Energy for Sustainable Development 23 (2014) 1–14

Contents lists available at ScienceDirect

Energy for Sustainable Development

Are biofuel concerns globally relevant? Prospects for a proposed pioneer bioethanol project in South Africa

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ARTICLE INFO

Article history:
Received 13 January 2014
Revised 27 June 2014
Accepted 30 June 2014
Available online xxxx

Keywords:
Biofuels
Food security
Carbon footprint
Life-cycle assessment
Black economic empowerment

ABSTRACT

Biofuels are controversial because of uncertain environmental benefits and reported social drawbacks, including 'land grabs' and threats to food security. The present study investigates the relevance of these concerns for a proposed bioethanol project in Cradock, South Africa. The proposed project is anticipated to lead to economic upliftment and could therefore contribute to reduce poverty and thus strengthen food security. With a projected annual production of up to 16,000 l ethanol per hectare, yields would be substantially higher than in most other countries. Agricultural activity would take place on existing farm land, or on biomes classified as 'least concern'. We estimate a carbon footprint reduction of ~30% for sugar beet ethanol in the area. Because various global biofuel concerns do not apply to the proposed Cradock fuel ethanol project, we argue for a more nuanced approach for the evaluation of biofuel projects with more focus on case-specific attributes.

Introduction

Climate change and the concomitant depletion of fossil fuels form the driving force behind the utilization of alternative and renewable energy sources (Balat and Balat, 2009; Cockerill and Martin, 2008; Escobar et al., 2009; Puppán, 2002). In the transportation sector, two forms of liquid biofuels, bioethanol and biodiesel, are already widely used as fossil fuel replacements in many countries (Demirbas and Balat, 2006). First generation biofuels are derived from agricultural crops, such as biodiesel from oil seeds and ethanol from starch or sugar-rich plants. These crop-based fuels account for the vast majority of currently produced biofuels (Havlík et al., 2010).

The global biofuel controversy

Much controversy has emerged from various sectors regarding the desirability of first generation biofuels. Advocates argue for their potential to reduce greenhouse gas (GHG) emissions and mitigate climate change (e.g., Demirbas, 2009; Puppán, 2002). Amigun et al. (2006) highlight the socio-economic benefits that biofuels offer, such as energy supply self-reliance, independence from oil imports and the creation of domestic employment. However, opposition to biofuels has increasingly gained momentum over the past decade. A prominent concern is that biofuels could be in direct competition with food production (Ewing and Msangi, 2009; Pimentel et al., 2009; Tilman et al., 2009). The Food and Agriculture Organization of the United Nations, specifically concerned with food security in Africa, warned that biofuels potentially threaten food security (FAO, 2013a). Furthermore, socially inequitable development, 'land grabs', and the exploitation of vulnerable groups have been linked to biofuel production (Cotula et al., 2008, 2009). Most significantly in developing countries, the earmarking of indigenous lands for an emerging biofuel industry has been found to cause social tension due to the displacement of people living on and farming the land, as well as to reduced access to land, resources and heritage sites (Cotula et al., 2008, 2009; Friis and Reenberg, 2010). Some studies have also challenged the notion that biofuels significantly lower GHG emissions, due to the extensive chemical and electricity use during cultivation and production phases (Börjesson, 2009; Crutzen et al., 2008; Stephenson et al., 2010), as well as the direct and indirect changes in land-use driven by agricultural expansion (Fargione et al., 2008; Searchinger et al., 2008). Other studies have highlighted additional negative environmental impacts that may outweigh the possible benefits of biofuels, such as soil acidification and eutrophication through fertilizer use (Börjesson and Tufvesson, 2011; von Blottnitz and Curran, 2007), as well as biodiversity threats and habitat destruction from agricultural

Abbreviations: ARDA, Agrarian Research and Development Agency; BEE, black economic empowerment; dLUC, direct land-use change; EIA, environmental impact assessment; GHG, greenhouse gas; GM, genetically modified; iLUC, indirect land-use change; LCA, life-cycle assessment; RSB, Roundtable on Sustainable Biofuels.

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http://dx.doi.org/10.1016/j.esd.2014.06.005
0973-0826/

activity (Fletcher et al., 2011; Wilcove and Koh, 2010). Despite these criticisms, biofuel production has increased globally (Demirbas and Balat, 2006), with bioethanol production rising by roughly 500% since 1990 (Renewable Fuels Association, 2013).

Biofuels are intensively produced and widely used in the United States and Brazil, the two countries which to date have led the production and consumption of renewable transport fuels (Renewable Fuels Association, 2013). The 2000 European Union's Green Paper initially aimed to replace 20% of conventional transport fuels with biofuels by 2020 (European Commission, 2000), although this target has later been challenged due to environmental concerns and the issue of food security (European Commission, 2009, 2012).

The South African biofuel program

Biofuel production on the African continent is minimal; however, in 2007, simultaneously with other sub-Saharan countries, the South African government established plans to produce biofuels, which were published in the policy paper 'South African Biofuels Industrial Strategy' (DME, 2007). The motivation to establish a biofuel industry in South Africa derives from its anticipated benefits, such as the socio-economic upliftment of rural areas, the strengthening and empowerment of historically disadvantaged groups, lowering GHG emissions, and promoting self-reliant energy supplies (DME, 2007). Four biodiesel and four bioethanol plants are currently in the planning stages (DME, 2013). The focus of the present assessment is on one of South Africa's first bioethanol projects, a fuel ethanol plant that is proposed to be built in Cradock in the Eastern Cape (Fig. 1A).

