Potential impacts of biofuel development on food security in Botswana: A contribution to energy policy

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a b s t r a c t

Biofuel development continues to be a critical development strategy in Africa because it promises to be an important part of the emerging bio-economy. However, there is a growing concern that the pattern of biofuel development is not always consistent with the principles of sustainable development. This paper assesses the potential of the impacts of biofuel development on food security in Botswana. Drawing on informal and semi-structured interviews, the paper concludes that there is potential for the development of biofuels in Botswana without adverse effects on food security due mainly to availability of idle land which accounted for 72% of agricultural land in the eastern part of the country in 2008. It is suggested that farmers could be incentivized to produce energy crops and more food from such land. Although it is hypothesized that the implementation of biofuel development programmes in other countries had an impact on local commodity prices during the period 2005–2008 in Botswana, it is argued that local biofuel production may not necessarily lead to a substantial increase in commodity food prices because land availability is not a major issue. The paper makes policy recommendations for sustainable biofuel development in Botswana.

1. Introduction

Production of first generation biofuels is expanding throughout the world, particularly in the United States, Brazil, Germany and other European Union (EU) member states (Balat and Balat, 2009). Second and third generation biofuels are still at the stage of research and development (UNIDO, 2007). The major drivers for biofuel development are concerns about energy security, climate change and environment and rural development. Biofuel development is perceived to be part of the rapidly emerging bioeconomy (Royal Society, 2008), an economy based on stable, resilient, and sustainable way of exploiting energy and other natural resources. The global production of bioethanol for transport fuel has doubled to over 52 billion litres during the period 2000–2007; while that of biodiesel increased eleven times to 11 billion litres (United Nations Environment Programme (UNEP), 2009). The leading producers of bioethanol are USA and Brazil which use maize and sugarcane as feedstocks for biofuel production, respectively. Brazil has a comparative advantage for bioethanol production because of the availability of land and suitable climatic conditions for the production of the sugarcane feedstock. Biodiesel production is dominated by the EU, with Germany accounting for 54% of the total production (Birur et al., 2007). Biofuel development is likely to continue to be an important development strategy in the foreseeable future as it promises to be an important part of the newly emerging bio-economy (Royal Society, 2008).

Notwithstanding these benefits, there is a growing concern that the pattern of biofuel development is not always consistent with the principles of sustainable development (FAO, 2008; Yang et al., 2009). The sustainability of biofuel development depends on the type of biofuel feedstocks used and the subsequent impacts on land-use change. It may, for instance, adversely affect food availability if food crops or productive resources (land, labor, water, etc) are switched from the production of food to that of biofuels. This may aggravate the problem of food security. For instance, it is estimated that there were 854 million undernourished people in the world between 2001 and 2003, and 96% (820 million) of these people were in developing countries (Escobar et al., 2009).

In many African countries, biofuel development is still at an early stage of development despite the fact that the continent has a great potential for its production. According to Smeets and Faaij (2008) (cited by Janssen et al., 2009), Africa has the potential to produce 41–410 EJ of biomass energy by the year 2050.

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Despite this, most African countries are still at the stage of drawing up their energy policies. A few countries have already undertaken biofuel development without being guided by clear regulatory and institutional frameworks (Amigun et al., 2011; Janssen et al., 2009; Balat and Balat, 2009). African countries which produce bioethanol include Malawi, Mauritius, Zimbabwe and Kenya, whereas those which produce biodiesel include South Africa, Zimbabwe, Ghana and Mozambique (Jumbe et al., 2009; Amigun et al., 2011). Most African countries, including Botswana, do not have detailed regulatory and institutional frameworks for the implementation of biofuels. South Africa and Mozambique are among those with the most advanced regulatory and institutional frameworks for biofuel development (Janssen and Rutz, 2012).

The Government of Botswana intends to start biofuel production in the year 2012, despite the fact that the potential may be low due to the semi-arid climate (Von Maltitz and Brent, 2008). Average annual rainfall in Botswana is 450 mm and it has a high variability (Ministry of Finance and Development Planning (MFDP), 2009). However, the Botswana National Development Plan 10 (NDP 10) states that there is potential for biofuel production in Botswana using sweet sorghum and Jatropha as feedstocks (Ministry of Finance and Development Planning (MFDP), 2009). This paper examines the impacts of biofuel development on food security in Botswana. The focus is on Botswana because it is one of the countries intending to produce biofuels despite the many challenges and also because there are few studies which have been undertaken on this subject in semi-arid environments (Wicke et al., 2011). The following research questions are therefore critical in understanding this general research objective: (1) What is the status of the development of biofuel policies and strategies in Botswana? (2) What is the likely impact of the selected biofuel feedstocks on food availability? (3) How is the use of idle and marginal land likely to determine food availability? (4) Is there any link between global biofuel development and local food prices? It is intended that by assessing the potential impacts associated with biofuel development on food security in Botswana, an awareness of decision-makers on the opportunities and risks associated with the implementation of these fuels will be raised.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature on biofuel development with particular reference to issues on sustainability and food security. Section 3 extends the literature to biofuel policy in the broader context of energy policy in Botswana. Section 4 describes the research methods used in the study while Sections 5 and 6 present and discuss the results, respectively. Section 7 concludes the paper and suggests policy recommendations.

2. Literature review

2.1. Biofuel development and sustainability

Although the initial efforts to produce biofuels dates back to the early period of the automobile, the renewed interest in biofuel development started in the 1970s in Brazil and USA in response to the oil crisis of the 1970s as a way of diversifying energy sources (Dufey, 2006). In the EU, biofuel production started in 1986 in order to promote rural development and diversification of energy sources (Dufey, 2006). However, concerns about climate change and energy security are now some of the major drivers for biofuel development (Commission of the European Communities, 2009). In Botswana, energy security in the form of diversification of energy supply sources is currently the main driver for biofuel development (Mguni, 2011), although rural development and concerns about climate change are also important goals (Ministry of Finance and Development Planning (MFDP), 2009; Loci Environmental, 2010). Regarding climate change, it is expected that biofuel development in Botswana will contribute to a reduction in greenhouse gases because it is assumed to be carbon neutral, though this is not necessarily true. Energy security is also important because the current sources of energy are dominated by fossil fuels which are finite and being rapidly depleted. There is also a desire to reduce dependence on imports, more especially because Botswana is a land-locked country (Loci Environmental, 2010).

