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Appropriate climate change solutions: Towards sustainable bioenergy agro-production in Africa for energy equality and poverty alleviation

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Appropriate Climate Change Solutions: Towards Sustainable Bioenergy Agro-production in Africa for Energy Equality and Poverty Alleviation

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Abstract: Limited energy access within developing nations particularly in Africa is a primary reason for poverty. Biofuel production has been advocated by many experts as a solution to meeting the energy needs of African countries while reducing greenhouse gas (GHG) emissions. Others argue that biofuel production will compete with land needed for food production. However it appears many African countries have available land beyond food needs, hence biofuel production may be an option for poor farmers to gain skills, create economic diversification and provide affordable energy without environmental degradation. This paper reviews the situation in Africa with regard to biofuels and sustainability. It argues that biofuels produced within a sustainable production framework, could improve rural infrastructure, job opportunities, education and health. A new bioenergy production framework is proposed which includes a novel element: agro-management alongside other sustainability elements. The framework is designed as a prerequisite for bioenergy project proposals in Africa. Addressing climate change by advancing biofuels, taking into account equality, land rights and environmental considerations, may be achieved in many African countries, with the implementation of such a framework.

Keywords: Africa, Agro-production, Biofuels, Climate Change, Land Degradation, Sustainability

Introduction

ONE OF THE overriding factors dividing people in developed countries and those in developing countries and in particular in Africa, is access to readily available energy. Development of biofuel projects under environmentally and socially sustainable conditions is sometimes promoted as a solution to this (Metzlaf and Hedin 2007). Biofuel production is also promoted as having the potential to address climate change in reducing greenhouse gas (GHG) emissions (Fischer 2009). As energy deprived citizens in developing countries often do not benefit from energy projects in their countries (von Maltitz et al. 2009), biofuel production, is unlikely to realise sustainability standards in African nations without prudent planning and preparation (Mandil & Shihab-Eldin 2010).

Africa, said to be plagued by corruption, neo-colonialism, desertification, skills shortage and poverty has considerable land (Hoogweijk et al. 2005); this asset which provides an option for addressing the many causes of poverty while addressing energy shortages. Biofuel produced on land in Africa which is poorly used, left idle or has been degraded has the potential to help advance agriculture which presently has production standards well below the international average (Block 1995).

Climate change impacts have spurred researchers and industry to look at alternate clean energy options. Considering fossil fuels are finite, with uncertain supply, and emit GHGs, there is a need to procure further renewable energy resources. Although agro-production of food has been heavily researched with regard to adaptation to climate variations (Hardy 2005), little research has been focussed on bioenergy impacts on food production.

Many experts fear that the expansion of bioenergy will jeopardise food security (Drexler 2008). Others argue that biofuel production is an opportunity to address poverty in many parts of the world (Johnson et al. 2009). Decisions for biofuel projects are often solely made by experts in government and industry who focus on cost-benefit analysis while neglecting the holistic approach of planning with stakeholder input (Haywood and de Wet 2009). The trust of developing countries in foreign investors has diminished as a result of a history of inferior planning and implementation of agro-production projects (Harrison et al. 2009; von Braun & Meizen-Dick 2009).

This paper looks at the potential for the development of a socio-environmentally sustainable bioenergy agro-production (SESBEAP) framework which takes into account agronomic techniques surrounding cultivation. Such a SESBEAP framework would interrelate with what Giuliani et al. (2009) suggest with regard to biofuel project development: they say social, environmental and economic assessment policy frameworks should work in association with national and international climate change policies and take into account sustainable development policies.

In this paper the section below discusses the possible impacts that sustainable biofuel production may have on climate change adaptation. The section following that covers the linkages that biofuel production associate with climate change. The paper then discusses the necessity for a sustainable production framework in which to develop biofuels. This is followed by an outline of the new proposed SESBEAP framework and finally conclusions are made regarding biofuels and sustainability in Africa.

Climate Change – biofuels and Adaptation

Devereaux and Lee (2009) suggest there are four main drivers influencing the appeal of biofuels. These four biofuel production factors are:

- reducing climate change impacts,
- improving energy security,
- reinforcing farm incomes, and
- Contributing to rural advancement

Devereaux and Lee (2009) say these drivers could address poverty, GHG emissions, environmental concerns and food and clean water supply. Their research and other contributions from the literature are discussed in detail below.

