

Section 5 includes a comprehensive review of current laws, policies, regulatory requirements and taxes as they apply throughout the biofuels production life cycle. The Energy Act of 2006 mandates that the government pursues and facilitates the production of biofuels, but does not articulate how this shall be accomplished. Under current law, biofuels must comply with local or international fuel quality standards developed or adopted by Kenya Bureau of Standards, although it is unclear whether this would apply to biofuels produced and consumed at the farm level and not for commercial sale. A standard exists for ethanol, but not yet for biodiesel. A petroleum license is required to blend biofuels with petroleum products, but again it is unclear whether this would apply to a farm-based operation that was consuming all of what it produced.

Health, safety and worker protections are also important considerations for any producer or seller of biofuels, and any associated laws or regulations must be complied with. Existing regulations pertaining to these issues under the Energy and Petroleum Acts presumably would govern the distribution and sale of blended biofuels as long as the blended fuels conform to the relevant standards.

Many aspects of biofuels production have direct and indirect environmental implications that would require environmental impact assessments. Laws and regulations governing air and water pollution, hazardous chemicals and waste disposal must also be adhered to. Growing an adequate supply of biofuel feedstock is an essential component of the production process. This may require the purchase and/or importation of seeds, which are activities regulated by the Seeds and Plant Varieties Act and the Plant Protection Act.

Issues of property law and equipment import and purchase are also important components of biofuels production and require attention to the laws and regulations in those areas. Finally, this section describes the current fuel taxes that apply to petrol (about Ksh 30 per liter) and diesel (about Ksh 20 per liter), their implications for biofuels and how they can be reduced or eliminated to promote the industry.

Environmental and Social Impact Assessment

Section 6 reviews the positive and negative environmental and social impacts that biofuels can have. In general, such impacts depend on the type of feedstocks used and the method and scale of production. The air quality and health benefits of biofuels can be quite significant. Air emissions from ethanol are lower than those from petrol in all six types of air pollution listed. For biodiesel, all major air pollutants are also lower than for petroleum diesel, except for nitrogen oxide (NOx) emissions, which are slightly higher. Although biofuels may produce much lower emissions from exhaust, emissions from other sources along the life cycle must also be taken into account.

Biofuels present an opportunity to help mitigate climate change by reducing carbon dioxide (CO_2) emissions from fossil fuels because the carbon that is released into the atmosphere during the combustion of biofuels is equivalent to the amount of carbon that is absorbed during plant growth minus the amount of fossil fuels used for transport and production. These climate benefits can be commoditized and sold as carbon credits through the CDM or the voluntary carbon market. Similar to the discussion above on other air emissions, the climate benefit of a particular biofuel is dependent on the scale and mode of production, as well as the type of feedstock that is used.

These potential GHG benefits may overlook the emissions resulting from land-use change that is caused by the direct growing of biofuels crops, or the indirect conversion of forest and grasslands to agricultural production resulting from the need to increase food production that has been displaced by biofuels crops. The release of GHGs from land-use change that is caused by growing biofuels feedstocks could undermine purported climate benefits and significantly reduce their overall environmental benefits. The use of waste materials, marginal lands and reforestation projects are essential to maximizing overall GHG emission reductions of biofuels compared with fossil fuels.

An issue closely related to GHG emissions is the amount of energy it takes to produce each unit of biofuels, known as net energy balance or energy return on investment. Different studies show a range of net energy balance for biodiesel and ethanol, although most are positive, meaning more energy is produced than used in the manufacturing process.

Biofuels crops may help to prevent soil erosion and reclaim marginal lands for agricultural use. Of course, depending on the crops and the scale of production, many of these potential gains in land use can just as easily be undone by, for example, the deforestation of tropical rainforests to make way for industrial-scale palm oil plantations. Large plantations on new agricultural lands can also push native plant and animal species out of the area, thus reducing biodiversity and overall ecosystem health. Another potential danger is the risk of invasiveness with some crops, such as castor, jatropha and switchgrass.

The conflict between food and biofuels is real. It is beyond dispute that food prices of major staples that are also being used as feedstocks for biofuels production have increased dramatically over the past several years as biofuels production has boomed. What is not entirely clear is the causal link between the two and the best way to minimize the conflict in different parts of the world. On the one hand, the diversion of corn from food in the United States, which is about 40% of global production, and oilseeds in Europe and Southeast Asia *could* be the main driver for the rise in global commodity prices. However, as the U.N. Food and Agriculture Organization reports, most short-term price increases in food is more the result of increased demand for food from many of the world's fastest expanding economies, like China and India, as well as the high price of petroleum, which affects everything from transport to the price of agricultural inputs like fertilizer and pesticides. The success of sugarcane-based ethanol in reducing the price of fuel in Brazil may actually be helping to bring food prices lower.