Biofuel development is also associated with risks that may threaten sustainable development (Naylor et al., 2007). For instance, the impact of biofuel development on greenhouse gas emissions will depend on the type of biofuel feedstocks used and impacts on land-use change (Ravindranath et al., 2011). According to Fargione et al. (2008), conversion of land into agricultural use for biofuel development may result in the so called ''biofuel carbon debt'' due to CO_2 emissions which are higher than the greenhouse gas savings from the substitution of fossil fuels by biofuels. Biofuel development may also affect biodiversity negatively when there is direct conversion of land from forests/grasslands or when indirect impacts occur such that conversion of agricultural land leads to conversion of natural vegetation to agricultural production elsewhere (Smeets, 2008; Kgathi et al., 2012b). More relevant to this paper are the hotly debated issues of competition between food and fuel and links between biofuel development and commodity prices (see Section 2.2).

In order to ensure sustainable production of biofuels, sustainability certification systems are now being introduced in a number of countries. These systems require the buyers of biofuels to comply with certain standards or sustainability criteria (Smeets, 2008). Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009, recommends the development of sustainability criteria for biofuels in the European Union (Commission of the European Communities, 2009). Under these criteria, sustainable production and use of biofuels should not result in the destruction of bio-diverse land and also reduction of land of high carbon stock. Conversion of such land for biofuel production may result in biodiversity loss and negative greenhouse gas impact. The Directive also recommends that all the impacts of biofuel production, including the effects on food production, should be monitored. It also promotes the use of degraded lands for agricultural development as well as research and development on second and third generation biofuels (Commission of the European Communities, 2009).

2.2. Biofuel development and food security

FAO (2009) defines food security as a situation whereby ''all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life''. The concept of food security has evolved over a long period of time, and can be categorized into three phases. The first phase focuses mainly on the supply side, emphasizing the importance of food availability to food security. The second phase focuses on the demand side conceptualising issues on individual and household access to food, and the discussion was influenced by the seminal work of Amartya Sen on entitlement and deprivation (Barrett, 2002). The third phase looks at food security from a broader perspective, bringing on board issues such as ''uncertainty, vulnerability and non-food complementary inputs like health services, sanitation, education and public infrastructure'' (Barrett, 2002, p. 73).

Fig. 1. Four dimensions of food security.
Source: FAO (2008).

Subsequently, there are four main dimensions of food security: (1) availability, (2) access, (3) stability, and utilization of food (Fig. 1). Biofuel development is known to have linkages with these dimensions. It may, for instance, adversely affect food availability because land, labor, water and other resources may be used in its production instead of food. Therefore, the lack of a policy framework to guide the development of biofuels also presents a major challenge for food availability in most African countries. This is mainly because bioenergy policy helps to mainstream food security in the process of biofuel development (Sosovele, 2010). The increased interest in biofuel development in Tanzania has led to the setting aside of over 700,000 ha of land for biofuel production of which only 100,000 ha (14%) is estimated to be under biofuel production (Sosovele, 2010). Due to lack of a policy to guide biofuel production, most of the energy projects in Tanzania are situated on land that is suitable for food production and this is likely to make the country vulnerable to food insecurity. Tanzania has experienced shortages in supply of food in the past which resulted in the distribution of food aid (Sosovele, 2010).

A number of studies suggest that production of biofuels may adversely affect food availability if food crops or productive resources (land, labor, water, etc) are switched from the production of food to that of biofuels. The use of marginal and idle land for biofuel production is therefore suggested as a solution for reducing these adverse impacts. This idea was one of the key recommendations of the Gallagher Review, an independent study undertaken for the UK Government by the UK-based Renewable Fuels Agency. The review addressed concerns of policy-makers about indirect effects of biofuel production, particularly after the paper by Searchinger and others which suggested that biofuel production in the USA resulted in land-use change as it displaced existing agricultural production (Renewable Fuels Agency (RFA), 2008). According to this review, idle land is ''former or current agricultural land that will not otherwise be used for food production'' and ''land that is potentially suitable for agricultural production''. Marginal or degraded land refers to ''land unsuited for food production, e.g. with poor soils or harsh weather environments; and areas that have been degraded, e.g. through deforestation'' (Renewable Fuels Agency (RFA), 2008). The review recommended that policies should ensure that biofuel production is undertaken in suitable idle or marginal land. In Botswana, idle land is defined as the difference between total area under arable fields on suitable land and the total area that is used for arable production, suggesting that this is the land which is being used or has been used for arable agriculture. Definitions of idle and marginal lands in Botswana are consistent with those of the Gallagher review (Renewable Fuels Agency (RFA), 2008) which makes it easier to discuss issues of potential land availability for biofuel development in Botswana in the wider context.

Biofuel production may also hinder access to food because it is one of the drivers of food commodity prices (Mitchell, 2008; FAO, 2008; Renewable Fuels Agency (RFA), 2008). There is a general concern that biofuel development is responsible for soaring commodity prices which have aggravated food insecurity in developing countries (Mitchell, 2008; FAO, 2008). While the proponents of biofuel development contend that it has a small impact on commodity prices because there are other forces at play, the opponents attribute large increases of commodity prices mainly to biofuel development (Westhoff, 2010). The contribution of biofuels to the recent global increase in food prices (2002–2008) is estimated to range from 3% to 30% and even higher (FAO, 2008). Other contributory factors to the increase in commodity prices include some of the following: (1) high costs of food production resulting from high prices of petroleum products, (2) decline in food production in major exporting countries such as Australia due to weather-related shocks, and (3) strong demand of meat and dairy products due to high population and improved living standards in emerging economies of Asia and Latin America (FAO, 2008; Lustig, 2009). Recent studies attribute the rise in the price of food commodities such as maize and soybeans to their use for biofuel production. Assuming that other inputs used in the production of biofuels, such as labor and fertilizer, do not contribute to the increase in the price of commodity food prices that much, local biofuel production in Botswana may not result in a substantial increase in food commodity prices because of abundance of idle agricultural land. According to Von Maltitz and Brent (2008), there are strong theoretical arguments in southern Africa which suggest that biofuels can be produced without any significant adverse impacts on food security because of availability of idle land.

