POTENTIALS AND LIMITATIONS OF BIO-FUEL PRODUCTION IN TANZANIA

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ABSTRACT

Biofuels production and consumption are heating up debates and energizing activities in different policy forums in the world. It is believed that promoting widespread use of biofuels would provide greater energy security; counteract increasing fossil fuel prices, mitigate climate change effects through reduced greenhouse gas emissions, contribute to sustainable development though improved quality of life for rural and urban populations, increase incomes through job creation and poverty alleviation. Currently, the world is grappling with a new oil crisis whereby prices have just hit $139 per barrel and are poised to get higher. Biofuels are promoted as one way out. However, there are increasing concerns from different parts of the world on the high dependence on production and use of biofuels, mainly that biofuels are not a panacea to the energy crisis, and expectations could be unrealistic, and at worst could invite several ecological, socioeconomic, technical, and land insecurity problems. This paper analyses the potentials and limitations of producing and consuming biofuels in Tanzania through literature review and consultations. It was found that the country has potential resources that include suitable lands, as well as the willingness of the people, government and investors. Nevertheless, there are several limitations that hinder sustainable development of this energy source that need to be addressed. Of these, the expansion of the agricultural frontier is a key concern as it will have direct impact on land availability for competing uses, availability to food crops, overuse of water resources, and threaten biodiversity and environmental quality. On the social side, there are important concerns about the impacts of biofuel production on land security, food security, labour practices and the distribution of costs and benefits along the trade chain. Another more pressing issue is on whether raw products or processed fuels will be exported, and how much will be used domestically. However, despite these worries, with the increasing fossil fuel prices and security concerns, the need for fuel switching options to biofuels production and use in Tanzania can not be avoided. Therefore, there is a need for in-depth socio-economic, environment and technological studies before Tanzania capitalizes fully on the opportunity offered by biofuels sub-sector so as to minimize the possible associated negative impacts to the environment, economy, political and social arena. A policy and legal framework is required to guide the development and growth of sustainable biofuels sector in Tanzania.

Keywords: Climate change-Biodiversity-Food security-Environmental impacts-Policy framework

INTRODUCTION

The planet earth is getting warmer. This situation has resulted into unpredictable climate patterns. Extreme weather conditions and climate change threaten crop production especially in rain fed agriculture, human and animal health, and natural resources including biodiversity. Coastal flooding and severe storms are a recurring feature, and as sea water level rises coast lands are being submerged, saline water intruding into fresh water impairing water for irrigation and drinking. Increasing frequent droughts threaten crop production, and some water bodies are drying up (e.g. Lake Tanganyika) as consequence.

What is causing global warming? Simply put: human activities which add excessive amount of greenhouse gases (GHG) to the atmosphere (UNFCCC, 2004) are the main culprits. While many GHG occur naturally and are needed to create the greenhouse effect that keeps the

Earth warm enough to support life, human use of fossil fuels is the main source of excess greenhouse gases (Yamba, 2007). By using electricity from coal-fired power plants, or heating our homes with oil or natural gas, and driving cars, we release carbon dioxide and other heat-trapping gases into the atmosphere. Deforestation is another significant source of greenhouse gases, accounting for 20% of GHG emissions. Also with fewer trees, less carbon dioxide conversion is fixed, leaving the excess to contribute to global warming. As it gets extra wet here concurrently it is getting drier somewhere else. However, the most vulnerable societies to the impacts of climate change are in third world countries that depend on rain fed agriculture and natural resources, and have weaker adaptive capacity. Mitigation and adaptation to climate change requires a multi-pronged approach aimed at reducing emissions, and coping with the negative impacts of global warming. The use of biofuels and other potential renewable energy sources is promoted as one way of mitigating climate change by reducing the use of fossils fuel (coal and oil).

Biofuels are products of biological origin that have been converted into liquid, solid or gas form, depending on the raw material and the technology employed, for energy generation (Cloin *et al.,* 2007). Bioethanol and biodiesel are two of the most common forms of biofuels. Others include biomethanol, biodimethylether and biogas (Dufey, 2007). Biodiesel is made from oil-rich crops such as rape, soya bean and oil palm while bioethanol, which substitutes for petrol is made from sugar crops including sugar cane, sugar beet, sweet sorghum cane; and starchy crops such as cassava, maize and wheat. A new generation of 'lignocellulosic' bioethanol also includes a range of forestry products such as short rotation coppices and energy grasses (Dufey, 2007).The conversion into biofuels is not only driven by the changing climate but to a great extent on the fear of declining world's oil reserves commonly referred to as 'peak oil' and the increasing prices.

