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Bioenergy for sustainable development: An African context

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Abstract

This paper assesses the sustainability concerns of bioenergy systems against the prevailing and potential long term conditions in Sub-Saharan Africa with a special attention on agricultural and forestry waste, and cultivated bioenergy sources. Existing knowledge and processes about bioenergy systems are brought into a "sustainability framework" to support debate and decisions about the implementation of bioenergy systems in the region. Bioenergy systems have been recommended based on the potential to (i) meet domestic energy demand and reduce fuel importation (ii) diversify rural economies and create employment (iii) reduce poverty, and (iv) provide net energy gains and positive environmental impacts. However, biofuels will compete with food crops for land, labour, capital and entrepreneurial skills. Moreover the environmental benefits of some feedstocks are questionable. These challenges are, however, surmountable. It is concluded that biomass energy production could be an effective way to achieve sustainable development for bioenergy pathways that (i) are less land intensive, (ii) have positive net energy gains and environmental benefits, and (iii) provide local socio-economic benefits. Feasibility evaluations which put these issues into perspective are vital for sustainable application of agricultural and forest based bioenergy systems in Sub-Saharan Africa. Such evaluations should consider the long run potential of biofuels accounting for demographic, economic and technological changes and the related implications.

Keywords: Bioenergy; Sustainability criteria; Sub-Saharan Africa; Socio-economic; Environmental impacts

1. Introduction

The quest for sustainable energy sources in light of the environmental consequences of fossil fuels, increasing energy prices and the search for sustained local energy supply has resulted in increased global support of bioenergy as an alternative source of energy in Sub-Saharan Africa. Bioenergy systems are expected to result in the reduction/stabilisation of greenhouse gasses, diversification of agriculture, reduction of energy imports and provision of security against the depleting conventional energy sources and increasing energy prices (IPCC, 2007b; Commission of European Communities, 2006; Francis et al., 2005; Ackom and Ertel, 2005). However, bioenergy systems have the potential to cause negative environmental and socio-economic consequences. Negative energy balances, destruction of forests to expand land for feedstock production and the consequent loss of wildlife habitats, competing uses of land, and human and ecological toxicity impacts from chemicals and fertiliser use are some of the bioenergy use concerns (Blottnitz and Curran, 2006; Hooda and Rawat, 2005). Despite these problems a number of Sub-Saharan African countries are following the rest of the world in adopting bioenergy systems. However, given the unique socio-economic, environmental and climate change challenges that the region is facing and is likely to face in the future, a careful consideration of bioenergy programmes is required. It is against the background of these issues that this paper assesses the sustainability concerns of bioenergy systems against the prevailing and potential long term conditions in Sub-Saharan Africa. The paper brings together the available knowledge and processes into a sustainability framework to support debate about the potential of bioenergy systems in Sub-Saharan Africa. The

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paper will focus on the agricultural/forest waste and cultivated bioenergy sources.

2. Sub-Saharan Africa region: an overview

Sub-Saharan Africa houses 34 of the 50 poorest countries in the world characterised by low income, low production, poor markets, low skills, poor access to information, high child mortality and marginalisation of women (UNFPA, 2005). More than 218 million people, mainly rural, live in extreme poverty relying largely on agriculture and forests for food and energy (IFAD, 2007). The region comprise over 10% of the world population and is growing at a rate of 2.2% (UNAIDS, 2006; UNFPA, 2005). This population house 64% of all HIV infections posing a serious challenge on fiscal budgets (UNAIDS, 2006).