One very important consideration when selecting potential feedstocks for biofuels production is whether current domestic production levels are sufficient to meet domestic demand for food and animal feed. However, increasing imports of some foods due to increased biofuels production also may not be such a bad thing, especially if the domestically produced crop can fetch more value as a biofuels feedstock than a food crop and the local food market can meet demand at affordable prices.

Another reason for considering using an edible crop for biofuels is if the domestic cost of production for that crop cannot compete in global or regional markets. As long as Kenyan sugar companies enjoy protective tariffs that enable them to charge about twice the price for imported sugar – Ksh 53,540 per tonne compared with Ksh 28,874 per tonne for imported sugar – then it makes more economic sense to continue producing sugar as the primary product, with the molasses by-product used for ethanol. However, if and when protective tariffs disappear, then the ethanol alone would make more economic sense as the amount of income per hectare for the co-production of sugar and ethanol would drop to Ksh 240,505 compared with Ksh 248,500 for ethanol alone.

The environmental sustainability of biofuels is at the center of a global debate over whether they are as green as first advertised. Various sustainability standards have been developed by different organizations with similar features, although no unifying global standard has yet been adopted. Laws promoting biofuels can also help to ensure sustainability. The E.U., which has set an ambitious goal of 5.75% biofuels by the end of 2010, is now considering banning biofuels derived from crops grown on recently cleared forests, wetlands or grasslands.

While most of the efforts towards more sustainable biofuels discussed above are laudable and much needed, many hurdles remain to their successful adoption and implementation. Like other similar standards, the devil is in the details. Verification, compliance and enforcement are also keys to success. Without verifiable assurances that the standards are being adhered with regard to specific batches of biofuels delivered and consumed, then the standard itself is meaningless. Biofuels sustainability standards in Kenya and the rest of the world would do well to copy many of the mechanisms that have been developed for other similar processes, such as the Forest Stewardship Council's system for certifying wood products and the Gold Standard for verified GHG emissions reductions.

HIV/AIDS can have a deleterious affect on biofuels production by depleting the agricultural labor pool due to premature death and re-occurring periods of illness. This can incapacitate agricultural production and rural livelihoods. The impact of high rates of HIV in the community is exacerbated by the fact that those affected are disproportionately between the ages of 15 and 49, the heart of the labor force. Conversely, the introduction of biofuels cash crops to agricultural communities affected by HIV/AIDS could also have many positive impacts. For example, increased income from the sale of cash crops could reduce the need for woman to engage in unprotected sex in exchange for food and money. However, the labor intensity of different potential biofuels feedstocks should be taken into consideration in cases where large portions of the local population may be in a weakened physical state.

Roadmap & Recommendations

With the right combination of governmental support, private sector entrepreneurship and NGO outreach, Kenya could become the biofuels powerhouse of East Africa and beyond. Within five years, Kenya could be blending 10% ethanol (E10) and 2% biodiesel (B2), plus providing surplus production for stationary power and exports. Biofuels could revitalize rural areas, like Nyanza and Western Provinces, and provide an engine of growth throughout the country. Such a program could also provide a model for the sustainable production of biofuels to counter the increasingly unsustainable models being pursued by large industrialized countries. However, achieving these goals will take a concerted and coordinated effort by government, the private sector, research institutions and NGOs.

A combination of feedstocks would be required to achieve these targets. For ethanol, the logical choices based on availability of land, yield and economics are sugarcane and sweet sorghum. Over 58 million liters could be produced if 15,000 hectares of new land were dedicated to sugarcane (16.5% of suitable land that is not currently being used for food or cash crops) and a portion of current sugarcane were diverted to full ethanol production. Another 34.6 million liters could come from sweet sorghum planted on 24,700 hectares (1% of suitable new land). A combination of castor, coconut, croton, jatropha, rapeseed and sunflower would require about 50,000 hectares of land, some of which is already planted, to produce 32 million liters of biodiesel per year.

The Ministry of Energy's recently released biodiesel strategy makes a number of prudent recommendations to promote and develop the biodiesel industry in Kenya. Several key aspects of the following roadmap incorporate these recommendations from the Ministry, including the production of certified seeds, the establishment and upgrading of blending facilities, myriad aspects of research and development, and the creation of pilot biodiesel production plants. The authors of this study appreciate the Ministry's input and support.

- Help develop the value chain for ethanol and biodiesel production by:
    - Providing agricultural assistance to farmers;
    - Supporting programs, such as irrigation, to improve yields;
    - Improving the transport infrastructure;
    - Enabling cogeneration of ethanol at sugar plants and the use of alternative feedstocks at stand-alone ethanol plants;
    - Supporting farm-based biodiesel production;
    - Investing in research to develop optimal seeds and management practices for new crops like croton and jatropha; and
    - Testing different biofuel blends in various potential applications, including vehicles and generators.
- Design and implement an appropriate regulatory and fiscal framework.
    - Establish specific goals for a National Biofuels Program, such as an E10 and B2 by 2013.
    - Select, empower and fund a lead agency to coordinate disparate government agencies and enable the government to speak with a unified voice on biofuels. The Energy Act provides a mandate to the Ministry of Energy to take the lead on defining a national biofuels policy, which it has already begun to do through the formation of the NBC. Because biofuels implicate many sectors that fall outside of the Ministry of Energy's mandate, it makes sense to establish a high-level task force of the various interested ministries, including: Energy, Agriculture, Environment & Natural Resources, Lands, Water and perhaps others. All other potentially affected government agencies, representatives from the business community, NGOs and development partners should also be consulted thoroughly. The most sensible place to locate the National Biofuels Programme is within the Renewable Energy Department at the Ministry of Energy, or with the creation of a new division. Additional

personnel and resources will be crucial for this new Programme to flourish.

