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Biofuels in Tanzania: Status, Opportunities and Challenges

[REVIEW PAPER]

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ABSTRACT

Biofuels in solid, liquid and gaseous forms are all renewable fuels derived either directly or indirectly from plant material. Recently biofuels have emerged as alternative fuel with potential to replace finite fossil fuels resources. In Tanzania liquid biofuel (biodiesel and bioethanol) developments are at an infancy stage and there is so far no commercial liquid biofuel production. Nevertheless, such biofuel activities in Tanzania show that being part of the world is not left behind for the promotion of biofuels as an alternative source of energy. To that effect the objective of this review article was to understand the key issues pertaining to liquid biofuels and their status as well as to highlight gaps and strategies to address the gaps in Tanzania. Therefore this study is based on reviewing pertinent literature relating to liquid biofuels in Tanzania and elsewhere. The study looked at policies and strategies in place, mode of production of biofuels feedstock's, players in biofuels and their roles, value chain, social-economic and environmental issues of biofuels, land tenure issues and food security, sustainability, research and development. Information generated in this article revealed that policy, foreign influence, economics, environmental and political factors are main drivers for biofuel industry. It was also evident that in Tanzania biofuels could provide some opportunities for national consumption or for export and offer some genuine development opportunities. However, clear policies, strategies as well as regulations for biofuels development are still not in place. One important and immediate activity needed is for Tanzania's government and stakeholders to fast tracking the establishment of national biofuel policy to ensure sustainability of the biofuels industry. In conclusion, Tanzania has comparative advantages in the production of biofuels. However management of the potential negative effects of the biofuel industry to ensure that benefits outweigh any ecological, economic and/or social costs should to be taken into account and given utmost priority.

Keywords: Biofuels, biodiesel, bioethanol, Tanzania, Policy, National biofuel task force

INTRODUCTION

The energy balance of Tanzania shows that biomass in the form of fuel wood and charcoal use accounts 90% of energy consumptions while petroleum and electricity accounts for about 8% and 1.2% respectively. Coal, biogas and other renewable energies account for the remaining 0.8%. Tanzania is currently one of the major consumers and importers of fossil fuels in East Africa because it does not have fossil fuel reserves. Demand and price for petroleum products are growing rapidly at a rate of more than 30% per year (GTZ, 2005). This has resulted into great expenditure of foreign currency of up to 25-40% causing a heavy burden to the country economy. On the other hand, the dominance of traditional biomass in energy share/pattern

consumption among Tanzanians is linked to poverty and the lack of access to other fuels. Therefore poverty and poor access to modern energy are linked and cannot be separated hence must be tackled together (Wolde-Rufael, 2006). Given such a situation, which will continue for unforeseeable future, Tanzanian government has formulated an energy policy, which promotes development and utilization of appropriate new and renewable sources of energy (URT, 2003). However, in the energy policy, which calls for efforts to promote switching from petroleum to other alternative and environmentally friendly fuels biofuels are not mentioned in the policy documents, because biofuel production was barely considered at the time when the policy was drafted.

Biofuels are all fuels derived from organic material. As such, they are renewable as most biofuels come from material derived either directly or indirectly from plants, which are considered by some as carbon neutral, that is the carbon dioxide produced in their use is absorbed by the plants grown to produce more biofuels (Amigun et al., 2008). Furthermore, the term biofuel describes a wide variety of energy sources (fuels) derived from organic materials/crop plants and include biomass directly burnt (solid biofuels), thermochemical processes (gasification, pyrolysis, liquefaction), liquid biofuels especially biodiesel from plant seed-oil, and bioethanol from fermenting grain, sugar, sap, grass, straw or wood etc. Gaseous fuel (biohydrogen and biogas) is fuel derived from anaerobic digestion of almost all organic materials (Amigun et al., 2008). However, the production of bioethanol and biodiesel (liquid biofuel) from agricultural products (crops grown to make them) has dominated primarily as the main substitute for petrol and diesel in transportation sector (Azar et al., 2003; Okonko et al., 2009). To that effect, in recent past biofuels have rapidly emerged as a major issue for agricultural development, energy policy, natural resource management, energy and food security and global climate change (Action Aid, 2010; Dellomonaco et al., 2010).

In Tanzania recently biofuel activities, in particular biodiesel and bioethanol, have increased considerably because they are considered as potential new source of agricultural income and economic growth in rural areas (Okonko et al., 2009;Sulle & Nelson, 2009a). There is therefore growing interest from local and foreign private investors in establishing biofuel projects in the country (Sulle, 2009a). However, interest in expanding biofuels production is not based on meeting the energy needs of Tanzanian, but rather the influence of foreign biofuel policies to develop a biofuel sector geared towards mainly for export marginalizing the local energy poverty (Oxfam International, 2008; Christian Aid, 2009; Martin et al., 2009; Sulle, 2009a; Sulle & Nelson, 2009a). Theoretically Tanzania has a potential to contribute to the global market of biofuels. The country is considered a good environment for biofuels production because of so-called “idle and marginal land” and land space available, favourable climate, stable political climate and relative cheap labour (Kamanga, 2008, Sulle, 2009a). There are three main biological derived biofuels: biogas, biodiesel and bioethanol being considered for commercial production. There are other biofuels, such as biomethanol, biopropanol and biobutanol are not in as common use. In Tanzania biofuel development concerns biological derived liquid biofuels (bioethanol and biodiesel). Nevertheless, liquid biofuel developments are still at an infancy stage and there is virtually neither commercial biofuel production nor biofuel policy in Tanzania (Martin et al., 2009). Although there is no policy to guide biofuel development in Tanzania, the biofuel industry is already developing anyway. Therefore there are some opportunities/prospects, constraints and challenges provided by this relatively new source of investment in Tanzania. This article aimed at reviewing explicitly the key issues concerning biofuels sector in Tanzania by focusing on an overview of the status of biofuels, biofuel policy, investment and production pattern, biofuels feedstocks, mode of production of biofuel crops, land tenure impact of ongoing biofuel investments, stakeholders and their roles in biofuels and the impacts of biofuels on food security. Attempts were also made to review other key biofuels issues such as employment and

gender, politics on biofuels, sustainability of biofuels, research and development on biofuels, biofuel value chain, land issues and impacts of biofuels on climate. Plausible considerations of the key biofuel issues by stakeholders in Tanzania could guide the future prospects and sustainability of biofuels concerning technical, political, environmental and socioeconomic issues of the production, promotion and implementation of biofuel.

An overview of the status of biofuels in Tanzania

Biofuels can directly contribute to access to modern energy, enhance energy security and promote sustainable development in any country if produced responsibly (Dellomonaco et al., 2010). In fact, biofuels has become a major business and a new commercial venture (UNEP, 2009). Tanzania, like many other countries of the world, has experienced a dramatic increase in biofuel investment in recent years in particular bioethanol and biodiesel (Sulle & Nelson, 2009a). Evidence suggests that biofuel industry is viable in Tanzania by virtue of available land capable of supporting sufficiently high-energy crop yields (FAO, 2007; WWF-Tanzania, 2009). However, the emerging biofuels industry is not well fully understood by many stakeholders and the concept of energy crops is relatively new in Tanzania (Kamanga, 2008; Martin et al., 2009). Nevertheless, both the Tanzanian and foreign governments/companies are promoting biofuel investments (Kamanga, 2008). For example in order to quickly proceed with the introduction of biofuels Tanzanian Government has taken an immediate action to enter the learning-by-doing process-and not wait formulation of national biofuels policy to guide biofuel industry development (Kamanga 2008; Martin et al., 2009; Sulle, 2009a; Sulle & Nelson, 2009a). However, it has been recently cautioned that production of biofuels should focus on feedstocks that (i) do not compete with food crops, (ii) do not lead to land-clearing, and (iii) offer real greenhouse-gas reductions (Tilman et al., 2009).

Baggase waste from sugar industry is used for heat and electricity production by co-generation. Researchers had estimated that Tanzania has great potential for bagasse co-generation of up to 101 GWh (Hathaway, 2006). Palm oil is the main feedstock for biodiesel in other developing countries, and is found in some places in Tanzania (Sulle & Nelson, 2009a). A variety of other plants are used on a small scale, including for example native species in Tanzania such as the croton tree, but the greatest attention is being given to *Jatropha*. Therefore current biofuel development in Tanzania centers mainly around the cultivation and processing of Jatropha plant seeds which are very rich in oil. However, at the moment, the biofuel industry is underdeveloped it is therefore difficult to quantify costs and benefits involved in the production and marketing of biofuel. This is due to the fact that the realistic gross margins and financial feasibility of biofuels production can only be determined when biofuels activities are in place and developed for commercial purposes; nevertheless potential high profits can be anticipated (Philip, 2007). On the other hand, equally high risks, and continued volatility in investment patterns is to be anticipated (Kamanga, 2008). Although biofuel developments in Tanzania are still in an infancy stage some initiatives exist for both local and international investors in producing both bioethanol and biodiesel (Martin et al., 2007). Only small-scale production of straight vegetable oil (SVO) from oil seeds, e.g. *Jatropha*, oil palm, etc does exist and promoted by local private companies and NGOs. Biodiesel production is being experimented by a local NGO called TaTEDO (The Tanzania Traditional Energy and Environment Development Organization) and is already using SVO to run vehicles (with minor engine modifications). Multifunctional Platforms (MFP), at the moment supply electricity to more than 100 households using locally, produced *Jatropha* oil to run generators (Massemaker, 2008). Diligent, a Dutch company has installed a facility with capacity to produce 1,500 liters of oil per month. However, due to the limited supply of *Jatropha* seeds the current production is between 600-800 liters per month (Songela & Maclean, 2008). On the other hand, Barrick Gold Mining Corporation (BGMC)/Barrick Gold Tanzania have goal to have 1,500 ha of out growers with anticipation to produce about 20,000 liters of biodiesel daily (Barrick Gold Tanzania, 2008).

Biogas is one of the micro scale biofuel activities wide spread in Tanzania, aimed to provide fuel for clean-burning cooking stoves. At present there are roughly 1000 biogas plants being installed throughout the country (Mshandete & Parawira, 2009; Martin et al., 2009). Liquid biofuels may also play an important role in cooking applications. Moto Poa Company Ltd has installed capacity to produce 2,000 tons of ethanol jelly per day, which, is used for cooking application.