Biofuels are likely to increase the pressure on food stability or increase the risk of chronic food insecurity (FAO, 2008). Hence, the threats to food supply and security will occur when high quality land suitable for agricultural food crops is allocated for the production of biofuels (Amigun et al., 2011; Jumbe et al., 2009; FAO, 2008; Kunen and Chalmers, 2010). However, where the availability of land may not be an issue, the threat to food security would be minimal or nonexistent. An increase in the prices of food resulting from biofuel production is expected to negatively affect food security in countries that are already net food importers. The increase in commodity food prices tends to cause what is called the ''food-price dilemma'' because it affects net-food buyers negatively and net food sellers positively (Lustig, 2009). Most southern African countries are net food importers and would be vulnerable to the impacts of price increases of agricultural food crops (Amigun et al., 2011). Since most people in urban and rural areas in Botswana are net food buyers, the rise in food prices will adversely affect net-buyers of food, particularly the poor as their expenditure on food accounts for a large proportion (55–75%) of their income (Naylor et al., 2007).

The food security dimension of ''utilization of food'' may be positively or negatively affected by biofuel development. The concept of utilization of food refers to ''people's ability to absorb nutrients'', and it incorporates the wider issues of access to clean water, energy services, sanitation, and medical services (Faaij, 2008, p. 10). For instance, small-scale production of Jatropha oil (Kgathi et al., 2012a), may lead to the production of modern

energy in the form of bio-electricity (as is the case in Mali and Tanzania) which may lead to an improvement in the way food is prepared, hence improving the health and nutrition of rural households (FAO, 2008; Sanga and Meena, 2008). However, it is not yet known which value chains of Jatropha will be taken advantage of in Botswana. Also, if biofuels lead to scarcity or pollution of water resources, there is likely to be an adverse impact on utilization of food. According to Ravindranath et al. (2011), the cultivation of biofuel crops may involve the use of nitrogen, pesticides, and even herbicides which are likely to adversely affect water resources, particularly when irrigation is used for biofuel production. Since it is not clearly known whether or not Jatropha biodiesel production in Botswana will involve irrigation, it is difficult to comment on the extent to which the cultivation of biofuels will affect water bodies in Botswana.

An assessment of the impact of biofuel development on food security in Botswana is necessary, particularly because this country has a high dependency on imports of cereals and petroleum products. The high dependency is due to constraints such as low erratic rainfall, lack of inputs and lack of skilled manpower (Ministry of Finance and Development Planning (MFDP), 2009). Botswana is one of the 22 countries in sub-Saharan Africa classified by the FAO (2008) as being very vulnerable to food insecurity, despite the fact that its per capita gross national income is among the highest in Africa, estimated at USA$ 5840 in 2007 (World Bank, 2008). In 2006/7, the national demand for cereals in Botswana was 191,000 metric tonnes as compared to a national production of only 27,000 metric tonnes or 14% of the total national cereal requirements. The proportional contribution of the agricultural sector to GDP has also declined overtime from 40% in 1966 to 1.7% in 2006/2007, partly due to the relative increase in output of the mining sector and decrease in the output of the agricultural sector. However, agriculture still remains a key sector of the economy since 70% of the rural households still derive much of their livelihoods from it. The improvement of food security is therefore one of the key policy objectives of the agricultural sector (Ministry of Finance and Development Planning (MFDP), 2009). Therefore, it is not only necessary to aim at promoting both food and fuel production in Botswana, but also important to ensure that future biofuel production does not compromise food production.

3. Biofuel policy in Botswana

Before formulating a biofuels policy the Government of Botswana, through the Ministry of Minerals, Energy and Water Resources, decided to carry out a detailed feasibility study in 2007 to assess the potential for the production and use of liquid biofuels for transport in Botswana. The information was considered vital for the development of a biofuel policy. This study recommended Jatropha for biodiesel and sweet sorghum for ethanol production (EECG, 2007) due to their lower production costs, and the latter was considered to have more potential. It was also suggested that the feedstocks for bioethanol should be grown in Chobe District (Fig. 2) by large-scale farmers (100 ha), supported by small-scale outgrower schemes, where there will be a plant of 20 million litres per annum for processing the feedstock (EECG, 2007). The study also suggested that the feedstocks for biodiesel should be grown in the Central District (Fig. 2), using contract farming, where farmers would be contracted by private companies to grow crops on their land. Due to a large potential for biodiesel production in the country, a large plant of 50 million litres/year was recommended. The plant will have the potential to produce biodiesel for blending with fossil diesel at ratios of 5% (B5) and 10% (B10) (EECG, 2007). The feasibility study also stated that in order for biofuels to be competitive, there was need for removal of levies (75% for biodiesel and 50% for bioethanol) (EECG, 2007).

Currently, even though the drafting of a biofuel policy is in progress, there are policy statements on biofuels in the draft national energy policy and National Development Plan 10 (Ministry of Finance and Development Planning (MFDP), 2009; Ministry of Minerals Energy and Water Resources (MMEWR), 2010). The Government is currently focussing on the production of biodiesel. The draft national energy policy states that by 2020, local production of biodiesel will account for 10% of the supply of diesel in the country (Ministry of Minerals Energy and Water Resources (MMEWR), 2010). Even though this blending ratio is considered feasible in Botswana (EECG, 2007), a lower target of 5% could be more sustainable considering the risks associated with biofuel development in semi-arid environments (Von Maltiz et al., 2009). To kick-start biodiesel production, the Government wants to construct a smaller 5 million litre/day biodiesel plant in 2011 as opposed to the recommended 50 million litres/day plant (Mguni, 2011). It is expected that biodiesel production will commence in 2012 using meat tallow until 2016 when Jatropha will be used. A study on the feasibility of producing biodiesel revealed that there is a potential to produce only 10,000 l/day using 11.5 t of tallow produced per day by the Botswana Meat Commission (BMC) in Lobatse, a figure which is lower than 20,000 l/day expected when the production at the commission is at full capacity. Production is currently not economically viable, but the Government is determined to go ahead with the project due to the strategic importance of biodiesel production (Future Fuels Africa, 2010; Mguni, 2011). Although production of biodiesel from Jatropha is expected to commence in 2016 (Ministry of Finance and Development Planning (MFDP), 2009), it is most unlikely that this deadline will be met as Jatropha plantations have not yet been cultivated.