Kenneth Deffeyes, a highly respected geologist, said in his 2005 book, *Beyond Oil*, "It is my opinion that the peak will occur in late 2005 or in the first few months of 2006" (Deffeyes, 2005). The peaking of world oil production will be a seismic event, marking one of the great fault lines in world economic history because when oil output is no longer expanding, no country can get more oil unless another gets less. If 'oil peak' is to occur, then oil-intensive industries will be hit hard (Brown, 2007). Higher oil prices have long been needed (market regulated) both to more accurately reflect the indirect costs of burning oil, such as climate change, and to encourage more-efficient use of a resource that is fast being depleted. It is on these bases plus the growing politics on oil between the big high oil producers (Arab world) and the big oil consumers that emphasis is pegged on possibilities of turning into a new energy sources.

The 'primary option' has been on the use of biofuels which is said to be both environmentally-friendly and economically and technologically viable.

Countries in the north see biofuel as an alternative energy source, while those in the south see biofuels production as an economic opportunity for them to utilize their own natural resources and attract the necessary foreign and domestic investment to achieve sustainable development goals (Cloin *et al.,* 2007). Promoting widespread use of biofuels would provide greater energy security, improved quality of life for rural and urban populations, economic development, opportunities for job creation and poverty alleviation, especially in rural areas. However, there have been some challenges from all around the world on the high dependency on production and use of biofuels. Although it is largely an economic choice, biofuels might also contribute to global warming if natural forest are cleared to cultivate to and replaced by monocultures of biofuels plantations. Generally, forests are considered better carbon sinks than agricultural fields.

The case against biodiesel is highlighted by the clearance of the virgin rainforest in Indonesia and Malaysia to make way for soya bean and oil palm plantations. As a result, more CO_2 is being released into the atmosphere by deforestation than is being saved by reductions in fossil fuel (Girling, 2008). On the other hand prices of cereal crops has/will go up as more agricultural land is devoted to raise crop for biofuels rather than food. For example, FAO (2007) reported that international trade in biofuels and biofuel feedstocks has increased rapidly over the past years and is expected to increase further in the coming decade. This will leave the majority of world's poor food insufficient. Consequently, food riots are increasing worldwide. In addition, as most biofuels feedstock including sugarcane and maize require a lot of water for irrigation, this will create water shortage for other users. Injudicious use of agrochemicals to amplify crop yields will contribute to water and soil pollution. The clearance of natural forests and wetland to produce biofuels will threaten ecosystem services such hydrological regulation and biodiversity. Unfortunately, most third world countries have no good policies to control biofuel production and where policies are in place, poor governance (e.g. Corruption) may displace most of the rural poor for intensive and large scale commercial biofuel production.

Fuel and fuel demands

Fossil-based fuel is the world's main source of energy. It is estimated that global oil demand will rise by about 50 per cent by 2020 (Brown, 2007). Notwithstanding recent evidence that suggests China's oil demand is actually slowing down at the moment (The Oil Drum, 2008), the prospect over the medium term is for sustained and significant growth in demand. Despite the projected increase in demand, the most crucial concerns are about inadequate supply. These concerns arise from the fact that despite technological advances in oil extraction and use, oil demand has increased to a point where more barrels are required to meet domestic demands of most developed countries with the US as a leading consumer. The critical question is how to meet this insatiable demand and when the peak will be reached.

New concerns arise from some quite contradicting perspectives on the continuing availability of fossil fuels, summarized as 'peak oil' which was earlier projected by a geologist King M. Hubbert via his famous bell shaped curve 'Hubbert's Peak' (http://www.hubbertpeak. com/hubbert/1956/1956.pdf). Hubbert (1956) predicted accurately "that America's oil production would peak and begin to decline in the early 1970s"; some think the peak in global oil production will come between 2010 and 2020. Concern about the depletion of conventional global reserves seems to have intensified for several reasons. These include technological improvements in geological data gathering and analysis, the increasingly sparse reserves discovered by new drilling, and concerns that much of the world's conventional oil, especially in the Middle East, is coming from old and over-exploited mega-fields that are becoming less productive. It is not clear however, whether it is the technology of extraction aging, or the oil reserves getting exhausted. Parallel arguments can also be raised on the influence of politics and power relations on the current and future of oil supply and consumption in the world. The war in Iraq and lately, war mongering involving Iran cannot be isolated from the politics for oil.