  - o Create a transparent and inclusive process of defining the specific strategy and measures for encouraging the production and use of ethanol and biodiesel.
  - o Implement policies that promote biofuels production and protect consumers, workers and the environment. The regulatory and fiscal review contained in this Study can be used as the basis of the reforms.
  - o Adopt a blending mandate that specifies the amount of ethanol and biodiesel that should or must be blended by a certain date or dates. As described above, E10 and B2 could serve as reasonable goals.
  - o Design fuel quality and blending standards. KEBS must establish or revise fuel quality and blending standards for both ethanol and biodiesel based on the blending mandate and existing standards in Kenya and internationally.
  - o Designate priority feedstock crops. Based on economic, agronomic, social and environmental criteria and analysis, optimal crops should be selected for biofuels. For ethanol, sugarcane and sweet sorghum seem to make the most sense; and for biodiesel, castor, coconut, croton and jatropha should be emphasized.
  - o Identify and certify optimal seeds for the priority feedstock crops. KEPHIS, KARI and/or KEFRI should be responsible for identifying, testing and certifying high yielding seeds that are adapted to the different agro-ecological zones in which they might be grown.
  - o Review and revise all licensing requirements along the entire biofuels value chain where necessary to protect consumers, workers, communities and the environment. If possible, the licensing requirements under the various laws and regulations discussed above should be integrated, thus eliminating unnecessary and onerous regulation.
  - o Adopt tax incentives to promote the new biofuels industry. Fuel taxes can make or break the feasibility of biofuels, so some combination of tax exemptions or subsidies will almost certainly be required to promote the industry. Additionally, farm-scale production, where the fuel being produced is not being sold, should also be exempt from fuel taxes, as the cost of production of biodiesel at the farm-scale would be prohibitively expensive if taxed fully.

    Government revenues can be protected even as taxes are reduced or eliminated for biofuels by accounting for the increased revenue from new biofuels businesses and/or marginally increasing the existing fuel tax on petroleum products to make up for exempted biofuels. For example, a Ksh 0.5 per liter increase in the roughly Ksh 20.5 fuel tax on diesel would cover the loss of revenue if biodiesel were completely exempted from fuel taxes up to a national B2 blend. Neither consumers nor the government would be affected by the change, although biodiesel production would become a much more attractive investment for project developers and farmers alike.

- ▪ Develop and implement sustainability standards for biofuels that are stringent but achievable.
  - o The use of various crops that can grow in semi-arid areas combined with sophisticated mapping to minimize conflicts with existing food

production areas, would enable large quantities of biofuels feedstocks to be produced in addition to, rather than at the expense of, existing food production.
  - The reliance on tree crops like croton and jatropha could be combined with reforestation and afforestation projects, as well as efforts to reclaim marginalized lands.
- Support pilot projects and research in the areas of agronomy, fuel and blending standards, production technology and processing, markets and consumer use.
- Inform and create awareness among decision makers and the public.

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[i] Use of the term "biofuels" throughout this study refers to liquids such as ethanol and biodiesel.
[ii] U.S. Department of Energy, Energy Information Administration, "World Marketed Energy Use by Fuel, 1990-2030," <http://www.eia.doe.gov/oiaf/ieo/excel/figure_11data.xls> (10 December 2007).
[iii] U.S. Department of Energy, Energy Information Administration, *International Energy Outlook 2007*, <http://www.eia.doe.gov/oiaf/ieo/index.html> (10 December 2007).
[iv] Suzanne Hunt and Peter Stair, "Biofuels Hit a Gusher," *Vital Signs 2006-2007* (Washington, D.C.: Worldwatch Institute, 2006), 40-41; F.O. Licht, *World Ethanol and Biofuels Report*, vol. 4, no. 17 (May 2006), 395; Renewable Fuels Association, "Statistics," <http://www.ethanolrfa.org/industry/statistics> (25 November 2007); "World Biodiesel Output Growth May Slow - Licht," PLANET ARK, 29 March 2007, <http://www.planetark.com/dailynewsstory.cfm/newsid/41147/story.htm> (15 December 2007); F.O. Licht, *Ethanol Production Costs* (2007) 75; F.O. Licht, *World Biodiesel Markets: The Outlook to 2010* (2007) iv.