However, at present, the company is operating below capacity due to the low demand of the ethanol jelly fuel (WWF-Tanzania, 2009). On the other hand, there have been other initiatives for using *Jatropha* oil for cooking application using Protos stoves (BOSCH plant oil stoves) (KAKUTE, 2008; Martin et al., 2009;WWF-Tanzania, 2009). Tanzania has the potential of producing about 4010 and 1726 million liters of ethanol and biodiesel, respectively per year. The local annual demand for ethanol and biodiesel are estimated at 568 and 886 million liters, respectively. This means, the country has annual export potential to the world market of ethanol and biodiesel of about 3442 and 840 million liters per year, respectively (Philip, 2007). Nevertheless, these assumptions are based on using a high percentage of available arable and resources with potentially serious effects to the Tanzanian people and environment (Philip, 2007). There is also an anticipation of production of 103 million liters of biodiesel/year from oil obtained from *Croton megalocarpus* an indigenous trees species (E-INFO-WILMA, 2006).

Over 40 organizations of varying types are engaged in differing ways in bioenergy development in Tanzania at the moment with a significant presence of foreign capital. In contrast, wholly Tanzanian owned companies are few and far apart. Typically, the proposals from these prospective investors entail capital outlay ranging from US $ 60 million to $ 1.5 billion to produce biomass for either bioethanol or biodiesel on land measuring from 30,000 acres (12,146 ha) to 2,000,000 acres (810,000 ha) (Kamanga, 2008). This has lead to discrepancy between land requests and allocations, which compelled the Tanzanian government to partly suspend new biofuel projects until its policy on biofuel projects is finalized.

Biofuel policy and strategies

Biofuels sector is increasingly becoming an important sector in national and international economic development. It is expected that the growing impetus for biofuels is likely to instigate changes to the existing national development frameworks to incorporate biofuels strategies. The underlying problem on biofuels around the world is not with the type of biofuel crop or type of biofuel or good or bad biofuel but with the policy framework around biofuels production and use (Christian Aid, 2009). In fact, sound biofuel policies involve a convergence between policies to protect ecosystems and reduce greenhouse gases and policies to support food security and agricultural income (Ogg, 2009).

Biofuels era is here to stay, now is an opportune time for African countries to develop strategies in order to survive in the fast changing world bio based economy (Amigun, 2008). Unfortunately, most African countries lack regulatory frameworks to monitor this new biofuel sector leading in some situations where investors illegally grab land for biofuels production, beside such land being very inexpensive (Henriques, 2008; Jumbe et al., 2009). Tanzania is not an exception, policy challenges critical to biofuels development has been recently reported in details (Sosovele, 2010). These policy challenges that could significantly impede biofuel development in Tanzania include lack of integrated policy framework that takes into account agriculture, land use, the availability of water, transport and energy needs in order to guide the biofuel sector. There is also lack of a holistic and comprehensive energy policy that addresses the broad spectrum of energy options and issues, and weak or absent institutional and legal frameworks. In fact, lack of national policy on biofuels development remains a major obstacle towards the realization of the biofuel sector's huge potential in the country.

The current draft guidelines complied by national biofuel task force (NBTF) (URT, 2008) are not a suitable tool for this purpose and are inadequate to guide the development of biofuel in Tanzania towards the desired sustainability goals. For example; ongoing conflicts between investors and local communities are among problems associated with lack of clear policy guidelines. Since investors were given large tracks of land and began cultivation of energy crops even before a policy is in place. Without a policy document in place the applications and granting permission for land and biofuel development projects were on an informal or even arbitrary basis. Challenges, which had emancipated in the course of biofuels investments, could not be properly addressed because there are no legal and regulatory guidelines for the sector. Furthermore, lack of official policy dealing directly with biofuels has made implementation and operation of investments in the sector difficult and unmanageable. Therefore, without a biofuels policy, incentives, tax concerns, specific targets for biofuel production, development and blending mandate etc. will not be documented, thus making the risks for biofuel developments very high (Martin et al., 2009). These risks include not only those incurred on investors, but also national sustainable development concerns (Kaphengst et al., 2009). On the basis those shortcomings some stakeholders including the

Tanzanian government have called for a suspension on new biofuel development until appropriate policies, regulatory frameworks and laws are in place to guide the process (Sosovele 2008; Mwamila et al., 2009; Sosovele, 2010).

Based on the literature, observations and lessons learnt from current biofuel investment pathway in Tanzania it seems the end use purpose of the Tanzanian biofuel industry is to initially use most fuel and/or raw materials for export to rich countries and later when the local market has developed, direct some energy to the local market that will be given priority. That scenario will not only aggravate the existing energy consumption imbalance between rich and poor but will also contradict Tanzania's national energy policy, which strives to ensure sustainable energy supply, security, reliability and environment protection. In reference to the prevailing policy issues surrounding the new biofuel sector in Tanzania the following observations/concerns should be considered in revised/improved biofuel guidelines prior to drafting Tanzanian biofuel policy (Table 1). It is evident from the preceding biofuel policy issues and in the literature reviewed that if the biofuel concerns and challenges are not addressed responsibly and sensibly at the national policy level, biofuel development may not result in the anticipated biofuels benefits to Tanzania and the majority of its local communities. It is also important to note that, with current technologies biofuels can only, at best, substitute a small amount of the global fossil fuel needs. There is simply not enough land to produce sufficient biofuel for world liquid biofuel needs. Therefore, proper consideration and assessment of the potential negative effects of the biofuel industry is required, to ensure benefits outweigh any ecological, economic and/or social costs. Therefore strategic life cycle assessment (LCA) for production of liquid biofuels could be one way to enable better-informed decision-making and implementation of biofuels in Tanzania. The LCA studies will result in data on the energy balance, the greenhouse gas balance and the land use impact (soil, water, vegetation structure and biodiversity) of the liquid biofuel system.

Production and status of biofuel feedstock

Biofuel development is sought through available and potential avenues, and agriculture becomes the most practical system of production. This is because biofuel have already been identified from crops, which some will have to satisfy both food and energy needs (Dellomonaco et al., 2010). It is well established that biofuel production cost is currently higher than that of the fossil fuels; the critical factor being the raw material/feedstock cost which represents the largest cost of production in all current biofuels production systems (Peskett et al., 2007). According to Schmidhuber (2007), in large ethanol production plants, feedstock costs can account for about 70-80 percent of total costs. On the other hand, the major economic factor to consider for input costs of biodiesel production is the feedstock, which is about 75-80% of the total operating cost. Other important costs are labor, methanol and catalyst, which must be added to the feedstock (Haas et al., 2006). Nevertheless, the continuous efforts to increase in the raw material yields as well as the advances in production technologies will make this cost relationship more favorable for biofuels in future. In Tanzania, at present, oil palm and *Jatropha curcas Linnaeus* are the main energy crops anticipated for biodiesel production. Sugarcane is widely cultivated in Tanzania to produce sugar, and many proposals have been developed to diversify and expand the use of sugarcane for bioethanol production. Additionally there is the potential to produce bioethanol from sorghum (white and sweet sorghum) and biodiesel from crops such as sunflower, neem, *Moringa oleifera*, *Pongamia pinata*, *Croton megalocarpus* and castor bean (Table 2). There are some proposals to use cassava for bioethanol, coconut and even avocado for biodiesel, but no biofuel projects using these crops are currently operational in Tanzania.

Table 1: Tanzanian national biofuel policy issues of concern.

Sn	Issues	Explanations
i.	Policy definition of biofuels	Defined in the policy document, to refer to all solid, liquid and/or gaseous fuel produced from biomass resources (waste from agricultural or forest and planted biomass) that can be blended with or replace diesel, petrol or other fossil fuels for transportation, stationery, portable and other applications. Include straight vegetable oil (pure plant oil), biodiesel, bioethanol and other biofuels like biogas, bio-hydrogen, bio-methanol, biosynthetic, etc.

ii.	Blending Targets	Be calculated in relation to land requirement and variation on productivity potential. Aim at mainstreaming biofuels in the energy vision of Tanzania. Set a target of achieving certain percentage of blending in conventional fuels with biodiesel or bioethanol, at a specified time frame.
iii.	Land use policy and marginal land	The policy should consider and recognize the existence and right of commons by avoiding dangerous assumptions about the extent of "marginal" lands and how they are to be defined. Scientific studies should be carried out to determine who lives on these "marginal" lands and to establish the actual marginal lands available. Land that is "marginal" to one person may be a vital resource to another in deed it has been used sustainably by commons.
iv.	Biofuels feedstocks	State in the policy that biofuels should be based on non-food feedstock raised on land that is not suitable for agriculture and indigenous species of trees bearing non-edible oilseeds will be exploited. Tanzania is a net importer of edible vegetable oil and has under-supply of sugar. Therefore the biofuel policy document should not permit utilization of edible vegetable oil (such as palm oil) and sugar cane juice for biodiesel and bioethanol production, respectively. State in the policy that molasses by-product of the sugar industry should be major source of bioethanol production instead of sugar cane juice.
v.	Policy framework	Should incorporate the views of all stakeholders taking into account government, private and academia dialogue Should indicate clearly sector linkages to be put in place by policy makers and the government. Should be driven by local or community energy needs, rather than foreign driven or external energy needs. Should avoid the top down approach, which, understate social acceptability of the new biofuel venture/project. Should have a pro-poor impact which indicate poverty reduction strategies featuring prominently in document
vi.	Biodiversity	Every effort should be made to ensure biodiversity conservation. Clearing of large areas of natural forests habitat to give way to biofuels mono crops farming should be avoided. Genetically modified plants (GMP) for biofuels production should be scrutinized carefully if there is a need to grow them otherwise should not be allowed due to the fact the effect environment and human health is still unknown
vii.	Marketing linkages and purchase price	The oil marketing companies (OMC) should be entrusted with the responsibility of storage, distribution and marketing of biofuels. Biofuel indicative purchase price (BIPP) for procuring biodiesel and bioethanol should be fixed.
viii.	Financial incentives that encourage biofuel development	The entire biofuel value chain should be considered as a primary sector activity that is eligible for priority lending by all financial institutions/banks. Policy should encourage the sale of biofuel in indigenous markets and prohibit exports. To encourage investments in biofuel sector. Policy should also favour discounted excise and custom duties on plant and machinery for the production of biodiesel/bioethanol and for engines running on biofuels.
ix.	Research and development (R&D) on biofuels	The policy should support continuous research, development and demonstration on all aspects of biofuel production, from feedstock production to end-use applications. R&D to generate advanced and cost-effective bioconversion technologies is vital step in large-scale promotion of biofuels technologies in any country in the world. Regulatory authority, which can be responsible for coordinating biofuels research and development, should be established. Biofuel demonstration projects should be entitled to grants, subsidies and fiscal incentives and should be encouraged through public private partnership (PPP).