Needs for alternative energy sources

In the long run, alternative energy could be the only answer to the eventual diminution of oil supplies. Currently there is no panacea, however; each source has its disadvantages. Regarding transportation, oil remains the indisputably cheapest source of fuel. Many alternative fuels including coal and nuclear power are also non-renewable and will eventually run out. Unlike nuclear energy, non-renewable fossil sources represent sequestration of millions of years of energy from the sun. As these get exhausted, the human race will be forced to rely more on the renewable energy sources. Some of the alternatives sources of renewable energy include solar, wind, hydropower, hydrogen, thermo and the biomass fuels. Unfortunately, each of these sources has advantages and disadvantages.

There is still a huge reserves of unexploited coal, but it also one of the dirtiest energy source regarding both extraction and operation, although advances in technology are mitigating this, including finding ways to sequester coal's CO_2 emissions. Natural gas is also abundant and its use is the current standard for heating homes (Goffman, 2005). Limited reserves of Uranium exist in certain parts of the world, but the politics of Nuclear Power remains extremely controversial, including fears of nuclear explosions and radiation leaks as does the danger of terrorist hijacking. Use of Solar power, the most commonly discussed renewable energy source is constrained by reliance on expensive, and easily breakable, solar panels. Energy storage is probably the biggest problem remaining with solar power (WWF, 2007). Wind is cheap and abundant, and European technology has made far more efficient windmills. Energy storage, again, is a problem. These limitations of alternative energy sources continue to create a long term dependency on fossil fuel in the planet.

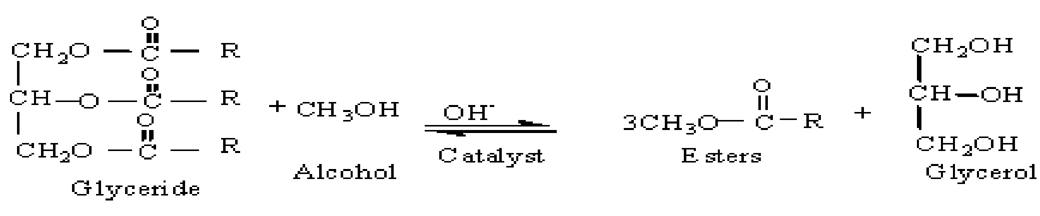
Despite the pressure for oil supply and demand from across the world market, there is currently much hype surrounding biofuels in the international energy scene. Mitigation of climate change due to increasing awareness of the adverse environmental impacts of fossil fuels and international commitments assumed under the Kyoto Protocol have enticed industrialized countries to introduce alternatives such as biofuels within their energy portfolios. The European Union (EU) sees biofuels as a 'sustainable energy' source, while the US government regards them as a way 'out of addiction to and dependence on' foreign oil and as a technological solution to climate change. As demand rises, many developing countries see biofuels as a new export commodity.

Biofuels as alternatives to fossil fuels

Fossil fuel is used to power transportation, and in some cases to generate electric power to supplement other sources (e.g. hydropower and coal). For many years, efforts have been made to supplement fossil fuel oil with plant-based oil, commonly known as biofuels (CFC, 2007). Biofuels are liquid or gaseous fuels derived from renewable biomass, and the two most important liquid types are bioethanol and bio-diesel. Biofuels, in turn, are part of a broader category of bioenergy sources which includes fuelwood and charcoal.

Among liquid biofuels, bioethanol is the most widely used for transportation, normally blended with gasoline in a mixture not exceeding 10% for unmodified car engines (E10), but it can be used on its own in redesigned car engines. Unfortunately, it is 70% less efficient than gasoline, requiring a higher consumption rate. About one third of the world bioethnol is produced by Brazil from sugarcane, and a similar amount by the US from maize. In Africa, Zimbabwe started producing bioethanol in the 1980s, and production in South Africa, Mauritius, Madagascar and Malawi is rising. A particularly promising crop, especially for semi-arid tropics is sweet sorghum, especially the new high yielding varieties being developed by ICRISAT for low input production. It is noteworthy that its centre of origin is in various parts of Eastern Africa, offering a wide scope for selection and breeding of highly adapted but also high yielding varieties. Other candidate crops for bioethnol production include crops such as cassava and potatoes, whose starch can be converted through enzymatic degradation to glucose, and fermentation and distillation to produce bioethnol.