In order to finalize the process of the development of biofuels policy and also plan for its implementation, the Government of Botswana, in cooperation with the Japanesse Government, is currently initiating research on the cultivation and production of biodiesel from the recommended feedstock of Jatropha. Not much is known about the cultivation and use of this crop for biodiesel production in Botswana. The research, which will start in 2012 and finish in 2016, will cover issues on farming methods, post-harvest processing, bye-product utilization, and environmental and social impacts (Ministry of Minerals Energy and Water Resources (MMEWR), 2011). It is also expected that the research will also address issues on land availability, large scale production versus outgrower schemes, and domestic production versus export production.

The Department of Energy has finalized National Biofuel Guidelines which are intended to assist potential investors by providing information about processes to be followed and national rules on sustainable biofuel management in Botswana. The guidelines provide information on biofuels investment opportunities, sustainability framework for biofuel production, and guidelines for sustainable development of liquid biofuels in Botswana (Loci International, 2010). The guidelines stipulate that investors should first understand the sustainability framework for biofuel development in Botswana before engaging in detailed feasibility studies. This framework includes sub-guidelines on sustainability criteria and environmental impact assessment. The sub-guidelines for the criteria state that biofuel development should: (1) follow the laws of Botswana, (2) respect formal and customary land rights, (3) not change land-use for crop production to biofuel production without approval by the Government of Botswana (4), optimize the use of water resources, (5) contribute

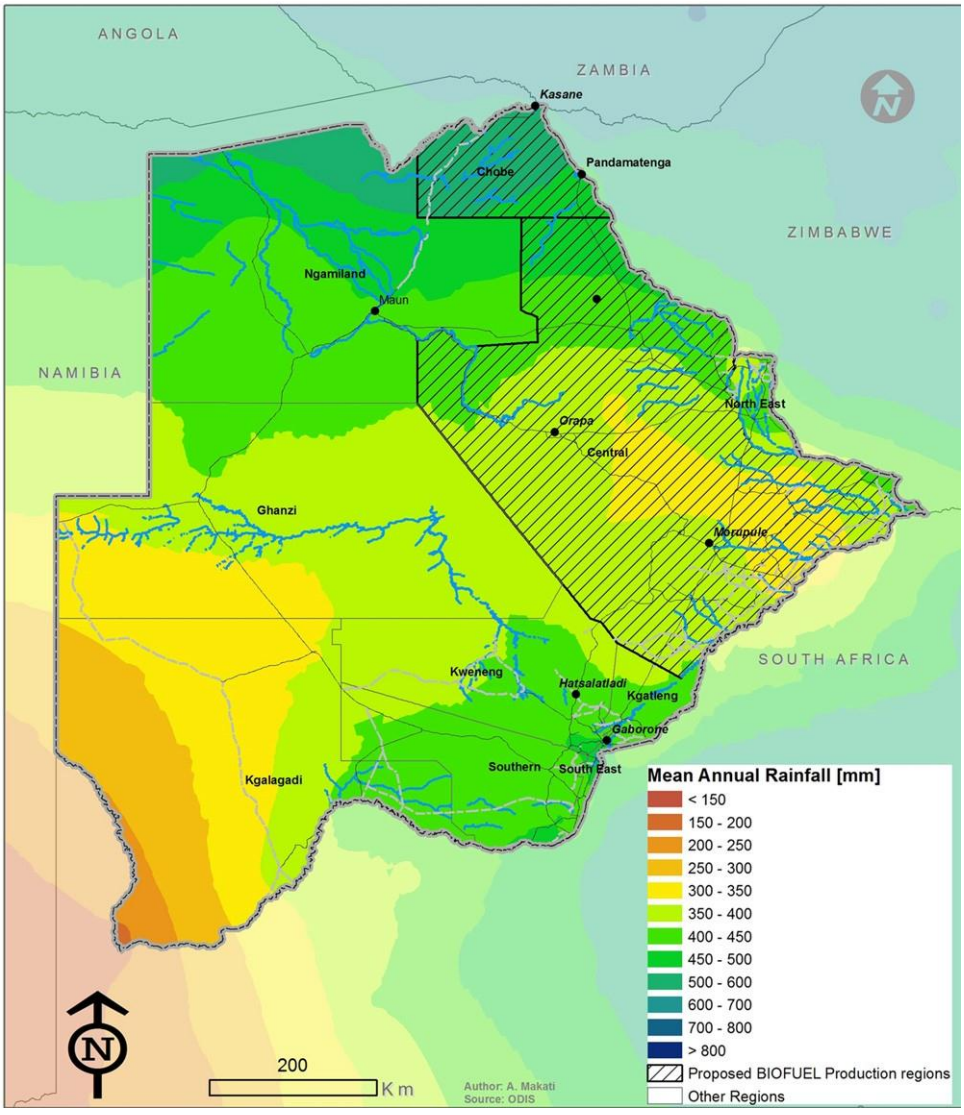

Fig. 2. Rainfall Map for Botswana.

to savings in greenhouse gases, and (6) contribute to rural development. The sub-guidelines for environmental impact assessment state that potential investors should carry environmental impact assessment before implementing their biofuel projects. The guidelines for sustainable biofuel development cover the following aspects: (1) institutional framework for biofuel investment in Botswana, (2) application and registration procedures, (3) procedures for land acquisition and use, (4) resettlement and contract farming, (5) farming practice and seed management, (6) efficient use of biofuel products, (7) carbon markets and trading, (8) community engagements, and (9) blending ratios (Loci International, 2010). A proper implementation of these guidelines would assist the Government in ensuring that the land for food production is not switched to biofuel production.

