Energy for Sustainable Development 30 (2016) 14–20

Contents lists available at ScienceDirect

Energy for Sustainable Development

# Jatropha potential on marginal land in Ethiopia: Reality or myth?

Mengistu Assefa Wendimu *

*University of Copenhagen, Department of Food and Resource Economics, Rolighedsvej 25, DK-1958 Frederiksberg C, Denmark*
*Danish Institute for International Studies (DIIS), Natural Resources and Development, Østbanegade 117, 2100 Copenhagen Ø, Denmark*

A R T I C L E   I N F O

*Article history:*
Received 31 January 2015
Accepted 4 November 2015
Available online 28 November 2015

*Keywords:*
Biofuels
Jatropha
Marginal land
Large-scale
Ethiopia

A B S T R A C T

Increasing fuel prices, concern about climate change and future energy security have led to tremendous global interest in the use of liquid biofuels in the transport sector which, in turn, has driven large-scale land acquisitions in developing countries for biofuel feedstock production. However, regardless of the vast nature of reported land deals and widespread concern about their potential negative consequences, implementation of most of the reported biofuel land deals in Ethiopia has not yet happened. Using a case study of large-scale jatropha plantation in Ethiopia, this paper examines the main causes underpinning the disappointing agronomic performance and finally termination of large-scale jatropha plantations. Although it has been argued that jatropha can be commercially grown well on marginal land without irrigation, this study indicates that moisture stress was the key factor in the failure of many large-scale jatropha plantations in Ethiopia. Furthermore, the use of untested planting material and conflict with local communities over the land were other important factors that contributed to termination of jatropha projects.



## Introduction

Increasing fuel prices, concern about climate change and future energy security have led to tremendous global interest in the use of liquid biofuels in the transport sector (Schut et al., 2010; World Bank, 2010; German et al., 2011). Liquid biofuel has attracted the interest of governments and policy makers because of its immediate usability in the existing transport sector and the ease with which it can be blended with fossil fuels (Borras et al., 2011). The increased interest in the use of biofuels in the transport sector, together with the favourable policy environment for biofuels both in developed and developing countries, has led to intensified land acquisitions for large-scale biofuel feedstock production in Africa. The enthusiasm for the use of liquid biofuels was followed by the global food price crisis of 2007/08, both of which further increased the rate and scale of land acquisitions for food crops and biofuel feedstock production (PRAI, 2010). Borras et al. (2011) argue that the growing demand for biofuels will not be sufficiently met, even if all the currently cultivated land in the United States and the European Union were converted to biofuel production. Thus, as part of the solution to the interlinked food and oil price crisis, and as a response to the food versus fuel discourse due to the competition between biofuels and food crops for land and water, a dominant narrative has emerged which suggests the existence of global agricultural land reserves that are 'marginal or under-utilized' (Borras et al., 2011; Makki and Geisler, 2011). This narrative advocates the transformation of these 'marginal or under-utilized' lands into zones for food and biofuel production, resulting in a 'win–win' solution for food and energy security concerns. However, the assumption about the availability of 'marginal' land that can be used for large-scale biofuel feedstock production, either on a global or national level, and the effects of such large-scale land conversion on social, economic, and environmental systems, raised serious concern among academics, civil society and NGOs even before the emergence of the global food price crisis (UN-Energy, 2007; IFAD, 2008).

Ethiopia has portrayed itself as one of the countries with the highest potential for biofuels in Africa, and the government has proposed about 23.2 million hectares of 'marginal' land be converted for biofuel feedstock production, mainly jatropha. The Ethiopian government's arguments for the use of 'marginal' land are based on two assumptions: (i) there is ample 'marginal' land in the country, and (ii) biofuel feedstock (jatropha) can be commercially grown on so-called marginal land. Despite the fact that more than 80 companies were licenced to invest in biofuels in Ethiopia until 2010 and acquired more than 700,000 ha of land only for jatropha and castor bean production, the implementation of most of these projects has been delayed for years, while several biofuels investment projects which took off have collapsed. As most recent studies about large-scale land acquisition for biofuels and other commodities in Africa mainly focus on the scale, drivers, actors, and the potential impacts of these land deals, there is very limited empirical evidence regarding the factors underpinning this failure or lack of implementation of biofuels and other large-scale projects (Cotula et al., 2014). Thus, the main aim of this paper is to investigate the key factors behind the failure of biofuel projects, particularly large-scale jatropha projects which were operational for some time. In this paper,

* University of Copenhagen, Department of Food and Resource Economics, Rolighedsvej 25, DK-1958 Frederiksberg C, Denmark.
*E-mail address:* assefameng@yahoo.com.

http://dx.doi.org/10.1016/j.esd.2015.11.001
0973-0826/

I hypothesize that the unsupported assumptions about the availability of 'vast tracts of marginal' land and the commercial level economic viability of jatropha on these land are the key underlying causes for the failure of most large-scale jatropha projects in Ethiopia.