Biodiesel is largely made from rapeseed with Germany leading, and is normally blended with diesel in a mixture not exceeding 20%. Other crops that can produce oil used for biodiesel include oil palm, coconut, soybean, groundnuts, cashew nut and sunflower. Other promising plants for biodiesel production include *Jatropha curcas* and *Pongamia* although further agronomic and industrial processing research is needed to realise the projected potential of these crops. The problem with biodiesel production is that it requires the availability of methanol that has to be mixed with plant oil before trans-esterification as shown below:



As a solution to this, pure plant oil e.g. from rapeseed and Jatropha can now be used for diesel engines with an external attachment to heat the oil to decrease its viscosity that is higher than that of diesel. In the case of bioethanol and biodiesel or straight plant oil, the challenge is to produce sufficient amounts to meet the demand.

Is biofuel a potential energy alternative?

Biofuel should not be considered as a sole source of alternative to oil. Currently none of the technologies is at a level of technological or infrastructure development to realistically replace oil-based fuels, particularly for the transport. Most of the fuels will remain significantly more expensive than gasoline, and have relatively poor performance in terms of range, cargo capacity, and ease of fuelling. Without considerable advances in alternative fuel and vehicle technology, or significant petroleum price increases, it is unlikely that any fuel or fuels will replace petroleum-based fuels in the near future. Studies by Korten (2006) show that even if the US dedicates all her present corn and soybean production to biofuels it would meet only 12% of the country's gasoline needs and 6% of diesel needs. While South Dakota and Iowa have already devoted more than 50% of their corn to ethanol production, this has unfortunately led to a diminishing supply of corn for animal feed and human consumption. Though one fifth of the US corn harvest was dedicated to ethanol production in 2006, it met only 3% of the US's total fuel needs (Bravo, 2006) indicating poor reliability of biofuels as a potential energy source. Biofuels are not a new source of energy. But the current advocacy on biofuels reveals overgrowing ambitions with more political flavor with little science. "The advancement of the "agricultural frontier" for biofuels is an attempt against the food sovereignty of developing nations as land for food production is increasingly being devoted to feed the cars of people in the North" (Altieri and Bravo, 2007).

What is the potential for biofuel production in Tanzania?

Tanzania, a non-fossil fuel producing country, bears the brunt of escalating oil prices and is locked in a vicious cycle of poverty, and is unlikely to meet the millennium development goals unless there is a let-up in the international oil market. This seems unlikely at the moment as indicated in the on-going budget presentation. Tanzania spends 40% its import bills on petroleum products. Is it possible to produce biofuels to meet local energy demands? From a perspective of land availability, initially this appears attractive, considering that Tanzania has over 85% of its suitable arable land unutilized, and that the15% that is cultivated is utilized sub-optimally. This provides a scope for increasing biofuel production. Good irrigable land that can be set aside for large scale sugar-cane production for bio-ethanol remains untapped. There are large areas in Kigoma region suitable for oil palm cultivation; and the scope for growing sweet sorghum, groundnuts and Jatropha in sub-humid and semi-arid also remains unrealised. Furthermore, large areas of the country which are suitable for growing cassava and sweet potatoes for starch-ethanol production are largely untapped.

Increased production of biofuel crops can be used to meet the local fuel needs by supplementing oil imports, resulting in a more favourable balance of payment by reducing foreign currency expenditure; assisting in increasing rural employment; and utilized for powering stationery engines for grain milling and electric power generation. The crop residues including sugarcane baggase can be used to generate steam for electric power production for rural electrification or fed into the nation grid. The oil can also be used for in-house lighting and cooking, soap-making, and processing of cosmetics, activities that have a potential to benefit women economically. In addition, the oil-press cake can be used for animal feed or as a fertilizer. It is for example estimated that one tone of Jatropha oil cake can provide an equivalent of 200 kg of N fertilizer. Most important, surplus biofuel production can be exported to the European and Chinese markets which are expanding rapidly. Wisely harnessed, biofuels production in Tanzania represents a unique opportunity to capture an emerging and most likely a lucrative market. Unfortunately, there is little experience in producing biofuels, particularly for biodiesel and straight plant oil in developing countries. Realistic yield estimates are hard to come by, and most claims are unsupported in practice.

What are the constraints to biofuel production in Tanzania?

Despite the high untapped potential for biofuel production in Tanzania, several questions on both at social, economic, environmental and technological platforms remain unanswered.