4. Study area and research methods

This section discusses the research methods with particular reference to secondary data collection, informal interviews, stakeholder questionnaire survey, and secondary data collection and analysis.

4.1. Secondary data collection

Secondary data sources included feasibility studies, environmental impact assessment studies, development plans, statistical reports, and recent academic journal articles. Secondary data were obtained from library and internet searches as well as from conferences and networks in which the authors were participants. Through membership in the EU co-funded project ‘‘Competence Platform on Energy crop and agro-forestry Systems for Arid and Semi-arid Ecosystems in Africa (COMPETE),’’ it was possible to obtain substantial information, including that on trends in bioenergy development in the global environment. This included information on biofuel development in the EU, Africa and other countries of the South with advanced bioenergy technologies, notably Brazil, Mexico, India and China. The COMPETE project promoted cooperation between partners in these countries and those in Africa in order to promote information exchange and technology transfer on bioenergy technologies (Janssen et al., 2009).

4.2. Informal interviews

These interviews took the form of open-ended and flexible discussions guided by a set of questions (Patton, 1990). They were undertaken during the period February to July, 2009. This was the first phase of the research aiming at understanding the issues before undertaking the stakeholder questionnaire survey. The aim was to identify sources of data for this study and to understand the general issues on biofuel development and policy in Botswana. Ten officers were interviewed from the following relevant departments and agencies: Department of Crop Production, Department of Energy, Central Statistics Office (CSO), and the Botswana Agricultural Marketing Board (BAMB). The departments were selected because of their relevance to issues on feedstock agriculture, food security issues and energy policy. The officers selected were those dealing with the issues under investigation. At the Department of Energy, the focus was on energy policy, energy balances, and status of development of biofuels in Botswana, including proposals for biodiesel development. At the Ministry of Agriculture, the interviews focussed on food security issues, availability of land for biofuel production, and the magnitude of idle and marginal land. At CSO and BAMB, the focus was on trends in food commodity consumer price indices and cereal prices, respectively. Appointments were made with relevant officers in order to ask questions about the issues under enquiry.

4.3. Stakeholder questionnaire survey

The stakeholder survey was carried out in Kasane (Chobe District) and in the capital City of Gaborone (Fig. 2) about the perceptions of stakeholders on biofuel development in Chobe District during the period March to April, 2010. The survey was a follow-up of the informal interviews undertaken in 2009, and was based on a semi-structured questionnaire which had questions on the perceptions of stakeholders about biofuel development in Chobe District. The District is situated in northern Botswana and has a land area of 22,052 km^2. Its population was 18,258 in 2001.

Interviews were conducted with key stakeholders from relevant departments, including those who were informally interviewed in the earlier stage. Kasane was selected because it is the capital of Chobe District, one of the regions suggested by the feasibility study on biofuel production and use in Botswana (EECG, 2007), whereas Gaborone was selected because key policy-makers are based there. Relevant officers were selected in order to fill in the questionnaire. The stakeholders were from all relevant institutions and government departments in Botswana. They were selected because of their importance to feedstock agriculture and energy policy. The respondents were officers dealing with issues under investigation. A total of 16 respondents completed the questionnaire which had both closed and open-ended questions. These respondents represented officers from all the relevant departments in these areas, hence the sample was representative of all key stakeholders in Botswana. The questionnaire included questions on the preferred biofuel crops for biofuel production, availability of idle and marginal land for biofuel production, and the potential impacts of biofuel production on food security in Botswana.

4.4. Secondary data collection and analysis

In order to determine trends in local commodity prices and also compare them with trends in international commodity prices, secondary data were collected on consumer price indices (base year¼2006) for selected food commodities (cereals and oils and fats) and non-food commodities (e.g. clothing and footwear). As already stated, the aim was to generate a hypothesis that the implementation of biofuel projects in other countries has an influence on local commodity prices. From data collected, trends in local food commodity prices and rates of inflation for these commodities were estimated. The analysed information was utilized to make comparisons between the inflation rates for food and non-food commodities. The inflation rates for cereals and oils and fats were then compared with the global ones.

5. Results

5.1. Feedstock selection and biofuel development.

The type of feedstock used for the biofuel production is a major factor determining the extent to which biofuels affect food availability (IRGC, 2008). As already stated, Jatropha and sweet sorghum are the recommended feedstocks for biofuel production in Botswana due to their lower production costs. The perceptions of stakeholders about the suitability of these feedstocks for biofuel production are discussed below.

The results of the stakeholder survey revealed that most of the stakeholders preferred sweet sorghum to Jatropha and sugarcane as feedstocks for biofuel production in Botswana. For example, 11 stakeholders out of 16 (69%) thought sweet sorghum was the most preferred feedstock for biofuel production in Chobe District. They said that since the crop was already being grown in the district on a small-scale, it could do well for biofuel production even when grown on large scale. However, they expressed reservations about the suitability of sugarcane and Jatropha for biofuel production. For instance, only 38% of the stakeholders thought Jatropha and sugarcane could be suitable feedstocks for biofuel production in the Chobe District. They suggested that research should be undertaken to determine whether these crops could be grown in Chobe District and other parts of Botswana. Regarding sugarcane, concern was raised that it is a water intensive crop which could not do well under rainfed conditions in Chobe District and other parts of Botswana, where the average rainfall is 600 mm and 450 mm, respectively, as Fig. 2 indicates.

5.2. Use of idle and marginal lands

Informal interviews with officers from the Ministry of Agriculture revealed that idle land is available in most parts of eastern Botswana for growing energy crops such as Jatropha and sweet sorghum. The officers revealed that the proportion of idle land in eastern Botswana was 72% in 2008, which suggests that only 28% was utilized for arable agriculture. This information was also consistent with the results of stakeholder interviews which suggested that there was idle agricultural land in Chobe District. For instance, 11 stakeholders out of 16 or 69% were of the opinion that idle land was available in the District. The majority of the stakeholders did not want the land currently in use for food production to be converted to biofuel production as this might adversely affect food security in Botswana.