The total potential for bioenergy production in Tanzania depends on the potential for crop production in the country. Tanzania has about 94.5 million total hectares of land, of which only about 10 million hectares are currently cultivated. With a total arable land area of approximately 44 million hectares, according to some estimates, the area of land suitable for the cultivation of energy crops production in Tanzania is estimated at

somewhere between 30 million ha (Sulle and Nelson, 2009a). However, recently, Haugen (2010) reviewed biofuel potential in Tanzania and FAO's estimates of available land and revealed that the biofuel policies must be based on cautious assessments of how much land that is actually available .Furthermore, Haugen (2010) found that the FAO's estimates figures are the higher side and as such it is not appropriate to apply them as a basis for planning agricultural expansion in Tanzania and in order to avoid direct conflicts with a broad range of human rights and environmental obligations due to production of biofuels. Nevertheless a range of factors indicates that biofuel development in Tanzania is technically feasible. The favorable factors include; high and growing energy needs presence of arable land near coast for easy exportation and high rainfall in coastal regions. To date, approximately four million hectares have been requested from the government for biofuels investment. Much less land, about 641,179 ha in total, have already been allocated for biofuel investments. Even less land 100,000 ha in total, has been fully secured by biofuel investors following the procedures for land acquisition.

Table 2: Biofuels crops and their proposed locations in Tanzania

Biofuel crop	Location	Purpose/initiative
Jatropha	Kisarawe/Coast region, Bagamoyo/Coast region, Rufiji/Coast region, Chalinze/Coast region, Kilwa/Lindi region,Dodoma, Mwanza,Shinyanga and Tabora regions, Mpanda/Katavi region, Mbalali/Mbeya region, Kilimanjaro and Dar es Salaam regions, Manyara region, Handeni and Pangani/Tanga region, Arusha region. Singida region, Morogoro region, Njombe region, Usangu/Mbeya, Lindi region	*Jatropha* oil and biodiesel production, seeds and *Jatropha* oil for export, production of *Jatropha* seeds for local market.
Palm oil	Kigoma region, Bagamoyo, Kisarawe and Rufiji in Coast region, Mvomero/Morogoro region	Crude palm oil and Biodiesel production, biodiesel for power use.
Sugar cane	Rufiji, Bagamoyo/Coast region	Bioethanol for export
Sorghum (white and sweet sorghum)	Bagamoyo/Coast region, Handeni/Tanga region,	Bioethanol for export
Croton megalocarpus	Biharamulo/Kagera region	Production of nuts for Croton oil and biodiesel mainly for local market
Sunflower	Dodoma region, Chalinze/Coast region, Shinyanga region,	Export of sunflower crude oil, biodiesel production
Pongamia piñata	Bagamoyo/Coast region	Biodiesel production
Neem	Bagamoyo/Coast region	Biodiesel production
Moringa oleifera	Bagamoyo/Coast region	Biodiesel production
Castor	Planning phase and location not yet allocated	Castor oil and biodiesel production

Sources: (GTZ, 2005;Kamanga, 2008; Messemaker, 2008; Oxfam International, 2008; Songela and Maclean, 2008; Sulle & Nelson, 2009a; Sulle, 2009b; WWF-Tanzania, 2009)

Oilseed bush Jatropha curcas Linnaeus is one of the crops often cited as ideal for growing on marginal/waste/barren land in Tanzania and elsewhere in the world by foreign and local investors. Various studies has shown that the non-edible drought resistant crop has considerable potential and value for small-scale production in its natural environment and can be grown on degraded lands and improve the quality of such lands by storing moisture and stabilizing soil (Dufey, 2006;UN-Energy, 2007; Dellomonaco et al., 2010). Nevertheless, claims of low nutrient requirement, low water use, low labor inputs, the nonexistence of competition with food production, tolerance to pests and diseases in combination with high yield should be taken with precautions since the claims are entirely not true (Drynet Position Paper on Biofuel, 2008). There is still lack of scientific evidence to support claims related to Jatropha high oil yield production particularly at large scale in marginal lands. There is also still a scarcity of research about the influence of various cultivation-related factors and their interactions and influence on seed yield. Furthermore information on cultivation, establishment, management and productivity of Jatropha under various climatic conditions is lacking in peer-reviewed literature (Parawira, 2010). The positive claims on J. curcas are

numerous, but only a few of them can be scientifically verified and sustained. According to Foidl et al. (1996) the predictions of productivity seem to ignore the results of plantations from the 1990s, most of which are abandoned now for reasons of lower productivity and or higher labor costs than expected. Genetic and environmental factors have effect on oil yield production factors. J. curcas is still a wild species and genetic identification of provenances and testing them in different locations and conditions is yet to be done. There is also still a shortage of research about the influence of various cultivation-related factors and their interactions and influence on seed yield (Parawira, 2010). Therefore it is important to distinguish between reality, promise and dangerous extrapolation about J. curcas as a biofuel crop whether on small-scale or large-scale plantation. Table 3 summarizes some of the claims about J.curcas as an energy crop compared to research findings and field experiences.

In Tanzania it has been reported recently that there is not enough knowledge on inputs, outputs and management of the Jatropha plant (Messemaker, 2008). Experiences demonstrate that there are low yields and oil content beside high costs of Jatropha cultivation. To maximize return on the land one needs to use fertilizer, irrigation and fungicide. In dry areas this will require large-scale mechanized irrigation (Messemaker, 2008). Furthermore in Tanzania commercial production of Jatropha on marginal land is not suitable, as it needs 500-6000 mm/year and fertile land such as on coastal areas, low land hinterlands and western high lands close to Lake Tanganyika (MAFSC, 2006). Therefore the dry land in centre of Tanzania cannot be recommended for Jatropha commercial production without irrigation (MAFSC, 2006). Upon that realization many agrofuel investors are choosing to develop their Jatropha plantations on well-watered, fertile lands, and not “marginal” lands (Sulle & Nelson, 2009a; Table 2). However, additional high-yielding genotypes of Jatropha should be selected for Tanzania for stable and economic biodiesel production. There is need for proper policies and mechanisms to regulate the sector to ensure that biofuels feedstock such as Jatropha are not given too much priority at the expense of other important values for nature, environment and society (Parawira, 2010). Of particular concern is the competition for land, water and the displacement of land for the cultivation of food and other crops (Openshaw, 2000).

Cooking oil wastes from restaurants and households can be used as alternatives in production of high quality biodiesel (Nakpong & Wootthikanokkhan, 2009). The price of waste cooking oil is 2.5-3.5 times cheaper than virgin vegetable oils, thus can significantly reduce the total production cost of biodiesel. Biodiesel obtained from waste cooking vegetable oils has been considered a promising option. Waste cooking oil is available at relatively cheap prices for biodiesel production in comparison with fresh vegetable oil costs (Demirbas, 2009). Furthermore, lipid (fat) production from algae holds much promise for the biodiesel industry since it makes up to 50 percent oil by weight and double their numbers in a single day. Microalgae are microscopic aquatic plants that carry out the same process and mechanism of photosynthesis as higher plants but do not require fresh water or arable land used for cultivation of food crops (Weber, 2009). Agriculture and forest residues provide a large potential as alternative feedstock, especially if the second-generation biofuel technology is applied to expand on the potential forest residues. Assuming that 4 tons of waste can produce 1 ton of ethanol, this may have better sustainability in terms of contribution to green house gases emission reduction and food security (Li & Chan-Halbrendt, 2009).

Table 3: *Jatropha curcas Linnaeus* biofuel/energy crop

Claims	Research findings and experience	References	Remarks
Wasteland/marginal biofuel crop	-Literature claims 1000g/plant. -Experience shows 200g/plant.	Achten et al., 2007; 2008; Orange, 2009	-Seeds and oil yields are much higher in conditions where the plant has adequate access to soil nutrients and water than hostile conditions (Parawira, 2010). -In Tanzania *Jatropha* plantation are being established/targeted coastal zone, forested, fertile, well-watered lands (Martin et al., 2009).
Low water requirement	-Without irrigation 1.2-2.77 tons per ha. -With irrigation 5.25-12.5 tons per ha.	Rajagopal, 2007; Orange, 2009; Kheira & Atta, 2009	-Optimal oil production from *Jatropha* requires significant annual rainfall of up to 1000-1500 mm/hectare (Gaia Foundation et al., 2008). -Seed yields are sensitive to soil fertility and moisture availability (Parawira, 2010).
Tolerance to pests and diseases	-*Jatropha* plant is not free from pests and diseases.	Messemaker, 2008; Christian Aid, 2009	-Tolerance of *J. curcas* to pests and diseases on few dispersed trees might not apply in general to trees in plantations (Parawira, 2010). -Pesticides and fungicides are applied for growth and survival of *Jatropha* in plantations (Messemaker, 2008).
Low labor intensity inputs	-*Jatropha* requires high labor intensity	Hakikazi Catalyst, 2008; Parawira 2010	- *Jatropha* oil production is labor intensive because labor is required to prepare the land, set-up nurseries, plant, irrigate, fertilize, prune, harvest and process the seeds ready for the market (Parawira, 2010).
Has low fertilizer/nutrient requirement	-Yields increase significantly with increased soil fertility	Orange, 2009; Weber, 2009	-Growing the plant with fertilizer produce as much as 4 kg per plant (Orange, 2009).
Has high yield	-*Jatropha* crop, predicted yields range from 0.6-15 tons seed per hectare per year.	Openshaw, 2000; Kumar & Sharma, 2008; Hakikazi Catalyst, 2008; Parawira, 2010.	- Projections of seed yield and oil yield on plantations in many literatures lack a sound scientific basis with wide variations and do not give description of conditions under which data were collected (Lapola et al., 2009;Parawira, 2010). - Failure to reach satisfying yields is the main problems encountered during *Jatropha curcas* cultivation (Foidl et al., 1996). - Poor yield being caused mainly by air cross-pollination which creates hybrids of different *Jatropha* varieties that do not possess the agricultural characteristics of *Jatropha curcas* (Kumar &Sharma, 2008)

Biofuels production models.