Impacting Climate Change

Since the early 1990s interest in renewable energy sources has intensified with growing concern about global climate change (IPCC 1995). Devereaux and Lee (2009) observe that transport is responsible for 25% of the world's carbon dioxide emissions (with expected growth in this percentage over the next two decades). Use of biofuels has potential for ad-

addressing climate change by reducing GHGs. Net emissions of GHGs in biofuel's projects vary considerably depending on the feedstock used, technologies employed, processes and consumption (Gutterson and Zhang 2009).

Developing second generation species has additional potential in reducing GHG emissions. Second generation biofuels are usually derived from lignocellulosic crops, crop residue or crops which do not compete with food crops such as *Miscanthus* (*Miscanthus sinensis*), sweet sorghum (*Sorghum bicolor*) and energy cane, a hybrid of (*Saccharum officinarum*). Many are perennial crops with lower inputs, are faster growing and potentially offer higher yields (Sierra et al. 2008). Fischer (2009) and OECD and FAO (2008) point out that growing second generation biofuels has the potential to diversify agriculture and may pave the way for addressing food supply adaptation issues in association with climate change and population increases.

Diaz-Zorita et. al. (2002) optimistically predict that when, in the medium term future, more sustainable and feasible energy options are initiated, land, water and agricultural infrastructure and skills used for biofuel production can easily be redirected to food production. However without adequate assessment, adverse effects are likely to impact on water accessibility for both local and regional populations and biodiversity (Chikari 2008). The risk factor in water accessibility and use is critical to survival and needs to be closely monitored in relation to weather variations, agricultural use, essential domestic requirements and environmental impacts.

Improving Energy Security

As countries look toward reducing their reliance on petroleum, interest in biofuels is unfolding as they represent the only current alternative to petroleum-based transport fuels. Realising the necessity to diversify their suppliers, countries have become increasingly focussed on secure alternate fuels outside of the Organisation of Petroleum Exporting Countries (OPEC) (Sinclair 2009). Until such time as possibly electric or hydrogen based vehicles can be produced economically, biofuels are one of the few options open to governments who are concerned about dependence on imported oil (Sinclair 2009).

Reinforcing Farm Incomes

International biofuel trade is limited with only 10% traded externally; most biofuels are consumed domestically. Many proponents of biofuel production say that it will support farmers' incomes by creating local economic and agricultural opportunities (Markelova 2009).

Rural Advancement

Biofuels offer potential for developing water supply infrastructure, transportation networks, and if new companies emerge locally within processing operations, job opportunities (Galor 2007).

Biofuels: A Sustainable Option for Alleviating Climate Change Complexities

Biofuel Advancement

FAO et al. (2010) says unrestrained agricultural development and associated deforestation is a driver of climate change. Such deforestation is funded by wealthy enterprises and supported by developing nations. Unsustainable practices, where developed countries drain developing countries of natural resources, with very little benefit to the local population, have left Africa with mistrust and suspicion (Johnson et al. 2009). Although biofuels have a place in the transferral of energy sources, their reliance on water and climate requires cautious estimates and flexibility in the planning of supply (Fischer et al. 2009).

Dominguez-Faus et al. (2009) place emphasis on cautionary planning on land and water, advanced methods of conservation, agricultural agronomy and species selection for the sustainable development of biofuels. With sustainably based planning and management, viable bioenergy options could provide investment opportunities in water supply infrastructure and agricultural production. The nations that proactively seek to produce a domestic sustainable energy supply have more likelihood of being at the forefront of economic opportunity, both nationally and internationally (Hakes 2008). Snell (2009) and O'Connell (2008) observe that insecure energy supplies have encouraged investigations into sustainable energy providing nations with an option of improving economic growth for rural populations and the reduction of GHG emissions. Unless social and environmental concerns are addressed a robust and sustainable biofuels industry will not occur in Africa (Leduc 2007). The pressing need for African countries to become less reliant on the external volatility of the fossil oil industry gives scope for business opportunities and a stable supply of sustainable fuels (Hakes 2008). For instance, from 2011 the Southern African Development Community's (SADC's) fuel demand is expected to grow by four percent per annum (de Bruyn 2010). De Bruyn (2010) says the overall the demand for oil in the SADC region would reach about one million barrels per day by 2025.