Informal interviews also revealed that there is marginal land in other parts of the country. Out of a total of 682,000 ha of arable land in eastern Botswana in 2009, 200,000 (29%) was estimated by the Ministry of Agriculture to be marginal land and the rest (71%) was agriculturally suitable land (Fig. 3). The stakeholder survey also revealed the availability of marginal land in Chobe District. For example, 10 stakeholders out of 16 (63%) suggested that such land could be used for biofuel production. They argued that fertile land should not be used for agricultural production as this could contribute to food insecurity. According to stakeholders from the Ministry of Agriculture, the marginal land in question was the 5000 ha of land in Pandamatenga area in Chobe District

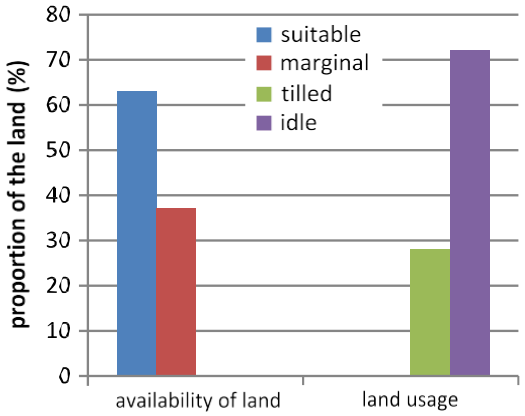

Fig. 3. Proportions of idle and marginal land in eastern Botswana. Source: Mafoko (2009).

which was considered not suitable for arable agriculture. According to Kgathi et al. (2012b), the soil in this area is vertisolic clay which is considered unsuitable for arable agriculture.

5.3. Incentives for food and biofuel production

Informal interviews revealed that despite the fact that the Government wants to embark on the production of biofuels, it is also necessary to ensure that food production is attained because it is the main mandate of the Ministry of Agriculture. In the current national development plan (Ministry of Finance and Development Planning (MFDP), 2009), an aggressive policy is being pursued to increase the use of idle agricultural land for food production through a combination of incentives such as provision of credit to farmers and development of infrastructure for the enhancement of agricultural production. The informal interviews also revealed that the Ministry of Agriculture was collecting additional information on idle land with the aim of repossessing arable fields which were not being used by the owners or encouraging them to lease the fields to commercial farmers. Leasing land to commercial farmers may contribute to more agricultural productivity if it is properly and efficiently managed, while the repossession of land may have the same effect if is used by the new owner. Some stakeholders also argued that incentives may be needed to promote the use of marginal land for biofuel production in Botswana because the land is usually less preferred for food production. These incentives could, for instance, include provision of credit, subsidies on inputs and assistance on irrigation development.

5.4. Global biofuel development versus local food prices hypothesis

As stated earlier, a number of studies suggest that biofuel development was one of the factors which contributed to the rise in the global commodity food prices since 2002. The rise in these commodity prices was sharper between 2005 and 2008. This was caused by diversion of land and other resources to biofuel production, particularly in the USA and EU. Even though Botswana does not as yet produce biofuels, biofuel development in Botswana may also result in high commodity prices if there is diversion of land and other resources to its production. The above results lead us to hypothesize that commodity food prices in Botswana are already being affected by the implementation of biofuel policies in other countries. To generate this hypothesis, an analysis of the trends in consumer prices of commodities in Botswana was undertaken.

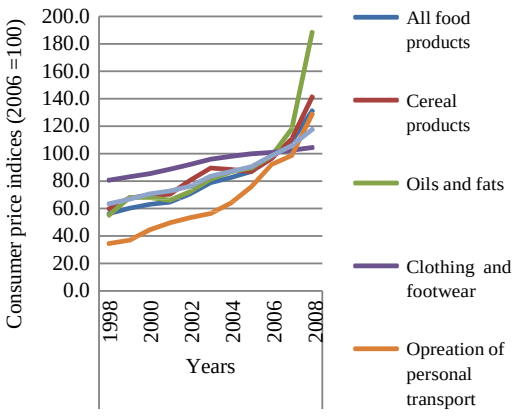

Fig. 4. Botswana consumer price indices (1998–2008).

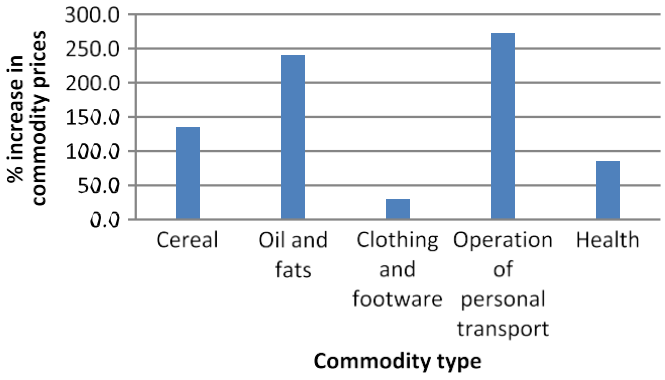

Fig. 5. Increase in commodity prices, 1998–2008.

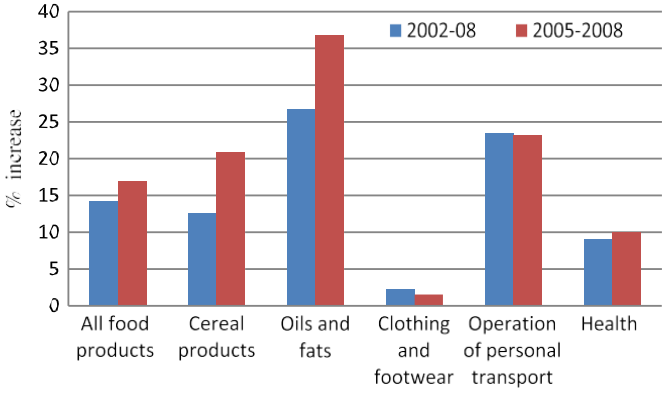

Fig. 6. Increase in prices of food and non-food commodities, 2002–2008 and 2005–2008.