The remainder of the paper is structured as follows. Section two presents the method used in the study. Section three discusses the development of the biofuel sub-sector, biofuel policy drivers and means of supporting policy to achieve targets in Ethiopia. To better understand the main causes of the failure of jatropha projects, section four presents conceptual discussions on 'marginal' land and the contested claims about jatropha performance on so called marginal land. Section five presents a case study of large-scale jatropha production in Ethiopia and discusses the major reasons for its failure. Section six discusses the main findings by highlighting the similarities in assumptions that led to the drastic failure of an East African large-scale groundnut scheme in present day Tanzania to the current assumptions used to promote large-scale jatropha production in Africa. Finally, section seven provides some concluding remarks.

## Research method

Most of the field work for this research was conducted in West Hararge Administrative Zone (Miesso District) in Oromia Regional Governmental State of Ethiopia between December 2011 and February 2012. Emami Biotech's large-scale jatropha plantation was the main focus of the research. Pastoral and agro-pastoral production systems are the two common agricultural practices in the district, which has a total area of 176,026 ha with altitude ranging between 900 and 1600 m above sea level (Feto, 2011). The annual rainfall in the district ranges between 400 and 900 mm with a mean value of 790 mm.

While the main field work was conducted in Bordede Kebele of Miesso District, additional field visits were made to Shinile Zone in Somali Region, Bati District in Amhara region and Wolaita Zone in Southern Ethiopia. A qualitative case study approach was mainly employed to collect data for this research. The data collection process involved field observations of jatropha projects and qualitative data collection at different levels aimed at identifying the key issues behind the failure of large-scale jatropha projects in Ethiopia. Semi-structured interviews with key informants were conducted at three levels.

First, national level interviews were conducted in the capital city, Addis Ababa, with biofuel experts and government officials at the newly established Ethiopian Investment Directorate under the Ministry of Agriculture, the Ethiopian Biofuels Development Directorate, the Ethiopian Investment Agency, and Melkassa and Wendo Genet Agricultural Research Centres. Furthermore, additional interviews were conducted in Addis Ababa with former employees of Sun Biofuels, the Director of the Horn of Africa Regional Environmental Centre and Network, an NGO that supports biofuel initiatives in Ethiopia, and biofuel project managers of African Power initiatives, ATIRF Alternative Energy PLC and Fri-Elgreen Power Ethiopia, of which the latter two companies were at the pre-implementation phase of large-scale jatropha plantation in the southern part of Ethiopia. The semi-structured interviews at the national level mainly focused on gathering information on the number of licenced and active biofuel companies, project locations, amount of land acquired by biofuel companies, implementation status, the challenges faced by the investors in implementing their projects, and the reasons for the declining investors' interest in biofuel development in Ethiopia.

Secondly, regional level interviews were conducted at the Oromia Bureau of Mines and Energy, Oromia Investment Commission, and Miesso District Agricultural Office. The interviews at the regional level were used to cross-check the information obtained from the federal institutions (national level interviews) and to collect some additional information not available at the national level. In total, 28 interviews were conducted at the national and regional levels. Finally, at the local level, mainly at Bordede, interviews were conducted with development agents, village leaders, former employees and community members positively or negatively affected by the Emami jatropha project. Overall, three focus group discussions with five to eight participants, six semi-structured interviews with previous employees, and 12 key informant interviews were conducted with village leaders, elders and development agents. The interviewees at the local level were mainly asked to describe the land acquisition process, consultation issues, compensation (if any) in case farmers were displaced, and the positive and negative effects of the investment on the local community. During the interviews, the participants were able to describe their views and opinions about the impact of the project that enabled the researcher to better understand the situation which led to its termination. Since the main company that was considered for this study abandoned its jatropha project a few months before the field work, those who were managing the project were not available for interview. Thus, it was not possible to verify the views and opinions expressed by the local communities, former employees and village leaders from the project managers. Although we were initially prohibited from visiting the failed jatropha project, after some negotiation we were allowed to visit the farm. The field observations on the jatropha farms enriched our understanding of the performance of jatropha on the land with low moisture and poor soil fertility. Finally, secondary data were collected from different sources such as government policy documents related to biofuel investment and online sources to supplement the primary data.

## Biofuel development in Ethiopia

In Ethiopia, large-scale investments in biofuels have a recent history with the first large-scale biofuel feedstock production being established in 2006 by the UK-based biofuel company, Sun Biofuels. Since 2006, Ethiopia has become a major destination for Foreign Direct Investment (FDI) in biofuels in Africa. Within 4 years, the interest to invest in biofuels increased massively so that, in 2010, about 83 companies had been granted a licence to invest in biofuels (Ethiopian Biofuels Development Directorate, 2011). Although most of the biofuel investments have not yet been implemented, the amount of capital that the biofuel companies committed to invest in biofuels represented up to 50% of FDI flow at the national level in 2011 (Bossio et al., 2012). According to the recent land deals data released in April 2012 by the International Land Coalition (ILC), in Ethiopia, more than one million ha of land was reported to be leased for biofuel projects out of which nearly 700,000 ha of land was reported to be leased for jatropha and castor bean projects (Land Matrix, 2012). However, according to the information from the Ethiopian Biofuel Development Directorate, in early 2012, there were only about five biofuel companies considered active which all together leased 102,471 ha.