Biomass fuels might seem cheap and easily available, particularly when made from agricultural feedstocks and other crop residues. However, to attain high biomass production requires various inputs such as fertilizers, irrigation and agrochemicals to optimize yields. Apart from the high costs associated with these inputs, the most critical socio-economic challenge is the wisdom of producing biofuels from food crops in a country facing perennial food shortages in both quantity and quality. Or can both be supported at realistic costs? A related question is whether production is directed at meeting the lucrative export market, or satisfying the local biofuel requirements, or meeting both; but at what ratio? Most pertinent, is there sufficient land, and other resources to meet biofuels production and at the same time support other land-use requirements, including biodiversity conservation, wildlife and marine life support, including protection of wetlands?

In addition, should land titles given to investors be short-term or long term, considering in particular, that the high rate of population growth (2.03%) will sooner than later require access to these land, especially given that most of the land requested by investors for large scale biofuel production also happens to be land earmarked for irrigated agricultural production of food crops like rice, vegetables and fruits. Some of such land currently supports wildlife or fisheries, or have a potential for increased livestock production especially the dry-lands which are advocated for ‘non-demanding’ crops like Jatropha. It is particularly pertinent in this context to recognize that second generation biofuels expected to come into commercial scale within the next 5 to 10 - years, will use more diverse biomass sources, hence rendering most of the land devoted to growing feedstock like sugarcane, corn, palm oil and Jatropha liable to be assigned to other uses. The overall implication is that informed and wise judgment is required in allocating land for biofuel production.

Biofuels from Sugarcane

Sugarcane is currently the most significant feedstock for bioethanol, supplying 40% of global production (CFC, 2007). But development and investments in any technology that will use sugar cane to produce bioethanol in Tanzania in particular will result to several environmental, social and economic impacts. First, the land most suitable for this crop i.e. river valleys, wetlands, and river deltas are also the most suitable for increasing rice production, fisheries activities, wildlife conservation, and conservation of mangrove forests. Sugarcane requires flat land with clayey-high fertility-well-drained soils. Secondly, intensive production methods including heavy use agrochemicals, harvesting by fire, are both likely to increase environmental pollution, with negative effects on various organisms including endemic flora and fauna and human health. Additionally, the high water consumption rate of sugarcane may negatively impact the hydrological balance. For example, sugarcane requires 400 m^3 of water to produce one ton of dry matter (http://www.sugarcanecrops.com), or 1,500-3,000 litres of water to produce 1 kg of sugar (http://www.bettersugarcane.org/assetsgeneral/claysugarcaneimpacts.pdf). Similarly, research demonstrates to produce higher cane and sugar yields on a sustainable basis application of adequate amounts of fertilizer nutrients especially N, P and K is essential (http://www.sugarcanecrops.com). A way out is to diversify the sites for sugarcane cultivation by selecting varieties which are less water and nutrient demanding so that they can be grown in less favourable areas. The use of sweet sorghum is an attractive option in the scenario.

Biodiesel production from oil-rich plants

For biodiesel production from oil-rich plants such as oil palm and *Jatropha* may result into several impacts. For example, production of oil palms may require extensive clearance of natural forests in high rainfall areas to raise this crop, leading to threats in biodiversity conservation, and land degradation. Also important, is whether the oil produced should meet the edible oil market or biodiesel needs. According to Janssen (2006) production of palm oil in 2004 from the Kigoma project was as low as 1 500 l per ha which could not meet the country’s oil needs and therefore necessitates the importation of the same from Malaysia and Indonesia. In general Tanzania is not self-sufficient in food oils. The level of production and use of non-edible oil plants like *Jatropha carcus* and *Pongamia,* both of which are highly promoted for biodiesel production, remains largely unproven. We have failed to find any credible report of successful large scale plantations of Jatropha any where despite wide claims. Most reports cite row plantings as wind breaks or farm boundaries.