Biofuel crops production, as with any form of agriculture, can be carried out under a range of different production arrangements often referred to as production models. In Tanzania several combinations of business models exist, ranging from models that limit the production of biofuels to smaller holder farmers in groups to that which relies on the out growers/contract farming and models that involves company owned farms/plantations/estates. Recently Sulle & Nelson (2009a) reported that biofuel companies using out grower and other contracted smallholder arrangements have little direct negative impacts on land access and represent the most positive model for local livelihoods and the environment. However, while out grower systems are currently considered more inherently 'sustainable' from a social and environmental perspective, it is important to consider hidden costs of independent production, including food security impacts of agricultural land and labor foregone from food production, water depletion, soil nutrient depletion, erosion and downstream impacts at the watershed level, as well as the risks of invasive species and potential risks from genetically modified organisms (RSB-GUI, 2009). As with large-scale biofuels, the experience is relatively very recent in Tanzania, particularly *Jatropha* biofuel crop. Land allocation for

production of *Jatropha* in Tanzania is 80% private, 56% plantation and 22% mixed (GEXSI, 2008). It is the spread of these large-scale operations, which is driving many of the social and environmental concerns about biofuel production in Africa (Scott, 2009) and in Tanzania at present (Sulle & Nelson, 2009a).

Plantation agriculture is often based on monoculture of a single variety or cultivar, which increases risks of pests and disease impacts, necessitating intensive management with tillage, fertilizers, pesticides, herbicides and other chemical inputs (RSB-GUI, 2009). Details of classification criteria for development of biofuels in Tanzania, features of production model/drawbacks and reasons for production model have been reported elsewhere (Messemaker, 2008; Martin et al., 2009; Sulle & Nelson, 2009a). Table 4 summarizes production models, production arrangement, status and challenges of existing, prospective and emerging biofuel crops production arrangement in Tanzania.

Players and institutions involved in biofuels in Tanzania: The motivations for governments to aggressively pursue biofuel development are complex and multidimensional since it entails exploitation of four principal resources namely; land, forests, water resources and labour (Kamanga, 2008). To ensure the sustainability of biofuels enterprise and those four strategic important resources, different countries of the world are developing their national strategies on biofuel development to include environmental and social criteria/aspects, which are intricately interrelated. Biofuels can be regarded as integral part of emerging bio-economy with great development expected to come especially for those countries like Tanzania with agriculture as the main activity. Production of liquid biofuels; bioethanol and biodiesel in Tanzania is new and still in its infancy stage. Nevertheless, the biofuel industry has attracted a wide range of investors. Besides a handful of local firms, foreign firms from Europe, USA, Japan and the Far East dominate the biofuel development initiative and investment(s) mainly often with the intention to export. This is often implicated mainly to the fact that Tanzania as a developing country lacks the necessary technology for the production of biofuels and capital investment. To that effect the country currently encourages foreign investment in biofuels and the likelihood of foreign investors dominating the industry is a clear reality. The foreign biofuel industry dominance and impact in Tanzania should not be underestimated but be taken as policy pointer since their dominance in local economies may also limit opportunities to negotiate equitable inclusion. The roles of different actors/players in Tanzania are summarized in Table 5.

Table 4: Existing and emerging biofuel crops production arrangement in Tanzania

Production models	Production arrangement	Status	Challenges
The Plantation (Estate)	Plantations by individual, cooperative or Corporate	-Currently virtually no and/or little by way of analyzed, empirical evidence to substantiate the perceived potential	-Not producing biofuels commercially and are only in their infancy. -Lack of structured biofuel policy means no documentation of incentives and tax. Thus making biofuels investment risks very high. -Legislative gaps, and compensation limited to loss of improvements like crops and trees (thus excluding loss of land) all undermine the position of local people. -Lack of transparency, checks and balances in contract negotiations deals that do not maximize the public interest. -Not enough knowledge on inputs-outputs and management of some energy plants.
The Out grower (Contract Farming)	Small-scale/small holders/village-level biofuel production by contract or independent farmer	-Many of these are in their initial stages and are run by foreign investors, primarily European. -Out grower schemes and sustainable farming are becoming drivers for business.	-Small scale development in biofuels exists on a limited basis
The Hybrid Production	Mixed plantation with integration of out grower schemes/small-scale farmers.	-Smallholder producers may control supply.	-Smallholders difficult to safeguard labor, wage and rights. -Market instability e.g. the instability of the seed market. -Potential of plantation employees being replaced by mechanized production. -Smallholder may collude to increase prices or disrupt supply.
Medium- scale	Batch and collection	-The most prevalent form of biofuel initiatives. -Established biofuel feedstock market, with development and growth prospects. -Actors do not produce liquid biofuel (e.g. in the form of biodiesel) but use (straight vegetable oil) for transportation.	-Unreliability of feed stock production and low oil content

Sources: (Messemaker, 2008 ; Mitchell, 2008 ;Songela & Maclean, 2008 ;Martin et al., 2009 ;WWF-Tanzania, 2009 ;RSB-GUI, 2009 ;Sulle & Nelson, 2009a ;Sulle, 2009b).

Table 5: Players, institutions involved in liquid biofuels in Tanzania and their roles.

Sn	Players/actors, institutions	Roles
1	Government of Tanzania both central and Local, including at Village level) and its Agencies;	-The role of government for the energy sector is to facilitate development, provide incentives for private investment initiatives and promote effective regulations, monitoring and coordination of the sector. -Ministry of Energy and Minerals supervises the implementation of the energy policy, which is the main guidance for changes backed by legislation and regulations. - Tanzania Investment Centre (TIC) maintains a database and suitable growing areas and offers a one stop shop to facilitate land acquisition, permitting and registration. TIC has developed a land bank of over 2.5 million ha, with several land plots for potential investment opportunities all over Tanzania. - The office of the Commissioner of Lands, the principal statutes regarding land, that is, the Land Act and the Village Lands Act, 1999. - Local government, Village Councils and Village Assemblies have been pivotal for accessing village land for biofuel development by investors via lease and are being centre stage of the ongoing expansion of the biofuel industry. - National Biofuel Task Force (NBTF) is working on policies, strategies and regulations to streamline the development of biofuels and to formulate and propose an enabling environment to facilitate the development of biofuels in Tanzania. -The Tanzania Petroleum Development Corporation (TPDC) is a national oil company responsible for exploration, promotion and development of oil and gas resources in the country. However does not control prices, and the market of petroleum products and biofuels as potential substitute for petroleum products are not mentioned in its establishment. - Energy and Water Utilities Regulatory Authority (EWURA) its role is to regulate the energy and water sector in Tanzania including the technical aspects of downstream petroleum business. EWURA will also be responsible for the regulation and monitoring of a future biofuels sector with additional powers to deal with licensing of biofuels - National Environmental Management Council (NEMC) is a government agency entrusted with the role of enforcing, reviewing and monitoring environmental impact assessment (EIA) studies. These studies include agricultural projects necessitating resettlement of communities; transportation of petroleum products; and the development of large-scale renewable sources energy. -Tanzania Bureau of Standard (TBS) responsible for international standards, technical specifications and codes of practice in order to upgrade supply chain infrastructure, quality of petroleum products and services provided. In regard to biofuels Petroleum Supply Act require EWURA to consult with the TBS.
2	Investors (existing, prospective; local and foreign)	-Different local and foreign are at various stages of developing and promoting the production of biofuels. - The preferred model of production is either plantation or smallholder/out grower) and/or both depending on particular investor(s). - Companies contract-farming or agreements with farmers whereby seeds and other agriculture inputs are provided by those who can then purchase the crops produced by the farmers. - Many companies are already planning and implementing supply chain innovations that include local people. But they focus primarily on the inclusion of small-scale farmers and pay much less attention to enterprises in the downstream supply chain. -More than eight multinational biofuel companies are reportedly finalizing colonial style agreements with villages to acquire thousands of hectares of land to cultivate biofuel crop. - Tanzania is not producing biofuels for export yet but biofuel industry is dominated by foreign based biofuel business companies
3.	The diplomatic community (Belgium, Brazil, Canada, Japan, Germany, India, Malaysia, Switzerland, UK,	-Development partners/ bilateral and multilateral donor organization -Government of Netherlands, SIDA and NORAD of Sweden and Norway, respectively have been supporting the NBTF in terms of financing the biofuel development guidelines, supporting project-monitoring unit as well as for hiring biofuels experts to support the

	USA) international development agencies (CIDA, DfID, EU, GTZ, JICA, ILO, SIDA, UNDP, UNEP, USAID) and International Financial Institutions (AfDB), IMF, World Bank)	Tanzania government and facilitating NBTF meetings. -Germany via GTZ has commissioned the first ever comprehensive study on the prospects of liquid biofuels for the transport sector and potential and implications for sustainable agriculture and energy in the 21st Century -FAO leading international cooperation developing a BioEnergy Food Security analytical framework which is set up in one country in each region in the world interested in producing biofuels. Tanzania country specific data is being developed by the FAO, which will result in a country specific scenario that will determine input to the analytical framework. -DfID, World Bank and USAID provide technical and financial assistance to develop the productivity and capacity of out growers and communities in palm oil and Jatropha growing areas -BEST (Business Environment Strengthening in Tanzania) under the BEST cluster competitiveness project donor finance capacity development (such as training, yield improvement and market research etc) of out growers in key growth sector -Millennium Challenge Corporation and other donors fund to offset infrastructure development costs associated with new production facilities (road linkages and irrigation etc)
4.	Tanzania Association of Oil Marketing Companies (TAOMC). TAOMC members include BP,Shell, Gapoil, Gapco, Caltex Oil, Oryx, Kobil Petroleum, Total, Engen Petroleum, OilCom andNatoil.	-There are more than 70 oil marketing and trading companies in Tanzania responsible for the distribution of petroleum product throughout Tanzania, these companies set-up create partnership with private individuals to operate petrol retail stations. - Could produce or use biofuels -Since biofuels are likely to be an enduring aspect of the oil industry development oil companies will be responsible for biofuels distribution and marketing in Tanzania. -Some oil companies such as BP are planning to be in engaged in biofuel production but waiting for biofuel policy to come out.
5.	Research and academic institutions both private and public	-Conventional role of teaching, research, consultancy and outreach activities, they could prove critical in several ways. -Some are engaged in conducting Environmental Impact Assessment (EIA), while others have been involved in conducting quantification for compensation of the villagers whose land has been dispossessed. -Training manpower in the disciplines of chemical processing, and energy engineering, besides providing consultancy services to stakeholders and thus positioned to influence public opinion and policy. - Expected to conduct applied research, process development and provide expert professional services to biofuel industry, government and other organizations -Research on biodiesel production from vegetable oil - Engine tests on pure biodiesel and biodiesel/diesel blends -Private research institutions carry out research related on biofuels such value chain and value chain analysis, biofuel value chain mapping etc
6	Civil society organisations (local and international) and the media	NGOs such as KAKUTE (Kampuni ya Kusambaza Tekinolojia), TaTEDO (Tanzania Traditional Energy Development and Environmental Organization), Faida Mali Market Link, Haki Ardhi, Jatropha Products Tanzania Ltd, LHRC (Legal and Human Rights Centre), LEAT (Lawyers Environmental Action Team) and the most prominent forum for the media is the organisation 'Journalists for the Environment' (JET). - Supply, construction, and maintain bioenergy facilities - Innovation in bio-energy technologies and energy. -Creation of public awareness on biofuels issues and related issues -Promotion of biofuels -Commissioning biofuels desk research