The South African biofuel strategy encourages the participation of emerging farmers in the upcoming biofuel industry, and in particular farmers from racial groups discriminated against by South Africa's former apartheid regime (DME, 2007). The Department of Rural Development and Land Reform manages programs that aim to strengthen the role of black people in the South African economy ('black economic empowerment', BEE). This includes a BEE program in Cradock, which envisages the production of ethanol plant feedstock by these emerging farmers (DRDLR, 2013).

Purpose and aims of this study

The present study aims to determine the magnitude and relevance of popular biofuel concerns for biofuel production at the proposed pioneer fuel ethanol plant in Cradock, South Africa. Based on the controversies outlined above, selected sustainability criteria assessed in this study comprised i) socially desirable development, including BEE and food security, ii) agricultural impacts from changing crop patterns, including water- and fertilizer use, iii) environmental and biodiversity impacts from biofuel feedstock cultivation, and iv) the carbon footprint of Cradock biofuel.

Given that the proposed Cradock fuel ethanol plant and the associated BEE program would serve as examples for future biofuel projects in the country, the results of this study have implications for the possibility of implementing an ecologically and socio-economically sound biofuel strategy at a national level. The present assessment also offers new insights into the desirability of fuel ethanol production on the African continent, where development pressure and food security are high priority issues (Ewing and Msangi, 2009). This study thus aims to contribute to a better understanding of the social and environmental risks and opportunities of fuel ethanol production in Cradock, South Africa, and to provide for a critical assessment of the applicability of global biofuel concerns to a specific African bioethanol project.

Study site and project description

The town of Cradock has a population of roughly 35,000 people, and its economy is based largely on agriculture. The town structure resembles typical apartheid planning that corresponded with racial segregation, forming a core built-up area and the adjacent but spatially separated settlements Michausdal and Lingelihle. The poverty rate of the area is high: more than 40% of the adult population in the project area is unemployed (Vivier et al., 2009).

Situated in the Great Fish River Valley of the Eastern Cape, South Africa (Fig. 1A), the Cradock area is part of the Karoo formation and is semi-arid with an annual rainfall of roughly 350 mm. Most of the valley's irrigation water (more than 80%) is supplied from the Gariep dam that accumulates water from the Orange River. A tunnel that connects the Gariep dam with the Great Fish River scheme has been operational since the early 1970s (Fig. 1B). As a result, many of the Cradock farms have shifted production from livestock-only to irrigated farms. Frequently grown crops include lucerne (*Medicago sativa*), maize (*Zea mays*), wheat (*Triticum* spp.) and more recently pecan nuts (*Carya illinoinensis*). Due to the regional climate, crops are grown exclusively under irrigation and are thus restricted to the proximity of the river systems (Fig. 1C). Currently, the main agricultural production of Cradock is

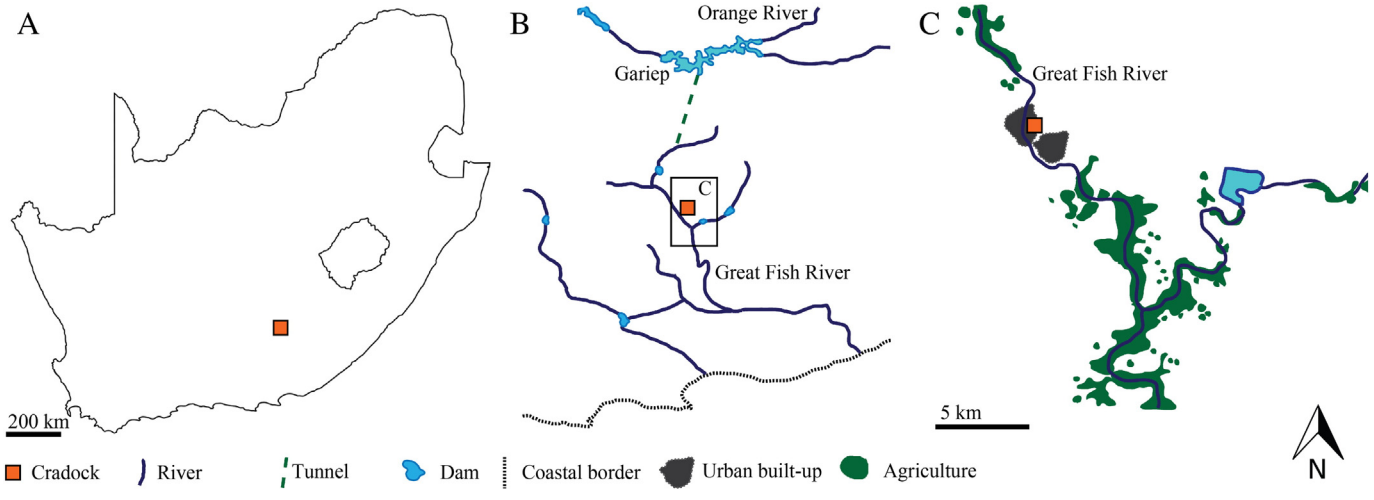

Fig. 1. Geography of Cradock in South Africa (A); water schemes of the Great Fish River valley (B), showing additional supplies from the Gariep dam (dashed line depicts an artificial tunnel); and agricultural development along the Great Fish River (C). Note how agriculture is restricted to the proximity of the valley's water bodies.