In addition, while *Jatropha* is projected as a non-demanding plant capable of producing good yields under low soil moisture and infertile soils, the realized yields are often commercially unattractive. Another limitation is that Jatropha seed yields are often extrapolated from strip-grown trees mostly from West Africa rather than in plantation configurations. Whereas, it is cited from literature that Jatropha can yield 1 – 8 ton of seed per ha, recent reports indicate that lower yields are more common, if no fertilizer or irrigation is used in marginal sites. Unconfirmed reports (Peter Bolland, *pers. Commun*.) from Arusha in Northern Tanzania seem to indicate that under optimum fertilization and irrigation, high yields of up to three harvests annually, producing 4 kg of seed per plant can be realized. Without such intensive inputs, yields are often less than 1 kg. The burning question is whether the returns justify, under the present price scenario, the cost for intensive production scenario. Also, can the yields be economically attractive to small-scale farmers? It is for example, assumed that for oil production from Jatropha to be able to compete with conventional diesel, the price paid for a kg of seed lies between 100 and 120 Tshs, or $83.6 to 100.3 per ton of seed. If yield is <1 ton/ha, the farmer will earn less, and unless prices increase, few farmers or investors will see little sense in investing in Jatropha cultivation unless yields can be increased under low input scenarios.

Immediate research is required to provide better yields, including through better site selection and matching, selecting/developing high yielding and yet widely adapted varieties; and the necessity for conducting agronomic as well as efficient processing research to develop packages that can be cheaply accessed by the rural farmers. Examples of possible agronomic packages include spacing, thinning, pruning, and intercropping trials. For example, how does yield vary by increasing espacement from 2x2 m to 4x4 m? What is the effect of pruning frequency and height on seed yield? How should pests be controlled? Which crops can be intercropped with Jatropha, and at what espacement or thinning regime?

The costs of production, energy efficiency and economic implications

Studies have shown that production of ethanol from primary agricultural products in the absence of subsidies is often not cost-effective, because the value of the crops often exceeds the value of the ethanol produced. Often it is also not environmentally sustainable. But a number of nations, including Germany, the UK and US, are developing second generation biofuels, but the capital costs needed to build commercial "biorefineries" have been seen as a major barrier (BBC, 2007). Bioconversion of lignocellulosic waste from agriculture - like sugarcane bagasse and sisal waste - for the production of bio-ethanol instead of on-field burning could be an effective method for reducing possible pollution. Extracting lignocellulosic materials sustainably, for example from forests without destroying the soil and by ensuring that forests rapidly regenerate, it is quite possible that one can have one's cake and eat it.

Pimentel (2003) reported that Ethanol production from corn is extremely energy intensive. To produce 10.6 billion liters of ethanol, the U.S. uses about 3.3 million hectares of land, which in turn requires massive energy inputs to fertilize, weed and harvest the corn. In turn these 10.6 billion litres of ethanol only provide 2% of the gasoline utilized by cars in the U.S. per year. Despite the studies of Shapouri *et al*. (2004) from the USDA that report a net energy positive return for ethanol production, Pimentel and Patzek (2005), utilizing data from all 50 states and accounting for all energy inputs (including farm machinery manufacture and repair and fermentation-distillation equipment) concluded that ethanol production does not provide a net energy benefit. Rather, they claim it requires more fossil energy than it produces. In their calculations, corn ethanol production requires 1.29 gallons of fossil fuels per gallon of ethanol, and soy biodiesel production requires 1.27 gallons of fossil energy per gallon of diesel. In addition, because of the relatively low energy density of ethanol, approximately three gallons of ethanol are needed to displace two gallons of gasoline.

Let's consider *Jatropha* as a crop 'claimed' to be less demanding and well adapted to poor growing conditions. However, under harsh conditions the yields of Jatropha are not worthwhile. Preliminary observations show that, to realize high yields the crop has to be irrigated and fertilized especially in its early stages of growing. Under such a scenario, it projected that a ton of seed is produced at a cost of about 125 USD (equivalent to 137,000 TShs). It is estimated as well that a single tree if well managed in this system will produce 4 kg of seed per year, or 10 tons per ha with 2500 trees. Assuming that 4 kg of seed are required to produce 1 litre of oil, this corresponds to a maximum potential yield of 2500 l per ha. In setting the price for the oil, establishment and tending costs, as well extraction costs need to be considered.

Under more realistic farm conditions, a Jatropha plant normally produces <1 kg of seed in the first three years, and 1 kg in subsequent years, suggests that 1,250 to 2,500 kg of seeds will be harvested annually. Under the current market price of 100 TShs per 1kg of seeds in Southern Tanzania (Chami *et al. Pers. Communic.*), a farmer will earn about 125,000 and 250,000TShs per year. Does this justify farmers to forego other economic and social activities on the same piece of land, assuming that this production is to be done in existing farmland? The partial analysis done above is totally inadequate however, to justify whether or not to cultivate Jatropha. Life Cycle Analysis (LCA) framework should be used to examine the feasibility of producing biofuels as compared to other fuel sources. LCA incorporates socio-economic, environmental, ecological and technological costs and benefits. The Driver-Pressure-State-Impact-Response Framework should be used to examine the environmental sustainability of each production-marketing-utilization stages.