Sources: (GTZ, 2005;Keamey, 2006; Kamanga, 2008; Messemaker, 2008; Sulle & Nelson, 2009a)

Impact of biofuels on food security

The competition between food and energy crops has become an international debate. Prices increases for some biofuel crops that are also staple foods place food security at risk by raising prices and increasing rather than decreasing poverty. This is likely to happen if it is more profitable to sell food crops to biofuels producers (WWF-Tanzania, 2009). The assessment of impacts of food security from biofuel developments is normally based on basic production models namely; plantation/estate, out grower and hybrid. Whereas out grower models are seen as more supportive of food security, despite substitution of land and labor to production exported from the micro-level system, integration of cash and food crops provides benefit of intensification and diversification of cultivation, reducing risks from pests and diseases to which mono-cropped systems are more susceptible. Reduced risk may mean that the farmer could potentially make more cash, thus improving her/his risk to food security (RSB-GUI, 2009). Food security is improved when the main food crop and cropland are not diverted to biofuel production, as is the case with bioethanol or biodiesel. The food and livelihood security of farmers displaced by biofuel plantations will be affected, while those encouraged to grow feedstock on their own land instead of food crops, may be at greater risk of food insecurity (Scott, 2009).

The potential impact of biofuel production on the price of food crops, in Tanzania and around the world, has been raised as a major issue of concern on the part of civil society organizations, government policy-makers, foreign donors, local communities, and in some cases the investors themselves (Sulle & Nelson, 2009a). Cultivation of energy plants, which goes hand-in-hand with forced resettlement, have recently been reported that could most likely affect food prices in Tanzania and compound even more the country's dependency on food imports (Kamanga, 2008). Also, at household level in Tanzania it had been reported that there is evidence that food prices in local markets are beginning to increase because of the industrial biofuel companies in their locality (Action Aid, 2010). Beside the empirical evidence from a number of sub-Saharan countries including Tanzania show that the majority of farmers or rural households are not net food sellers but are net buyers of food and consequently they are the most vulnerable to rises in food prices (Action Aid, 2010). Increasing pressures on investors to scout for cultivable land had inflamed the food versus biofuel debate and spurred major controversies over the large-scale biofuel plantations in relation to food security in Tanzania. Therefore, the danger that Tanzania might soon be overrun by such biofuel crops investments is threat to its already precarious food security situation (Redfern, 2008). Scientific evidence is steadily moving against industrial biofuels (first generation biofuels) and the link between biofuels and food insecurity is strong. There is a connection between the two, particularly from a women's rights perspective, and the extent to which the right to food is being undermined by industrial biofuels (Action Aid, 2010). In fact in developing countries, rural women produce 60-80% of the food. For example in Sub-Saharan Africa countries such as Tanzania women produce about 80% of household food (UN Millennium Project, 2005). In regard to water supply and quality it has been reported that many feedstock – including sugar, palm oil and maize–are highly water intensive, meaning that their expansion is likely to make water less readily available for household use, threatening the health status and food security status of affected individuals (FAO, 2008a). Fear of food shortages and mounting pressure from environmentalists, farmers, NGO's have prompted the Tanzanian government to suspend the allocation of arable land, processing any new applications for biofuel projects and eviction of farmers over biofuel projects, pending ratification of a law and establishment of a regulatory mechanism to govern the sector and monitor the biofuel industry.

It should however be acknowledged strongly that research suggest that the relationship between biofuel and food is very complicated (Kaye-Blake, 2010). Table 6 summarizes the relation ship between biofuel and food in Tanzanian context and elsewhere applicable.

Table 6: Complexity of the relationship between biofuel and food

Issue	Explanation
Population	Growing population and improved diets are placing ever-greater demands on land for food production. So that competition and conflict with biofuel production using current methods will ever increase the demand for food where in a world about one billion people are already hungry/underfed (FAO, 2008a). What does it mean for a future with even less biofuel and more people?
Knowledge	With more knowledge, better management and increased capital, the same, finite amount of land can produce more food and fuel. The greater production does not require more land and does not

	necessarily require more of other resources. Greater efficiency does allow someone to have more. However, finite amount of political considerations and institutional structures and should therefore be evaluated.
Distribution	Food shortages and price fluctuations are not necessary a result of biofuel crop cultivation but distribution. Production of more food will not solve the distribution problem. The problem is how food and productive resources are distributed. Distribution problems are often the result of poor infrastructures, storage and political problems, such as civil war (Jenkins & Scanlan, 2001)
Poverty	The problem of poverty is in the form of access to food and the capacity to produce food and not directly related to biofuel production. Peasant agriculture does not generate sufficient returns for farmers and cannot invest in improvements in human, physical, financial and social capital that could allow them to produce more. Farmers are trapped in their poorly productive systems and are unable to invest in water supplies, farm improvements and new technologies. The results of rural poverty need sound institutional and infrastructure arrangement, policy decisions interventions (World Bank, 2007).
Environmental impact	Environmental impact from bringing more land under cultivation. In order to meet both the demand for food and an increased demand for biofuel, more land may be brought under cultivation. More agriculture but lower greenhouse gas emissions certainly deserve some consideration (International Energy Agency (IEA), 2004). Biofuel may reduce carbon emissions, for example, but what are the impacts on water quality or biodiversity?
Production	Production, however, is a combination of land, water, various sources of energy, plant cultivars, knowledge and physical capital. Food security problems are not production problems, so focusing on how much food or biofuel is produced does not solve the problems. It is impossible to determine how much food and biofuel they might end up being produced. But If biofuels production if managed properly will have a positive effect on the rural economy and food security, by enabling more people to have sufficient income to be food secure planned (Scott, 2009; Christian Aid, 2009; Action Aid, 2010).
Investment	Biofuel has the potential to resolve the problem by providing a new use for commodities. Food could become more expensive but possibly only marginally. However, farmers could increase incomes, they could invest in improvements to their education, health, technology and land.

Impact of biofuels on employment opportunities: The arguments put forward in support of investment in biofuel production include the contribution it will make to rural economic growth, employment and incomes and poverty reduction (Raswant et al., 2008). Because biofuel production is labor intensive, there could be significant employment creation thus can also contribute to alleviating poverty. There is remarkably little information available on actual incomes and employment in biofuels production, perhaps because it is relatively new and as yet limited in scale (Scott, 2009). Although jobs may be created and expanding plantations other jobs may be displaced if the land used for plantation was previously farmed. Net jobs gain may be minimal or possibly more jobs may be lost than created (Christian Aid, 2009). Additionally, new created jobs are often of much poor quality in terms of wages and conditions (Christian Aid, 2009). The nature and significance of the impacts of the introduction of biofuels production upon women and men will depend on the technology and specific context as well as local settings (Scott, 2009).

The labor situation for men and women in biofuel industry in Tanzania is more of the same nature as that across the globe and the concerns are analogous to the concerns in the rest of the world. Making the agriculture sector which, employ 80% of the population in Tanzania attractive in terms of employment prospects is one the objective of the Tanzanian Employment Policy of 1997. Therefore, among reasons supporting the production and use of biofuels in Tanzania includes promotion of the development of new agricultural markets and income generation in rural area (Jenssen, 2006). Based on one job per hectare (De Keiser & Hongo, 2005), the earmarked 700,000 ha of land for liquid biofuel in Tanzania, can be equivalent to 700,000 direct jobs and another equivalent number of jobs can be created indirectly. This can be achieved through additional capital inflows, create demand for goods and services that provide employment, reduce rural-urban migration, and create linkages and multipliers. Nevertheless, "the growing global demand for liquid biofuels, combined with the high land requirement that characterizes the production of such fuels, in Tanzania might put pressure on the so-called "marginal" lands, providing an incentive to convert part of these lands, which may be perceived as less important and of less 'use', to biofuels production." Typically owned and/or

farmed by women, these marginal lands provide critical subsistence functions for the rural poor. It have been recently reported by Rossi & Lambrou (2008) on gender and equity issues in liquid biofuels that the conversion of marginal lands to plantations for biofuels production "might cause the partial or total displacement of women's agricultural activities towards increasingly marginal lands," with a negative impact on the employment and income earning/generation. This is likely to happen due to the fact that the present employment status of women in Tanzania is deplorable and the gender bias is a prevalent and significant problem, with women working twice or triple work days in the fields than men (Migiro, 2004). On the other hand if women get employment in biofuel plantations, experiences elsewhere revealed that women tend to be disadvantaged compared to men, concerning employment conditions, and there is evidence that women receive less training and instruction than men (AWID, 2008; Rossi & Lambrou, 2008). A recent report noted an example from Malaysia where women represent about half the plantation workforce and are predominantly employed as sprayers of chemical pesticides and herbicides. Without proper training and safety equipment, this can result in "serious implications for the long-term health of these women workers" (AWID, 2008; Rossi & Lambrou, 2008). Additionally, it is also well documented that large-scale mono crop plantations require mostly seasonal workforce with working conditions mostly deplorable, labor rights non-existent and low payment (Christian Aid, 2009). Already there are concerns of low daily wages payment in *Jatropha* plantation scheme have been reported in Tanzania (Redfern, 2008). Nevertheless, research in Tanzania suggest that *Jatropha* plantation could provide significant source of employment (5 employments per 1ha of *Jatropha*) since mechanized harvesting of fruits is inefficient because fruit do not ripen at the same time and hence have to picked individually (HakiKazi Catalyst, 2008). On the other hand pilot and experimental projects, mainly by NGOs such as KAKUTE, TaTEDO and companies such as Diligent found in Tanzania shows potential to increase access to energy access for the poor, and even provide sources of income/employment for rural households, especially women. For marginal women farmers in Tanzania such income/employment opportunities may still be perceived as relatively attractive. However, in Tanzania biofuel development policies should also be consistent with (and, possibly, contribute to) the promotion of gender equality and the empowerment of women. In this regard measures should be taken to ensure that women and female-headed households have the same opportunity as men and male-headed households to engage in and benefit from the sustainable production of liquid biofuels. This is important in light of the increasing feminization of the agricultural workforce and the growing number of households headed by females (42% of the total in Southern Africa), particularly in the poorer and more food insecure countries of the world (Deutsch et al., 2001) often due to male out-migration or loss of male labor force due to HIV/AIDS (FAO, 2004). Therefore ensuring women have increased access to and control over land and other productive assets would improve women's welfare and they're bargaining power within the household and would also improve increase agricultural productivity.