Education, Skills and Modernisation of Rural Developing Countries

There is potential for the poor to benefit from biofuel production in areas where land is available and where the necessary infrastructure investment is available. This might be accelerated by policy facilitating sustainable production on suitable idle and marginal land (Gallagher, et al. 2008). The production of biofuels could encourage modernisation in rural developing countries with increased incentive for agricultural investment by the governments and the private sector. Competition for labour could increase wages and improve the conditions of those living in poverty. Policies which encourage local agribusiness with manufacturing, processing and service provisions have the potential to increase employment opportunities and consequently wealth in rural areas (Ogaboh 2010). Biofuel development provides an opportunity for much needed rural infrastructure such as potable water, roads, railways, electricity and communications. Unless basic amenities in sort supply, such as health and education, are improved, biofuel advancement will be frustrated (Ogaboh 2010). Biofuel production also has the potential to facilitate the necessary capacity building needed in the agricultural sector in Africa. Courses, workshops and college scholarships will need to be

provided by companies developing biofuels in Africa if required skill levels for successful biofuel development are to be met (Ogaboh 2010).

Within many African nation's, land holders are unable to hold title to the land. This presents situations where landholders are unable to offer security for loans and a lack of incentive for them to protect soils from degradation (Ogaboh 2010). Also as ownership of land is a contentious issue there is uncertainty regarding future land tenure, biofuel project security, population displacement and livelihoods (Boddiger 2007). These issues are likely to intensify if local populations are forcibly displaced by biofuels being introduced without a sustainable production framework.

Land and Ecological Degradation

Bringezu et al. (2009) consider that since increased resource productivity is needed on a global scale, the challenge is for affluent economies to change their patterns of consumption and production, and for developing countries not to instil policies encouraging environmental degradation. Developing African countries need policies which emphasise sustained social-economic growth, high environmental benefits and climate change adaptation and mitigation. Interest in biofuel production will broaden as feasibility improves with diligent research on species, recognising ideal climatic conditions and management standards (Schurr 2007). This accentuates the importance of producing a set of conditions under which biofuels are most viably and sustainably cultivated (Schurr 2007).

Wullenweber (2008) raises the serious concerns that unsustainable land clearing will take place to pave the way for biofuel production, which will incur deforestation and grassland devastation, potentially outweighing any GHG savings from biofuels. The temptation of prospective profits will induce governments to moderate environmental protective policies, contributing to the loss of biodiversity. Bringezu et al. (2009) say the use of land and the manner in which the feedstock is produced has the largest potential for biodiversity harm and social disturbances. UNCTAD (2010) recommends governing bodies and investors, together, must:

- have an independent environmental assessment prior to project approval,
- give preference to increasing productivity or reclaiming resources already in use,
- preserve the future availability of resources while enhancing resource utilisation,
- show keen environmental consideration in agriculture, processing and manufacture,
- encourage desirable ecosystem services, and
- provide management plans that regularly monitor and address negative environmental and social impacts including biodiversity considerations.

The high level of population growth rates in developing African countries and associated increasing land degradation is of serious concern. In its simplest form, Stringer (2009) points out that desertification is land degradation manifested in dry lands and continues to be exacerbated by inaction, less precipitation in arid areas and mounting food needs. Stringer (2009) also points out that soil degradation is closely associated with agronomic performance in various ways, including loss of soil fertility, soil structure and soil erosion. Sustainable biofuel cultivation includes in its goals the aim of not adversely affecting soil quality. Stringer

(2009) emphasises land degradation has long been linked to food insecurities, which potentially will be worsened by the advancement of unsustainable biofuel production.

Poverty Alleviation – climate Change Mitigation

There is a resolute need for assessing current biofuel projects, as well as those in the planning stages. Whilst debates on the merits and demerits of biofuel cultivation continue, biofuel projects are well into implementation within developing countries (Mulugetta 2009). Current biofuel projects in Africa do not necessarily capture opportunities for socially and environmentally sustainable production over the long term. One problem is that subsidies given in the United States or European Union for their local biofuel cultivation remove the competitive advantage that developing countries have with lower production costs (Mandil & Shihab-Eldin 2010).

As most biofuel expansion is taking place in the more vulnerable African nations, both their environment and people have more at stake. Although adoption of European biofuel production standards for African projects may seem best practice implementation, the achievement of sustainability may prove problematic without local input. For example, the African country, Senegal, in producing biofuels encouraged by the European Union-Africa energy partnership, has to abide by European standards on which Senegal has no local stakeholder input (Lima 2009). The problem is not the quality of the standards but that sustainable production is more likely to succeed with local stakeholder cooperation. A framework for agro-biofuel projects which embraces the view point of local sustainability, a “long term outlook, benefitting today and planning for continued future benefits” (Porder et al. 2009), should decrease project failure whilst providing increased agro-ecological performance and reduced social disruption.