The opportunity costs

Goal One of the MDGs states that "Promoting the use and production of biofuels in developing countries would provide greater energy security, improved quality of life and economic development, opportunities for job creation, and poverty alleviation especially in rural areas. It also fosters the agricultural production of well-known energy crops and promotes rural development". Goal two emphases the possibility of biofuels in providing an alternative lower carbon intensive development path, that can reduce greenhouse gas emissions. However, whereas biofuel production has the potential for increasing rural employment, and promoting secondary production chains, including local cottage industries like soap manufacture, these projections are still largely theoretical.

For example, it is anticipated that the type of employment created will be largely low paying menial labour incapable of addressing the rural-urban immigration. Also, the land tenure systems are not clear to most Tanzanians. Most of them own small pieces of land without any legal documents. There are no prospects that the system will change soon before the establishment of agro-fuel fields by big companies and individuals. Today, most Tanzanians living in resource rich areas are being displaced to give room for intensive resource exploitation for example by large mining companies in Northern Tanzania. It is likely that the same approach will be used in the case of large-scale biofuels farms, as already claimed in Kisarawe district.. This will in turn produce more 'refugees' migrating to urban areas or 'slavery' in agro-fuel farms, if labour conditions are not scrutinized. In Brazil for example, it is claimed that soybean cultivation displaces eleven agricultural workers for every new worker it employs. As a result, about 2.8 million people were displaced by soybean production. Many of these now landless people moved to the Amazon where they cleared pristine forests (Altieri and Pengue, 2006).

Biofuels will be produced on land earmarked for food production to feed the 'engines' in foreign countries, threatening domestic food production and availability. For this country, this means more imports of basic foods, loss of food security, increasing food prices and more hungry poor people. On the other hand, biofuels will encourage large monoculture plantations which may degrade soil quality including increased soil erosion and reduced soil fertility (Mkindi, 2007). Impoverished soils will necessitate increased application of industrial fertilizers to increase productivity, further putting pressure on foreign exchange as most fertiliser will have to be imported. Biofuels production will affect consumers directly by increasing the cost of food and fuel unless subsidies are introduced. Therefore, unguided rush for biofuels could bring food shortages and increase poverty with a potential for political instability. For example according to Altieri and Bravo (2007), experience from the US shows that as more than 70% of the corn grain is used for feedstock, doubling or tripling ethanol production will increase corn prices, and as a consequence, increase the price of meat produced using more expensive animal feed. The author further found that demand for biofuels in the US has been linked to a massive rise in the price of corn which led to a recent 400% increase in *tortilla* prices in Mexico.

The fate of the environment

The scale of production needed to yield the projected crop mass will likely encourages industrial methods of monoculture production with drastic environmental side effects. In the US for example, in areas where farmers have abandoned crop rotations to grow corn and soy exclusively, the average soil erosion has increased from 2.7 to 19.7 tons per acre annually (Pimentel *et al.,* 1995).

One of the main arguments of biofuel advocates is that these new forms of energy will help mitigate climate change. However, by promoting large-scale mechanized monocultures that require agrochemical inputs and machinery, an overall increase in CO_2 emissions is more likely (Bravo, 2006; Donald, 2004). As carbon-capturing forests are felled to make way for biofuel crops, CO_2 and NO_2 gas emissions will increase rather than decrease. The extent to which large monoculture farms will impact the other forest attributes is not yet established although it can be speculated to be grave. For example, forest soils store between one quarter and a half of the carbon in the forest - and that too is released during clearing and burning. A UK scientist once said, "It is a mistake in climate change terms to use biofuels" (BBC, 2007). Of most concern is the trend to clear new land for biofuel crops as has happened in Brazil, Indonesia and Malaysia. In Malaysia, the government had granted 92 licenses to set up biodiesel plants, while the Indonesian government has allocated some 5-6 million hectares of plantation land for biofuels projects.

Clearing forests produces an immediate and disastrous release of carbon into the atmosphere, accompanied by a loss of lives, livelihoods and habitats for wildlife. For example, the destruction of peatlands in Indonesia results in large amounts of GHG emissions, while clearing of forests in Malaysia are destroying the last habitats of *Orang utangs*. A similar scenario is not unlikely in Tanzania especially if wetlands and forests are cleared for establishing biofuel crop monocultures.