Power and politics on biofuels: Biofuel politics relates to the scenario of who has the power to make decisions on issues pertaining to biofuel development/industry. The politics of biofuels are more complicated than superficially seen. The stimulation of biofuel production/industry by governments of the world is purely a political decision of bureaucrats and politicians. The political decisions, influence biofuel industry development in several ways such as in terms of subsidies on the growth of biofuel crops, production processes and the prices at the pump as well as in terms of regulatory frameworks/guidelines/policies. Elimination governments could impose barriers success and other necessary interventions in favor of the industry such as tax incentives.

Biofuels production in itself is not bad, it is the way it is currently being done that can be so problematic and/or raise concerns by stakeholders. In Tanzania already, over 40 companies/projects have biofuel projects at different parts of the country predominantly along the coast mainly with *Jatropha*, sugarcane, sweet sorghum and palm oil as energy crops. Despite this number of biofuel investors/projects/initiatives Tanzania's biofuel development particularly liquid biofuels (ethanol and biodiesel) are new and is still at infancy as well as not fully understood. There have been evidences of current biofuels production displacing local small farmers creating social-economic issues in Tanzania (Sulle, 2009b). It is however also evident that in Tanzania biofuel production for local energy consumption is undermined by the obvious intent of multinationals international investors to target foreign markets. Also, there are no plans and/or scant plans to invest in

infrastructure in Tanzania to process biofuels for local use.

In controversial new sectors such as biofuels, the potentially social and environmental consequences are expected to be so remarkable that many groups and individuals from all walks of life are exercised by recent biofuel developments and intend to engage in the biofuel debate about where the biofuel sector should go (Caniëls & Romijn, 2009). In Tanzania so far politicians, decision makers, bureaucrats, media (local and international), public, civil societies and NGOs are divided with respect to the current biofuel development/investment by both local and multinational companies. Nevertheless, some members of parliament, civil societies and activists have already warned against the invasion of arable land by multinationals seeking to cultivate biofuels whose priority market is not Tanzania but for export to rich economies of the West. The concerns had an impact to the extent that the current state President has recently ordered all regional authorities to halt current and future biofuel projects and acquisition of land from villagers until clear biofuel policy is established. On another development linking policy with practice, field experiences and input from different organizations is vital at this early stage of biofuel development in the Tanzania. To that effect the NBTF is apparently willing to adapt policy provisions to input generated through local experiences and recommendations from numerous workshops, consultations, and stakeholders (such as WWF-Tanzania, Hakiardhi and other NGO's) discussions and perspectives (Sulle & Nelson, 2009a,b). Understandably biofuel investment in Tanzania is being encouraged as it has a potential to aid rural development, local livelihood, improve energy security and reduce oil imports. However, the way biofuel investments are being carried out needs to be effectively coordinated for biofuel industry to benefit a broad section of the society and keep social and environment impacts of biofuel investments to a minimum. Therefore the biofuel policy needs to address the sustainability concerns about biofuel industry such as biodiversity, ecological, economic, cultural and environmental issues. Highlights of the contributions of power and politics on biofuels in Tanzania are summarized below.

- The power imbalances that come into play around land issues that poor people's rights are intrinsically under threat by increased demand for land for biofuels crops.
- The biofuels regulations, which could enable preparation of clear policy on biofuel investments to pin down investors once they have done something against the interests of the country so far, are yet to be approved by the cabinet in Tanzania. Thus, if the right biofuels policies were in place, there would be no need to displace farmers.
- Investors in Tanzania have been able to receive necessary investment, land and environmental approvals to start biofuel crops plantations even without concrete biofuel policy in Tanzania.
- Through linking policy and development Tanzanian government and foreign donors have identified biofuel as priority growth sector and are prepared to provide extensive support at highest levels to accelerate biofuel investment.
- Local government, village councils and village assemblies (along with the some respective members of parliament) have been instrumental in facilitation of investors are accessing village lands for biofuel development and have been on a centre stage of the ongoing expansion of the biofuel industry in Tanzania.
- Tanzanian petroleum supply bill amendment is on the way to allow for the blending of fossil fuels with biofuels.
- The Tanzanian government have initiatives to be implemented soon which include "agro-ecological zoning" to determine specific areas for different uses, including biofuels investments.

Sustainability of biofuels: There is a hypothesis that biofuels can be produced in a "sustainable" manner if policy makers would choose to do so (Haugen, 2010). The biggest challenge to biofuels sustainability is ensuring that high-value land is preserved either because it stores large amounts of carbon (as does forest land) or because it is well suited for human food production (Bramble, 2009). In general worldwide type of feedstock, biodiversity, ecological, economic, cultural and environmental issues are some of the key issues that are examined to determine the sustainability of biofuels investment. It is well established that introducing large-scale agricultural production of any kind can threaten forests and biodiversity, carbon stocks, land and water resources (UNESCO, SCOPE & UNEP, 2009). These impacts have all been identified with biofuel production, whether on wetlands, semi-arid lands or farms land. There are massive impacts on habitats and biodiversity. Some biofuels crops such as sugar cane, soy and palm oil are either directly grown

in tropical forest areas and other high biodiversity hotspots, or are displacing other activities such as cattle ranching into these areas (Action Aid, 2010).

In Tanzania impact on forests and biodiversity for biofuel crop production is one of a major concern as biofuel plantations are set up in Tanzania. This is manifested by clearing of large areas of natural forests habitats such as miombo woodlands and coastal forests to give way to biofuels crop farming (WWF-Tanzania, 2009). As new crops are introduced and used as feedstocks the effects of these on native fauna and flora is uncertain, some may turn to be aggressive invasive species that may affect neighboring land (Caniëls & Romijn, 2009; Sulle, 2009b,WWF-Tanzania, 2009). The prospect of industrial, mono crop agriculture nowadays also raises the prospect of genetically modified (GM) crops. Introduction of GM crops is yet another risk in Tanzania and elsewhere. GM crops are being developed to increase energy crops yield to meet biofuel demand and reduce the need for pesticides. This may result to cross-pollination with wild relatives and thereby affecting biodiversity (Envirocare, 2007).

Globally agriculture accounts for 70% of water use and 90% of use in developing countries such Tanzania. Water is a scarce resource in many parts of Tanzania. In a study of three Sub-Saharan African countries, Rosen & Vincent (1999) found that women spend, on average, more time than men on water provision: 700 hours a year in Ghana, 500 hours/year in Tanzania and 200 hours/year in Zambia; women also tend to collect higher volumes of water compared to men. Water used for biofuels could limit the amount of water available for domestic uses and for other land uses such as food crops and deplete the local water table. There is also risk of large-scale irrigation to cause salinisalation. This is likely to occur in irrigated areas, which have low rainfall as well as in coastal areas due to reduced water table (WWF-Tanzania, 2009). Many biofuels projects in Tanzania are planned for both dry and coastal areas (Kamanga, 2008; Sulle & Nelson, 2009a). It therefore, likely that salinisalation could have a large potential effect to the water supply and fertility.

The processing of biofuels can also consume substantial quantities of water, thus the ability to provide more for biofuel crop production and processing of biofuels requires careful analysis at local and regional scales. Due to the current status of biofuel production in Tanzania, discharge of effluent from processing biofuels is of low priority than the other issues linked to biofuels in Tanzania. However, regulation and control of effluents to mitigate negative environmental impacts should be taken (WWF-Tanzania, 2009). Indirect land use change occurs when one form of land use is displaced to another area and for a viable biofuels industry, the land must also be capable of supporting sufficiently high crop yields for production to be economic (UNESCO, SCOPE & UNEP, 2009). In Tanzania some of the current proposed biofuel production plantations pose a large threat to biodiversity as they plan to employ large work force, which will need houses to be built after clearing natural habitats. A casual laborer will have an impact on surrounding areas and forest reserve as they could be involved in logging, charcoal production etc when employment in plantations is not available (WWF-Tanzania, 2009). Pleas have been made at the international level that rules governing the international liquid biofuels market should be agreed on and adopted, and the social and environmental sustainability of biofuels production should be ensured. Establishing one or more of the following could do this: codes of conduct, voluntary schemes, certification, bilateral agreements and multilateral frameworks (UN, 2007). A number of national and international initiatives aimed at ensuring the sustainability of biofuels production and processing are already underway, such as the International Bioenergy Platform (IBEP) and the Global Bioenergy Partnership (GBEP), both housed within FAO, and the Roundtable on sustainable biofuels (GBEP, 2007).

Research and development on biofuels: There is emerging global opportunity for producers of biofuels. Tanzania can benefit if it chooses to engage in this opportunity aligning industry sustainability and development goals via research and development (R&D). R&D on biofuels to generate advanced and cost-effective bioconversion technologies is the first step in large-scale promotion of biofuels technologies in any country in the world. More research and investment is required to develop the potential of small-scale biofuel production aimed at meeting the energy needs of people living in Tanzania. Traditionally, both public and private universities should conduct basic and applied research, process development, provides expert professional services to industry, government and other organizations.