Sustainable Land Use

Biofuels policies need to ensure feedstock utilisation does not cause net additional pressure on current agricultural land. This includes the use of appropriately defined idle agricultural land, marginal lands, wastes, residues and intensification of current production. Further work is needed to develop consensus definitions for idle and marginal lands, agreed upon by all relevant stakeholders (Bringezu 2009). Assessment tools must be developed and procedures implemented to confirm the suitability of specific locations before any land change occurs. They should take into account:

- the land’s existing use (de jure de facto),
- the land’s productive potential,
- the net carbon impact of using the land for biofuels,
- the land’s existing environmental value, and
- social and economic implications of land use for biofuels.

Current policies on land use do not ensure that additional production of biofuels moves only to suitable areas. For example, in the district of Kisarawe in Tanzania, Sun Biofuels has engaged eleven villages, whose inhabitants live in extreme poverty, and has rented 9000 hectares

of land (Habib-Mintz 2010). The villagers are unsure of what land is left for them to produce food crops, which may lead to increased soil degradation and poverty.

Planning for Risks

UNCTAD (2010) mentions that, investments in biofuel projects can carry different types of risks if governance is weak, when rights are not well defined, or where those affected by changes to land use decisions lack voice. The prime risks are:

- food insecurity,
- increased corruption,
- environmental harm in the immediate area and beyond,
- displacement of local populations, social polarisation,
- negating or undermining existing rights,
- political instability, and
- nutritional deprivation and loss of access to land and livelihoods.

Elgahali et al. (2007) adds that an evaluation of a biofuel project needs to: identify gaps in sustainable biofuel production knowledge; identify trade-offs between differing objectives; and develop attributes that represent bioenergy systems at different scales and encompass the concerns of all affected stakeholders. If biofuel project planning is carried out in an organised manner, where production is based on availability of sustainable supply of resources, the promise of sustainability is possible.

Biofuel Production Framework

Environmental Assessment

Elgahali (2007) mentions that there is a need to strive for an assessment of biofuel production which does not just suit the wishes of an individual project developer but is able to resolve and unite varied stakeholder aims and goals. Harrison et al. (2009) point out that many assessment tools lack transparency and practical operation for most stakeholders. Also cumulative impacts are often ignored. The traditional environmental impact assessment (EIA) is usually a “snapshot” assessment of a point in time and does not include potential effects which evolve over time (Zah et al. 2009). In these cases if a variation occurs during project development or operation a new assessment is carried out as it now constitutes a new project.

A desirable framework for biofuel production focuses on the practical solutions for a project to successfully cover the three pillars of sustainability (Sadar 1994; Malik et al. 2009). Lima (2009) points out that those who speak against biofuel development should be allowed representation for an assessment to be representative of all members of society. If assessment before project implementation, including stakeholder involvement, is not carried out effectively and efficiently, viability and sustainability can be affected (Haywood & de Wet 2009). Problems with either EIA design or its operation will affect the physical environment which invariably has an immediate negative effect on poor populations.

Innovative schemes which involve both the investor and local communities in which both share the risk and reward, possibly have the best chance of long term sustainable impetus.

When conducting an evaluation on a biofuels project, often the impacts of other projects being developed simultaneously in the surrounding area are not considered. Haywood and de Wet (2009) point out that projects which do not consider the cumulative effects “die a death by a thousand cuts.” They add that a single analysis cannot assess different scenarios or the long term view of where the development proposal can be improved.

Biofuel Evaluation Framework Development

Lima (2008) recommends the requirements below for comprehensive criteria with holistic values in a biofuel project evaluation.

- Efficiency: Best use of the resources available,
- Biophysical sustainability: No negative impacts on ecosystem integrity (for example, air, water, soil, biodiversity, climate),
- Effectiveness and fairness: It helps to meet people’s needs, prioritising poverty eradication, and does not exploit power or other vulnerabilities of countries or populations,
- Responsiveness: It responds to the needs and interests of all, giving priority to the populations and countries who are most in need,
- Inclusiveness and participation: Due involvement of all concerned stakeholders, especially those who will be most affected by decisions,
- Accountability: Liability and compensation mechanisms are present to hold actors accountable for their decisions and actions,
- Cooperation and consensus orientation: Multiple views are on board, interests are balanced, and decisions are taken through cooperation and consensus,
- Transparency: Accessible and understandable information for actors; a decision-making process open to observation and scrutiny, and
- Rule of law: There exists a clear and structured legal framework, which is internally consistent and enforceable (Lima 2008).

As related by Paavola (2008), these principles have similar values advocated by the World Bank in its lending policies and by the FAO, IFAD, UNCTAD Secretariat and the World Bank Group (2010) as a reference by which agriculture should be responsibly developed.