Fig. 4 shows that the consumer price indices for all food products and selected food products of cereals and oil and fats in Botswana normalized to the year 2006 (base year¼2006). The results reveal that the indices of food commodities have been rising during the period 1998–2008. Cereals increased by 135%, while oils and fats increased by 240%, suggesting that the annual rate of inflation was 14% for cereals and 24% for oils and fats during the period 1998–2008 (Fig. 5). The rate of increase of the prices for these food commodities was of the same order of magnitude during the period 2002–2008; 13% for cereal products and 27% for oils and fats (Fig. 6). However, the increase in food commodity prices was greater during the period 2005 and 2008; as was the case globally (FAO, 2008). During this period, oils and fats registered an annual inflation of 37%, while cereals increased by 21% (Fig. 6). The index of operation of personal transport

(which includes petrol and diesel) also increased by a proportion of 23% during the periods 2002–2008 and 2005–2008 (Fig. 6). This should be expected because the fossil fuels account for a large proportion of this index. However, the trend in the indices for food prices significantly differs from that of the indices of clothing and footwear, a non-food commodity. The nominal price index for this commodity increased by only 2% and 1.5% during periods 2002–2008 and 2005–2008, respectively (Fig. 6). In addition, health, another non-food item, also increased by only 9% and 10% during these two periods, respectively (Fig. 6).

These results are consistent with the trends in international commodity food prices which also soared since 2002. A number of studies reveal that production of biofuels was among the factors that contributed to the rise in global commodity food prices, which were sharper between 2005 and 2008. It is therefore hypothesized that there is a link between local commodity food prices in Botswana and global biofuel development because of the ripple effects. This idea is also suggested by other scholars (Naylor et al., 2007; Westhoff, 2010).

6. Discussion

As already stated, the type of feedstock used for production of biofuels is a major factor determining the impacts on food availability (IRGC, 2008). Although Jatropha is not a food crop, its production for biofuels may indirectly compete with food production due to the use of other resources such as fertilizers, water and land (if biofuel crops are not grown on idle land). Using idle land for growing biofuel crops is good for food security. Displacement of food crops from fertile agricultural land is avoided, hence reducing associated negative impacts of land use change (FAO, 2008). Other commentators argue that the food–fuel conflict could be minimized by intercropping food and energy crops which is currently the case in Mali and Zambia (Green, 2009; Janssen et al., 2009). However, a study undertaken in the Central District, Botswana, on the effects of Jatropha on local farmers revealed that some of the most experienced commercial farmers were against the practice of intercropping their crops with Jatropha. In their view, Jatropha would compete with other crops for nutrients, therefore resulting in low crop yields. Therefore, it was suggested that there should be separate fields for planting Jatropha in order to avoid adverse effects on other crops which play a vital role in meeting livelihoods of rural households.

Despite the fact that Jatropha is reported to do well in marginal land, the yields tend to be lower on such land, hence more land may be needed to grow it. According to Green (2009), studies undertaken in India suggest that Jatropha yields from marginal lands may be as low as 1.1–2.75 t/ha after a period of five years. However, Jatropha yields on marginal land under irrigation were estimated to range from 5.25 to 12.5 t/ha after five years (Green, 2009). However, because of Botswana's semi-arid conditions, the growing of Jatropha is likely to require irrigation and fertilizer inputs in order to improve its economic viability. Other scholars argue against the growing of biofuel crops on marginal land due to its low productivity. For instance, Janssen et al. (2009) argue that growing Jatropha on marginal land will, to use their words, ''negatively influence the economic competitiveness of bioenergy production in Africa and block African countries from socio-economic development.'' This issue is however context specific and cannot be generalized. There is, therefore, a need for more research in Botswana to determine the agronomic aspects of the Jatropha. Subsequently, and as already stated, the Government of Botswana, in cooperation with the Japanesse Government, is undertaking research on the agronomic, socio-economic and environmental aspects of Jatropha cultivation and biodiesel production in Botswana (Ministry of Minerals Energy and Water Resources (MMEWR), 2011). Even though Jatropha production may not be a complete success, there might be certain advantages such as income generation, improvement of local energy needs and rehabilitation of degraded areas (Renewable Fuels Agency (RFA), 2008).

Table 1
Agricultural area planted in Botswana.

Year	Area planted (ha)	
2004	106	755.4
2005	719	98.1
2006	137	824.0
2007	68	488.1
Average area planted (ha)	96 (228,733.60)[a]	266.4

[a] The figure in parenthesis denotes the average area of idle land.

This study has also shown that 72% and 29% of the land in eastern Botswana was idle and marginal in 2008, respectively. The feasibility study for the production and use of biofuels in Botswana also revealed that the four year mean (2004–2007) for the total area planted to crops in Botswana was 96,266 ha, whereas the total area which was fallow was 228,733 ha (Table 1). From the above figures, the proportion of idle land can be estimated to be 70% as compared to that of utilized land of 30%. A study undertaken in Gaborone and central regions on ''Declining Interest in Arable Agriculture in Botswana'' also revealed that 48% of the households did not plough their land because of a number of reasons such as HIV/AIDS related ill health, lack of drought power, poor rainfall, and lack of funds (Fidzani et al., 1999 cited in EECG, 2007).

A number of studies have also shown that there is an availability of potential land for additional food and bioenergy production in several African countries. For instance, in Mozambique, only 10% of the land was under cultivation in 2008 while the amount of land available for food and biofuel production was 30 million ha (Renewable Fuels Agency (RFA), 2008). In Tanzania, the available land for food and biofuel production was 55 million ha in 2008 (Renewable Fuels Agency (RFA), 2008). Idle and marginal lands for growing biofuel crops should be used in such a way that they have positive impacts on food security. As already stated, Botswana has a high dependency on food imports and this suggests that that attempts should be made to address this problem. As the population increases in Botswana, there will be an increase in the demand for food and fuel, hence it is crucial to monitor land-use change over-time. There is also a need to make careful assessment of food security and other implications of using marginal land in Botswana. The common land-uses in Africa usually negatively affected by biofuel production on such land include hunting and gathering, livestock grazing and cultural services (Wicke et al., 2011). Although, land availability is currently not a problem in Botswana, there is need to ensure that the production of biofuels will not have an adverse impact on food security in the future.