With regard to biofuels there has been scientific research going in Tanzania. Biogas a gaseous biofuel produced by anaerobic digestion of almost all organic matter (with no competition for land, food, water etc). It is a promising, affordable, decentralized renewable

energy of today and the future in Tanzania. In Tanzania the biogas research and development has been going on for the past twenty years and centered mainly at College of Natural and Applied Sciences (CoNAS) at the University of Dar es Salaam in collaboration with counterparts in foreign Universities (Mshandete and Parawira, 2009). On the other hand, research and development on bioethanol and biodiesel have been initiated but is still at an infancy stage. Research on bioethanol production from sisal bole waste, sawdust waste, bamboo juice, coffee wastes, sugarcane feedstocks using indigenous microorganisms isolate have been carried and others are at preliminary stage particularly at CoNAS and at College of Engineering and Technology (CoET) University of Dar es Salaam. Recently natural occurring osmotolerant fermentative *Saccharomyces* yeasts suitable for industrial very high gravity fermentation application have been isolated from traditional brews and wines in Tanzania (Sumari et al., 2010). With regard to biodiesels there have been research and development on biodiesel production from vegetable oil, pure biodiesel and blended biodiesel engine testing. Further research on the use of indigenous crops, including non-food crops, agricultural waste and forest residues is proposed in the context of biofuel production as well as research into increasing the land efficiency. To that effect research on vegetable oil for biofuels other than *Jatropha curcas* potential for oil bearing have been initiated at CoET. Nuts and seeds of *Aleurites moluccana*, *Croton megalocarpus*, *Jatropha curcas*, *Moringa oleifera* and *Pachira glabra* were collected from the wild and their potential for vegetable oil production assessed in terms of seed/nut acreage yield, seed/nut oil content, harvesting requirement, and upstream processing before vegetable oil recovery. All five varieties were found to contain acceptable oil content and yield. But *C. megalocarpus* was ranked as the plant with the highest vegetable oil followed by *M. oleifera* and *J. curcas*, A. *moluccana*, and *P. glabra* (Kibazohi & Sangwan, 2011). On the other hand there have been several researches on liquid biofuels done in Tanzania by postgraduates foreign students supported by countries like Germany, the Netherlands and UK. Furthermore, there has been reports and research commissioned by local and international NGOs, civil societies, CBOs, development partners, organizations such as GTZ, WWF-Tanzania, Christian Aid, Land Rights Research and Resources Institute (LARRRI) and Joint Oxfam Livelihood Initiative for Tanzania (JOLIT), Envirocare, independent international research organization, The International Institute for Environment and Development, The Tanzania Natural Resource Forum, Diligent Energy Services and Ameco Environment Services and Match Maker Associates Ltd. Kilimanjaro BioFuels Corporation (KBC) is a private establishment to research and develop the opportunity to promote Bio Jet Fuel from *J.curcas* as a sustainable resource. KBC was established with *J.curcas* as the first feedstock opportunity to be investigated fully as the future of Bio Jet Fuel, it also considered in terms of algae. Both the soda lakes Magadi and Natron in Tanzania are considered to have excellent potential as areas with the desirable characteristics required in promotion of commercial algae cultivation.

However, R&D of the energy sector inclusive biofuels is characterized by a lack of institutional co-ordination with respect to various on-going research activities. To facilitate the development of the sector in Tanzania, there is need to establish a regulatory authority, which can be solely responsible for coordinating biofuels research and development activities. There should be investment in R&D appropriate to local conditions/settings, and to maximize opportunities for poor people; for example in appropriate oilseed production, small-scale processing, and in biofuels technologies able to increase access to clean energy in remote areas. The research institutions should put emphasis also on R&D work for the entire biofuels value chain via integrating research themes across the value chain: environmental and economic sustainability, fuel standards and conformity assessment issues, life cycle assessment, greenhouse gas balances, barriers to deployment, etc. Demonstration projects could be entitled to grants, subsidies and fiscal incentives and could be encouraged through public private partnership (PPP). Furthermore, research initiative could involve the identification and substantiation of the potential gender differentiated, socio-economic risks and opportunities of liquid biofuels production at both the intra-household level (i.e. on both men and women) and the inter-household level (i.e. on male- and female-headed households). Another interesting research initiative can be geared towards second-generation liquid biofuels. It is important to investigate and take into account the potential gender differentiated risks and opportunities associated with these new technologies. Land grabbing phenomena due to biofuel investment and use of indigenous crops including non-food crops for biofuel production are yet other research themes.

Biofuels value chain: The value chain describes the

full range of activities, which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers, and final disposal after use (Kaplinsky & Morris, 2001). Detailed features of biofuel value chain activities have been reported recently by Kondili & Kaldellis (2007). However, in summary the biofuels value chain includes a number of activities mainly, biomass production, biomass processing and bioproduct trading/marketing. Within a development perspective, the value chain framework can be used to analyze value chains and identify constraints and opportunities for development (Messemeker, 2008).

In Tanzania some biofuel development initiatives by local and multinational investors are taking place at different stages. In Tanzania's context, a transition towards biofuels based energy regime is still in a very early phase and that its future is still unclear. It also follows that with regard to biofuel value chain, little research that have been done to date and literature available reveals that limited local research infrastructure is one of the barrier in biofuels industry development. Also biofuel value chain mapping have been identified as one of the challenges in biofuel value chain. There is no commercial biofuel production in Tanzania. Currently several stakeholders are involved in biofuel development in the field of straight jatropha oil production. Therefore, most of biofuel value chain information or studies available for Tanzania are on *Jatropha* biofuel crop and products. A study on prospects for *Jatropha* biofuels in Tanzania with emphasis on analysis of strategic niche management by Eijck & Romjin (2008) showed that Tanzania's existing energy regime and agricultural regime remain prominent barriers. However, mapping of *Jatropha* biofuel value chain by Eijck & Romjin (2008) revealed that *Jatropha* production value chain production involve growing the plant and harvesting the seeds, processing and usage stage where the oil and seed cake are consumed or further processed to generate final products. On the other hand a study on assessment of the *Jatropha* value chain and its potential for pro-poor biofuel development in Northern Tanzania pro-poor biofuel by Messemaker, (2008) concluded that there is little knowledge on important issues such as production costs and feasibility compared to other crops. In general, *Jatropha* requires common inputs such as nutrients, water and farm management, thereby competing with food and other crops. Hence, it is not the promising biofuel crop it is said to be. Under certain conditions, the *Jatropha* value chain could contribute to pro-poor biofuel development in Northern Tanzania. But for now it is still in an incipient stage. With regard to value chain governance, the study showed that some stakeholders have taken steps towards acquiring governance in the chain, but in practice have little power over other actors yet. The *Jatropha* business in Tanzania is yet to be linked with global value chain. A feasibility study on local biofuel production to be linked to the energy production for use in telecommunication application in South Eastern of Tanzania was conducted by Diligent energy Services and Ameco Environment Services of the Netherlands in 2006. The study identified functions related to biofuel production in Tanzania such as consumption (usage) of either of SVO and biodiesel as fuel that are suitable for using in the diesel generators for the mobile phone antennas. The study also identified marketing functioning as part of the chain. Another study carried out by MMA (2007) on *Jatropha* subsector emphasized on *Jatropha* soap value chain analysis. The stakeholders in *Jatropha* based biofuel up to oil production include producers, collectors, collection centers, agents and transporters. The chain extends to distribution, medical stores and supermarket in *Jatropha* soap production chain. There is still lot of production drive and there is understandably tension between market development and production base development at this stage of value chain. Governance in a soap value chain exhibits the degree of organization and interactions in a value chain. Value chain is still developing hence there is little governance exhibited by actors/outside agents in this chain (MMA, 2007).

From the preceding few studies on biofuel value chain it can be inferred that biofuel value chain analysis in Tanzania relates especially to the production, marketing, distribution and support of biofuel based crops. Biofuel development and production could be a viable business proposition for biofuel growers in Tanzania due to the fact the demand for biofuel is presumably very large although much of it is still latent. It can be preliminary concluded that that there are still many obstacles in Tanzania's prevailing energy regime to the biofuel transition. The development of biofuels is still in an early phase hence more data and know how need to be gathered on Tanzania's biofuels potential, implications and challenges on biofuel value chain and how to respond and mitigate/and adapt to those challenges.

Land tenure issues: Land tenure involves securing access to land and management of land resources. It involves who can hold and use the land and its resources at specified duration and conditions (Lal, 2006). Land is a finite valuable commodity which first generation biofuels investors are keen to exploit to grow energy crops. Worldwide the current increasingly biofuels demand for transportation is likely to present a significant pressure on land resource use across the globe. Nonetheless access to land is one of the fundamental preconditions to fight against rural hunger and poverty. The rapid growth in demand for biofuels has lead to expansion of biofuel production, which is likely to lead to greater competition for access to land (FAO, 2008b).

In Tanzania even though the aggregate picture of land devoted to biofuel is uncertain, for those living in locations affected by individual biofuel projects there are real concerns about their impact on those who depend on the land acquired for their livelihoods (Sulle & Nelson, 2009b; Sulle, 2009b). Women compared to men own very little land. Instead, women often use communal land to grow crops, collect nuts, graze animals or collect firewood. But this very same land is being targeted for biofuel investment (Action Aid, 2010). The prevailing land acquisition for biofuels by foreign investors particularly in Africa partly is promoted by policy and legislative reforms aimed to attract investors to Africa and foreign Governments mainly Europe and USA promoting acquisition of farmland in foreign countries for biofuel production and/or biofuel feedstock's to meet their biofuel blending mandate targets stipulated in their respective biofuel policies (Oxfam International, 2008; Christian Aid, 2009; Action aid, 2010). The ongoing fast-evolving biofuel investment in developing countries definitely creates opportunities, challenges as well as risks (Oxfam International, 2008). Large-scale land acquisitions can result in local people losing access to the resources on which they depend for their food security and livelihoods (Lal, 2006). Local residents may be directly dispossessed of the land they live on, often their long-standing heritage (Cotula et al., 2008; 2009). The future land requirements for biofuel production are uncertain, what is certain is the acquisition of land in African countries for agricultural production, for both food and biofuel crops (Scott, 2009). Unfortunately, one of the side effects of biofuel targets in which companies or rich and powerful investors rush to buy up new land, potentially displacing vulnerable communities whose rights to the land are poorly protected (Christian Aid, 2009). On the other hand, increase in pressure on access to land in developing countries and the sheer speed of biofuel expansion may generate new pressures on land tenure arrangements, leading to alienation (IUCN, 2007). There is considerable fear that the poor may either lease, sell or be forced to relocate as the rush to meet increasing demand for land for biofuel crops production (Raswant et al., 2008). One of key reasons for Africa's attractiveness to outside investor is due to the perception that there are vast areas of unused or underutilized land, which can be readily given over to grow biofuel feedstock's (Cotula et al., 2008; 2009). Also Africa is said to have most of the underutilized fertile land in the world (Henrique, 2008) as well as land values being very, very inexpensive in Africa (Jung-a et al., 2008).

In Tanzania land ownership remains restrictive; under the Land Act of 1999, all land in Tanzania belongs to the state. However, non-citizen investors may occupy land for investment purposes through a government-granted right of occupancy, through derivative rights, or through sub-leases through a granted right of occupancy. Rights of occupancy and derivative rights may be granted for periods up to 99 years and are renewable (TIC, 2008,). Furthermore, in Tanzania, investors can lease and use 'general land'. Details of the procedures of how land can be transferred from 'village' to 'general' with the permission of the local community has been reported recently by Sulle (2009b). Although, land acquisition in Tanzania is difficult and time consuming, many Tanzanian citizens, local and international NGOs oppose land acquisition by foreign investors. This opposition is mainly based on negative experiences in the past with different crops and resources. There is considerable public fear that the same will happen when large patches of land will be exploited for biofuels by foreign investors (Caniëls & Romijn, 2009).