Although these requirements are commendable, a significant problem is that the impacts of agro-production are not fully acknowledged even though the highest social, economical and environmental costs of biofuel production occurs in growing the biofuel feed stock (Bringezu 2009).

Agro-management Element

Once a biofuel project is implemented, the ongoing management and agronomic performance is essentially the most important aspect in the production process (Bringezu et al. 2009). The most serious environmental and social impacts occur in producing the raw biofuels. Bringezu et al. (2009) says the use of land and the manner in which the feedstock is produced has the largest potential for biodiversity harm and social disturbances. Dinh et al. (2009) highlight that approximately 70-90% of the economic cost of biofuel is in acquiring the raw material. Additional to the framework recommended by Lima (2008), best agro-management

practices, decided by affected stakeholders, may provide a solution to below average agro-production within certain developing nations.

Criteria to be considered may include:

- species selection,
- site selection,
- agronomic performance,
- economic viability
- GHG emissions
- Soil maintenance,
- labour welfare,
- environmental welfare,
- externalities (cumulatively), and
- water use and accessibility (Alexandratos 1995; FAO 2008).

The criteria above, in relation to agro-management, largely overlap with the criteria recommended by Lima (2008), however agro-management practice could benefit from additional best practice guidelines for achieving sustainable cultivation.

Land Change Assessment (LCA)

The substance of land value apart from economic valuation varies significantly between cultures and natural habitats, presenting complexities for lifecycle assessment (LCA) processes. Targeted support to develop biofuel feedstock production should be directed to Africa, where the existence of underused arable land offers considerable potential for biofuels to realise socio-economic benefits (Ogaboh 2010).

As observed by Chiaramonti and Recchia (2010), obtaining an accurate quantitative lifecycle assessment of biofuel production seems an ambitious target. Biofuel agronomic techniques have huge variations in the amount of GHG emitted. Using minimum tillage techniques and efficient fertiliser applications in agro-production can substantially reduce emissions. These savings are improved by informed choices of feedstock species and varieties which suit the terrain, soils and climatic conditions. Full understanding of potential yield per unit of land area, available management expertise and timing of operations, adds to ensuring sustainability and GHG emissions reductions are achieved; this understanding needs to be spelled out as a project proposal precondition (Dragun and Tisdnell 1999).

Proposed Biofuels Agro-production Framework

A new socio-environmentally sustainable bioenergy agro-production (SESBEAP) framework is proposed here for biofuel cultivation which takes into account the immediate development effects of biofuel feedstock projects but also includes a longer term strategic outlook. The approach includes aspects such as the enhancement of soil quality, improved farming performance, environmental issues, decrease in fertiliser use and a decrease in energy use (de Vries et al. 2010; Mandil & Shihab-Eldin 2010). Figure 1 shows the ten elements of the proposed SESBEAP framework. The design integrates the elements related to planning,

implementation and cumulative assessment, thus forming a sustainable biofuels project assessment framework.



Figure 1: The Ten Elements On Which the SESBEAP Framework is Based

The SESBEAP framework includes the sustainable elements recommended by Lima (2008), which is in accord with conditions advocated by the World Bank in their lending policies (World Bank 2009). The additional and essential agro-management element is proposed to satisfy minimum production management standards from the first stage of project planning, through to monitoring of long term cumulative impacts.

Concluding Discussion

Sustainable opportunities with biofuel projects in Africa can only occur if developers are prepared to focus on mutual benefits for themselves and affected stakeholders, laying a platform for improving present lifestyles as well as futures that are environmentally harmonious in African countries (Vanwey 2009). The valuable time saved by not harvesting wood for fuel by poor populations may provide time to attend food crops and improve productivity. A sense of social and economic wellbeing could be created by the community becoming a productive unit, alleviating a sense of hopelessness and reducing welfare burdens on society (Vanwey 2009). The sustainability of biofuel cultivation in Africa is largely dependent upon biofuel projects presenting affordable energy to local populations where the projects are implemented.

The novel SESBEAP evaluation framework proposed in this paper which defines use of best agronomic practices together with environmental, social and economic values may offer means of producing biofuels sustainably by reducing GHG emissions, alleviating poverty and improving imbalances with nature. Biofuel production, if resolutely implemented within

a clearly defined framework may offer many solutions to alleviating poverty in Africa; benefitting stakeholders without negative environmental, social or economic implications. By narrowing the gap of access to affordable energy between African countries and their developed neighbours in Europe, while simultaneously reducing GHG emissions and providing improved fuel security, sustainable biofuel production can provide practical solutions to local sustainable development and climate change mitigation.

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