The positions of the selected policies in Tanzania

In Tanzania, the biomass energy sector in general operates within a complex and multi-layered regulatory context. The National Energy Policy (first approved in 1993 then revised in 2003) devotes significant attention to the biomass energy sector and policy statements include encouraging efficient end-use technologies. In a separate section devoted to renewable energy, the National Energy Policy commits to promoting *"efficient biomass conversion and end-use technologies in order to save resources; reduce the rate of deforestation and land degradation; and minimizing the threats of climate change"*. The section further states: *"Biomass, particularly wood fuel, should be conserved through efficient conversion and end-use technologies which could be complemented by tree growing at household level and beyond"* (URT, 2003). The energy sector is multifaceted with several sub-sectors, including power, petroleum, rural energy and biomass energy. Since developing 'The National Energy Policy' in 2003, the Ministry of Energy and Minerals has not yet begun work on a biomass energy strategy, but is considering addressing biomass energy within the context of a Biomass Energy Strategic Plan (WWF, 2007).

Currently Tanzania lacks a biofuels policy, has neither a strategy nor legal framework addressing the production and use of biofuels. The Biofuels Task Force was established in April 2006 (Mkindi, 2007) to promote development of the sector and develop legislation to stimulate the use of biofuels. The goal of the task force was to design biofuels policies and regulations suitable for Tanzanian conditions, Bioenergy Partnership, Promoting Applied Research and Development. To-date the Task force is yet to report.

Despite recent and continuing improvement in economic performance, poverty remains the principal national challenge in Tanzania, and any review of the energy sector and particularly the biofuels must operate against this backdrop. Therefore development of any policy and regulatory framework must include issues of: Fuel Tax Incentives, CO_2 Trading e.g. Clean Development Mechanism (CDM), Fuel Standards (e.g. Blending Mandates). This is because the biofuels industry will only develop and prosper if it is adequately protected with national security and sovereignty as the primary concerns. Mandatory blending targets will be needed to promote local use of biofuels. In this regard several policies need to be looked upon so as embrace the needs for production and use of bio-energies. This will include Energy, Land, Environment, Forestry, Wildlife and Agricultural policies to mention a few. Furthermore, since Tanzanian is a signatory to several International Conventions including the Convention for Biodiversity Conservation (CBD), the Ramsar Convention on Wetlands and The UN Convention to Combat Desertification it is important that we respect these as we embark on large-scale biofuels production.

CONCLUSIONS AND RECOMMENDATIONS

Continued over-dependence on fossil fuels has economic, social, climate and biodiversity impacts, especially to the most vulnerable developing countries like Tanzania. Fossil fuels are the most responsible for GHG emissions responsible for anthropogenic-induced global warming. There is now greater awareness and acceptance on climate change; and its largely negative impacts on the human and biophysical systems, which are expected to be most severe to less developed third world countries with less adaptive and mitigation capacities. As a way of mitigation, the CDM mechanism under the Kyoto Protocol has opened new opportunities in the Carbon markets for renewable energy initiatives for reducing GHG emissions, aimed at reducing dependency on fossil fuels. Increased use of biofuels is promoted as one of the options for countries to move towards a sustainable energy future. At the same time, it is worth noting that the increasing politics in oil trade and consumption coupled with the senses on the ‘peak oil’ concepts strengthens the need for alternative energy sources. All these facts emphasize a need to search for complimentary energy sources in which every potential producer has to participate.

In the very long term, a combination of such renewable sources as solar and wind with better storage and energy conservation, perhaps may be the ultimate energy solution. For Tanzania with its abundant sources of natural gas, there is a need to promote its wider use than only generating electricity as is currently the case, or digressing into the murky waters of biofuels. Therefore, there is need to work more on the science of biofuels production and its use and costs, and reduce the political pressure that is more engineered by the big fuel consumers in the North. Yet Tanzania cannot isolate herself as a country to participate in these looming global efforts and opportunity. This article concludes by advocating a precautionary approach, highlighting the need for in-depth socio-economic, environmental and technological studies before Tanzania embraces full-fledged biofuels production. Focused research should be undertaken at the earliest convenience to provide answers that will best position Tanzania at a better position to capitalize on the opportunity offered by biofuel sub-sector, while minimizing the negative impacts to the environment, economy, political and social arena. A policy and legal framework is required to guide the development and growth of sustainable biofuels sector in Tanzania.

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