Tanzania is one of the African countries that have attracted many initiatives in the line of biofuel business and the total potential for bioenergy production depends on the potential for crop production in the country. Bioenergy development is a land intensive activity and total requests of land in Tanzania are far more than has been actually allocated. Over 4 million hectares of land have been requested for biofuel investments, in particular for *Jatropha*, sugar cane and oil palm. But only 100,000 ha have been granted formal rights of occupancy (Sulle & Nelson, 2009b). Therefore, most of the impacts on local land tenure from biofuels

development are still to come as further deals are negotiated and finalized (Kamanga, 2008; Sulle & Nelson, 2009b). In Africa, concern has been expressed about the way the new biofuel investments may result in the loss of rights over land on the part of local communities (Scott, 2009). With interest in allocating land for biofuel expansion the security of land tenure and access or use rights on the part of local resident communities across rural could be compromised (Kamanga, 2008; Sulle & Nelson, 2009b). Table 7 summarizes concerns and impacts of biofuels investments on land tenure in Tanzania.

Although at any rate as far as investment on land is concerned, foreign investors are required to have a share with Tanzanians. However, the amount of share Tanzanians have been given is very, very small, for example, in the case of Sun Biofuel Plc's it is only 1% for two Tanzanians. On the other hand, the current State President has on several occasion directly exhorted villagers to identify village lands to be put to use by investors in mutually beneficial arrangements.

Table 7: Some concerns and impacts of biofuels investments on land tenure issues in Tanzania.

Sn	Concerns	Impact	References
i	Alienation and displacement.	• Land grabbing and the resultant displacement of village communities is one of the biggest and real threats of bioenergy. • Forcing local communities out of their territories could plunge the farming communities into economic and cultural exploitation, as they will be laborers in biofuel plantations. • Alienation of local communities on their rights over customary lands. In Tanzania land act provides for the conversion of customary tenure to leasehold for under 99-year leases.	Lal, 2006; Envirocare, 2007; Kamanga, 2008; Sulle & Nelson, 2009b ; Sulle, 2009b.
ii	Conflicts arising from land alienation and displacement	• Is causing tensions as investors' and requirements come into conflict with those of communities. • Lack of transparency in the way the investment is taking place particularly regarding the allocation of land is leading to conflict. • Insufficient proper consultation and poor understanding of traditional land authority on biofuel investment proposed on land is likely to compound even more in future the conflicts between biofuel commercial producers and local community.	ABN, 2007; Kamanga, 2008; Oxfam International, 2008; Sulle 2009a, b.
iii	Inadequate compensation of acquired land.	• Local people incur substantial opportunity costs in granting large areas of land to investors, which are not being factored into existing assessments of land values. • Payment of compensation limited to loss of crops and trees excluding loss of land itself undermine the position and welfare of local people.	ABN, 2007; Action Aid, 2010; Cotula et al., 2009; Knaup, 2008; Rughani, 2009; Sulle & Nelson, 2009a; Sulle 2009a, b
iv	Local interest and rights inadequately safeguarded	• Rights to use land for grazing, firewood collection, or wild fruit gathering stipulated in traditional land tenure systems is shuttered as the result of biofuel investment on the land. • Common lands are officially unrecognized and therefore ineligible for compensation by biofuel investors thus compromising local interests and rights.	Action Aid, 2010; Scott,2009; Sulle & Nelson, 2009a;Sulle 2009a,b.
v	Shuttered livelihood resulting from land alienation and displacement	• Loss of local villagers forest-based economic activities, including commercial charcoal production and harvesting forest products. • Loss of US $35-50 generally unaccounted-for per capita income, which have been estimated by World Bank from informal and non-industrial uses of forests in Tanzania. • Loss of forests which, provide 75% of all building materials, 95% of household energy supplies and 100% of traditional medicines. • The community loss of land without receiving compensation,	Kamanga, 2008;World Bank, 2007; Sulle & Nelson, 2009b; Sulle 2009 a, b.

		contrary to the Village Land Act as well as the community's livelihood interests. • Exclusion of any value attached to land itself, which do not appear to take any account of the opportunity costs villages face in diverting Miombo woodlands used for their economic activities for biofuel plantations.	

Sources: Oxfam International, 2008; UNESCO, SCOPE & UNEP, 2009;Action Aid, 2010.

Biofuels climate impact: The demand for biofuels is expected to continue to grow in the medium term, as is the production. A significant and increasing share of this type of fuel is being provided by tropical and subtropical developing countries and emerging economies, which have a comparative advantage in the production of biofuels feedstock such as sugarcane and palm oil (Jank et al., 2007). Thus policies supporting biofuel production and use have been established throughout the world at different levels (Worldwatch Institute, 2007). From an environmental perspective, the promotion of biofuels aims at reducing global greenhouse gas emissions (GHG) to limit climate change due to their anticipated lower carbon content compared to fossil fuels (Oxfam International, 2008). Plants grown to produce biofuels absorb as much carbon dioxide during photosynthesis as biofuels release during combustion. On the contrary the GHG mitigation potential of certain biofuel production technologies and systems has been challenged in several recent studies (e.g. Crutzen et al., 2007, 2008;Fargione et al., 2008). In this regard, the primary question has been how much GHG is emitted during the whole biofuel production chain, taking into consideration the emissions from cultivation, (use and volume of agrochemicals and farm machinery, etc.) extraction, transport, processing (type of energy required, energy efficiency), distribution and combustion. Some prominent features of biofuels climate impacts are summarized below:

- Direct land use change: Conversion of land to grow biofuel crops is an important cause of GHGs. The release of GHG from soils and vegetation almost systematically exceeds reduction of GHG emission that could result from the use of biofuels for some decades.
- Diversion of land: Diverting land previously used for food crops production to biofuel production often has a displacement effect and farmer clear other lands (forests or grassland) to maintain food production. The new land use may have a GHG emission impact, which can be quite large making the overall biofuel production system net releasers of GHG.
- Application of nitrogen fertilizers and crop burning: Releases of nitrous oxide (N_2O), often increase with enhanced use of nitrogen fertilizer and crop burning, both of which are common in biofuel production. N_2O is 300 times more powerful as a GHG compared to carbon dioxide released through the decomposition of nitrogen-based fertilizers. Poor management of nitrous oxide emissions can reduce or even eliminate the greenhouse gas benefits of a biofuel operation.
- Air pollution: Pollution from the burning of sugar cane before manual harvest contributes smoke, fine particles, and nitrogen gases to the atmosphere, causing acid rain and a variety of human health impacts. Ethanol and biodiesel can reduce the emissions of some pollutants from vehicle exhaust (e.g. fine particles and carbon monoxide), but tend to increase other pollutant emissions such as nitrogen gases.
- Emission from organic wastes: GHG emissions such as of methane and carbon dioxide from biological decomposing organic wastes and from nutrient polluted wastewater resulted during the production of biofuels.
- Lost opportunity for carbon savings: If the lands have the potential to revert to forests, conversion to biofuels represents a lost opportunity for carbon storage. The environmental and
- social consequences of inputs required to make degraded and marginal lands productive must also be considered.
- Utilization of organic wastes for biofuel production: Using wastes and agricultural and forest residues for biofuels is also likely to produce GHG benefits. In general, biofuels

made from organic waste are environmentally more benign than biofuels from energy crops. Using biomass primarily for material purposes reusing and recycling it, and then recovering its energy content can gain multiple dividends.

In Tanzania the current move towards biofuel production is necessitated by a number of factors, which are analogous to the concerns such as impact on climate echoed in the rest of the world. With regard to *Jatropha*, one recent study on land clearing and greenhouse gas emissions from *Jatropha* biofuels on African miombo woodland in Tanzania concluded that the carbon condition of soils appears to be more significant for the emissions balance than biomass and that whether net emissions reductions are achieved depends on the level of degradation of the ecosystem and alternative land uses (Romijn, 2009). Although it has been generally concluded recently by Action Aid (2010) that the industrial biofuels are the least cost-effective way of saving GHG emissions and their suitability in the fight against climate change is uncertain. However, using best agricultural management practices could reduce many of the negative biofuels impacts on climate, although choice of feedstocks and systems, and the overall demand remain critical. In addition, other environmental parameters such as negative impacts on natural resources must also be taken into consideration. Analytical tools such as life cycle analysis (LCA) can help identify the best environmental alternatives; however, social parameters have to be innovatively integrated in LCA. There is simply not enough land to produce sufficient biofuel for global liquid fuel needs. Finally, it should be noted that investment in biofuels is a relatively expensive way to reduce global greenhouse gas emissions. Other measures of exploiting other renewable energy sources may be more cost-effective innovations.

CONCLUSIONS

This is a first ever-comprehensive review, which categorized issues and provided the status of each issues pertaining to biofuels in Tanzania. The review also highlighted the gaps and proposed strategies of addressing the gaps related to opportunities/prospects, challenges/risks/constrains of the relatively new biofuels sector. In this review it was revealed that Tanzania has great potential for biofuel production due to the availability of land resource, high yield biofuel feedstock's, water resources, relative conducive climatic conditions and cheap labor force. It was also learnt that Tanzania could benefit if it chooses to engage in this biofuels opportunity by aligning industry sustainability and development goals. However, there is neither biofuel policy nor strategies to regulate biofuel industry although there some guidelines developed by NBTF. Even without the biofuel policy however investments have been going on. Multinational companies/investors have started large-scale production of biofuels mainly for export. At the moment biofuel production and processing in Tanzania is at its infant stage and there are no commercial production of biofuels (ethanol and biodiesel). There is only small scale production of straight vegetable oil (SVO) from oil seeds, e.g. *Jatropha*, oil palm, etc do exist which is promoted by local private companies and NGOs. The biofuels industry has potential for diversification of income particularly for rural poor small-scale farmers but the challenge is how to integrate them in the biofuel value chain and how will be the distribution of returns among economic agents involved in the industry. At least with the prevailing biofuel investment pattern in Tanzania, biofuels are likely to have negative impact on food security, biodiversity, and land issues if there is no well thought policies put in place to regulate the industry. Biofuel policy will be most successful only if integrated in comprehensive plans for climate, biodiversity, food and energy security. Therefore, proper consideration and management of the potential negative effects of the biofuel industry is required, to ensure benefits out weigh any ecological, economic and/or social costs.

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