The socio-economic problems in Sub-Saharan Africa are further compounded by dwindling environmental resources and the general degradation of the environment in the face of increasing populations. Unsustainable agriculture and over harvesting of natural resources has resulted in problems such as desertification and soil degradation (Darko, 1995). For example, in some parts of the region agricultural productivity was estimated to have declined by over 50% due to soil erosion and desertification (Lal, 1995). Past erosion reduced yields by 2–40%, with mean loss of 8.2% (Lal, 1995; Lal, 2001). These environmental problems could further be compounded by the adverse effects of climate change coupled by the low adaptive capacity of the region. The Intergovernmental Panel on Climate Change has concluded that Africa will largely be affected negatively by climate change due to increase in extreme weather events such as droughts, floods and heat waves. This is going to adversely affect food security as yields from rain fed agriculture are predicted to decrease by up to 50% by 2020 (IPCC, 2001b). IPCC also concluded that Africa is the most vulnerable to climate change variability due to multiple stresses and poor adaptive capacity. Therefore the potential negative impacts of bioenergy systems need not be undermined in this vulnerable region.

3. Sustainability factors for bioenergy: an African perspective

A number of studies have been undertaken to establish the factors that constitute a sustainable bioenergy system. There is an agreement that sustainable bioenergy systems must give positive energy balances and life cycle environmental benefits (Farrell et al., 2006; Hill et al., 2006; Larson, 2005; Pimentel, 1995). However, bioenergy life cycle benefits vary largely between different types of feedstocks, geography, the agricultural systems and the biofuel pathway. In this regard a number of studies to review life cycle results of various bioenergy feedstocks have shown conflicting results relating to energy balances and environmental benefits of bioenergy even for similar bioenergy sources in same geographical areas with similar pathways (Blottnitz and Curran, 2006; Pimentel and Patzek, 2005). The conflicting evidence of bioenergy potential makes it inadequate to justify the environmental value of bioenergy systems in Sub-Saharan Africa without case specific life cycle assessments. Such life cycle assessments are very limited in Africa and yet bioenergy programmes are proceeding without due knowledge of the likely case specific environmental consequences. Other important environmental issues that need accounting in the region include the impacts of land use changes that will come with bioenergy systems, especially in the light of the historic and current levels of land degradation.

Bioenergy induced land use, and land cover changes have a large bearing on the environmental sustainability for any bioenergy systems. It has been concluded that the general impact of converting land from natural cover to intensive annual energy crop production decreases the organic matter content of the soil, increase erosional, metabolic loss soil and subsistence, and loss of biodiversity habitats (Lal, 2001; Lal et al., 1998; Cook and Beyea, 1998; Tolbert and Schiller, 1996). Conversely, the conversion of land from intensive annual crop production to perennial crops has positive environmental benefits. For example, the conversion of land from annual crops to perennial switchgrass added an average of 1.1 Mg C per ha per year to the soil (Bransby et al., 1996). Sub-Saharan Africa, characterised by a long history of desertification and soil degradation, can take advantage of perennial tree crops and grasses as energy sources to rehabilitate degraded lands. Productive application of degraded lands reduces the competing demand for various land uses, including housing and other infrastructural developments.

There is a general agreement that bioenergy from agricultural based sources should not interfere with food production and its access chains (Hill et al., 2006; Fritsche et al., 2006). The Food and Agriculture organisation (FAO) has indicated that about 37% of the global land area is already in use and human society is already using almost all of the good-quality land (FAO, 2004). FAO has also indicated that food supply and access is not enough and the most vulnerable to this situation live in Sub-Saharan Africa (FAO, 2003a). Figs. 1 and 2 below show that over 200 million people from Sub-Saharan Africa will continue to be undernourished by 2015 and the average per capita consumption in the region will still be below the minimum threshold of 2880 kcl/person/day by 2030. Of note is that cereals and vegetables provide 83% of energy (proxy for food nourishment) to the world population and livestock providing 17% (FAO, 2003a). Bioenergy systems have the potential to aggravate this situation in three ways, (1) diverting food crops to energy uses (2) creating competition for land, labour and capital between energy crops and food crops, and therefore reduce supply of land, labour, capital and entrepreneurial skills to food production, and (3) increasing the prices of food through the increased demand of food crops. These potential negative impacts of bioenergy systems need to be critically evaluated in light of grow-