This study hypothesizes that the implementation of biofuel policies in other countries has affected commodity food prices in Botswana during the period 2002–2008. This is mainly because the pattern of local food commodity prices is similar to that of the global food prices, which also soared faster than other commodity prices, especially since 2005. The increase in biofuel production in the USA and the EU resulting from biofuel policies in these countries explains the role of biofuels in increasing global food commodity prices during this period, though other factors also played an important role in increasing food commodity prices. During the period 2005–2008, the production of ethanol in the

USA more than doubled which suggests that a substantial amount of corn was used for its production. Around the same time, production of bodiesel also rapidly expanded in the EU and other countries (Westhoff, 2010). Subsequently, the research evidence attributing the development of biofuels to the increase in commodity prices leads us to support the view of the Ghallagher review (Renewable Fuels Agency (RFA), 2008) that the targets for global biofuel development should not be too ambitious because they may increase the risks of biofuel development. In Botswana, a biodiesel blending ratio of 5% by 2020 and 10% by 2030 would be realistic targets rather than a blending ratio of 10% by 2020 suggested by the national development plan (Ministry of Finance and Development Planning (MFDP), 2009) as the process of cultivating the main feedstock crop of Jatropha has not yet begun.

In Botswana, an increase in commodity prices during the period 2002–2008 was also accompanied by an increase in fuel prices as revealed by our results, and this resulted in adverse effects on economic growth and macro-economic stability. In a number of developing countries such an increase in commodity prices, not only caused by biofuel development, has caused civil unrest and sometimes violence (FAO, 2008). However, it is not known whether local biofuel development will lead to a substantial increase in food commodity prices in Botswana. If it is undertaken only on idle and marginal lands, the negative impacts on food prices may be lower as compared to when it replaces land currently used for crops. Though the use of land for food production may be avoided, biofuel production will compete with food production for other resources (e.g. labor and fertilizers) which may lead to an increase in food prices. Although higher food prices may give farmers an incentive to produce more food in the medium and long term, the benefits may be limited in Botswana since the country is a net importer of food. In the long run, net food buyers, who are mainly the poorer households, are likely to be adversely affected and this may increase the risk of chronic food insecurity in Botswana.

7. Conclusion and policy implications

This paper has revealed that the Government of Botswana is currently working on a policy for biofuel development. It is intended that by the year 2012, the country will be producing biodiesel using meat tallow as a feedstock until 2016 when Jatropha will be used. This target is not likely to be met as Jatropha plantations have not yet been started. Jatropha was one of the biofuel feedstock crops recommended by the consultancy on the feasibility of biofuel production and use in Botswana (EECG, 2007). In order to reduce adverse impacts on food security, various policy statements suggest that two strategies will be adopted by the Government of Botswana: (1) use of idle and marginal land for biofuel production, (2) use of drought resistant feedstocks of Jatropha and sweet sorghum. About 70% of the land in eastern Botswana is idle, whereas the proportion of marginal land is 29%. Although, land availability is currently not a problem, there is need to ensure that the growth of the production of biofuels will not have an adverse impact on food security in the future. Farmers may easily switch from planting food crops to fuel, depending on the magnitude of relative prices of the crops. The new guidelines for the development of biofuels in Botswana are expected to discourage farmers from switching from their staple crops to energy crops as this may have an adverse effect on food security (Mguni, 2011). However, it is necessary to ensure that the monitoring of land-use is done over-time in order to avoid adverse effects on food production. This idea can be included in the new policy guidelines for the development of biofuels.

It is recommended that biofuels policy should endeavor to direct biofuel production in Botswana to both idle and marginal lands in order to reduce the risk of indirect land-use change. It might also be necessary to undertake an agro-ecological zoning in Botswana in order to identify suitable areas for various land-uses, including crop production and biofuel production. The current package of government incentives aimed at encouraging farmers to use existing idle land is a step in the right direction. It is therefore expected that more land will be used for food and biofuel production in the future. As noted by Escobar et al. (2009), it is crucial to define the amount of land that should be used for biofuel production in view of the scarcity of land for agriculture. The use of Jatropha as feedstock for biofuel production may reduce the food–fuel conflict as this crop can be grown on marginal land. However, if irrigation and fertilizers are not used, the yield may be low making the project unviable. Using sweet sorghum as feedstock is also associated with a number of advantages such as reducing adverse impacts of the food–fuel conflict as there are now new hybrids which can produce fuel (from stalks), animal feed (from stalks), and food (from grains). We suggest that farmers should continue to be incentivized to expand their food production and also diversify their crop by including energy crops.

Although this paper hypothesizes that the implementation of biofuel programmes in other countries affected local commodity prices in the past few years in Botswana, it is argued that the use of idle and marginal lands in Botswana will reduce the impact of local biofuel production on commodity food prices. Biofuel production will only compete with food production in the use of other resources such as labor and fertilizers which may, ceteris paribus, increase commodity food prices. The observed trends in local food prices is similar to that of global food prices which also soared faster than other commodity prices, particularly since 2005. This could result from the high degree of transmission of world food prices into local prices in Botswana, mainly due to trade openness. The increase in the demand for biofuels is therefore an important contributory factor to the increase in food prices, which are an important indicator of access to food.

In summary, measures should be taken to ensure that the production of biofuels in Botswana is sustainable. Failure to do so may result in adverse consequences for viability of achieving the Millennium Development Goals, particularly those of poverty alleviation and environmental sustainability (United Nations, 2005). To achieve the sustainability of biofuel development, it is suggested that the development of criteria for the production and use of biofuels should be promoted by Botswana's energy policy, and food security should be one of the parameters to be included. Other parameters should include greenhouse gas and energy balances, biodiversity, environment, and the wider socio-economic and political issues. Our hypothesis that global development of biofuels led to soaring commodity prices in Botswana during the period 2002–2008 if validated can lead us to agree with the Gallagher report that targets for biofuel development should not be too ambitious (Renewable Fuels Agency (RFA), 2008). Globally, it might be necessary to slow down the development of first generation biofuels and speed up research and development on second and third generation biofuels as they are likely to be more compatible with sustainable development. We therefore recommend that the Department of Energy in Botswana should join the global research and development efforts on second and third generation biofuels.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2011.12.027.

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