There were two main driving forces that were assumed to have contributed to the dramatic increase in the number of planned biofuel projects in Ethiopia. The first driving factor was the government's desire to secure its national energy supply by producing biofuels from domestically grown feedstock (MoME, 2007). As Ethiopia is a landlocked and non-oil producing country, its economy is fully reliant on imported oil and is highly vulnerable to higher international oil prices. In addition to the increasing oil prices, the country's oil demand is also increasing rapidly due to rapid economic growth and the expansion of its transport sector. Thus, the high oil prices and the increasing demand for oil in the country encouraged the government to look for alternative domestic energy sources.

The second driving force was the increasing demand for biofuels at the global level. The EU energy directive of 2009 endorsed a mandatory target of a 20% share of energy from renewable sources in the overall energy consumption and a mandatory 10% minimum target to be achieved by all member states of the EU, mainly from biofuels in the transport sector, by 2020 (EU Directive, 2009). The directive claims that since transport fuels can be easily traded, member states with lower domestic resource endowments will be able to meet the target by importing biofuels from elsewhere.

To support the development of the biofuel sector in the country, the Ethiopian government has made two main policy amendments. First, in 2009, the government introduced an ethanol blending policy that sets a blending mandate of 5% ethanol with 95% gasoline. The blending mandate was increased to 10% in early 2011 and there is a plan to increase it further to 25% by 2015 (but this target has not yet been achieved). Secondly, the government has made many amendments to its agricultural development and taxation policies to attract investments in large-scale agricultural projects including biofuels. Desalegn Rahmato, head of the Ethiopia Forum for Social Studies, described this as an, 'open door policy' that provides many incentives to attract investors to invest in biofuels and other agricultural projects (Rahmato, 2011). The increased demand for biofuel investments in the country has resulted in the preparation of the ambitious biofuel policy document entitled, '*The Biofuels Development and Utilization Strategy of Ethiopia*' in 2007 (MoME, 2007). The main assumptions underlying the focus on biofuels as an alternative energy source, according to the strategic document, are the availability of relatively cheap labour that can make biofuels competitive with petroleum oil, the 'availability' of a large amount of suitable 'marginal' land for biofuel production, and the presence of diverse soil and climate conditions suitable for the production of different types of biofuel feedstock. However, the strategy, which was developed mainly based on resource 'availability' assumptions, has triggered criticism from local NGOs, civil society and development partners. While the proponents, mainly the government, have seen biofuels as an opportunity to ensure national energy security, as a means to earn hard currency, and a way of modernizing the agricultural sector and increasing rural income, others have strongly argued that the conversion of large tracts of land for biofuels will have negative consequences for rural communities, national food security and biodiversity in the country (Lakew and Shiferwa, 2008). Thus, to avoid these criticisms, the government stated that only 'marginal' land will be used for the production of biofuels.

The Emami Biotech's jatropha plantation, the main focus of this study, was among few biofuel companies which became operational in Ethiopia. In 2009, Emami Biotech Limited, an Indian firm based in Calcutta, established its first overseas biofuel investment in the West Hararge Administrative Zone (Miesso District) in the Oromia Regional Governmental State of Ethiopia. In August of the same year, the company announced that it had leased 11,000 ha of land in the first phase with a renewable lease agreement of 45 years from the Oromia Investment Commission out of the 40,000 ha promised for the company's future expansion (The Financial Express, 2009). The company had planned to invest US $83 million in the establishment of large-scale jatropha plantations and a biofuel processing plant close to the plantation site over the investment period of 5 to 6 years. On its completion, it was estimated that the processing plant would have a processing capacity of 100,000 tonnes of crude-biofuel per year. By the end of 2010, the company had planted jatropha on 700 ha of land. However, after less than 2 years in operation, Emami Biotech abandoned its jatropha plantation at the end of 2011. We will return to the factors behind the failure of this and other similar jatropha projects in Ethiopia in the result section.

## Conceptual framework

### *'Marginal' land: from whose perspective?*

The term marginal land was first defined by Peterson and Galbraith (1932) from a purely economic perspective as land on the 'margin of cultivation'. According to Dale et al. (2000), the construction of 'marginal' land is context dependent and its definition varies widely depending on the country, local conditions, and the organizations studying the issue. While in economic terms land is marginal if the combination of yields and prices barely covers the costs of production, in practice the term is generally used more broadly to describe land that is not in commercial use in contrast to land yielding net profits from the services (Dale et al., 2000). Depending on time and space, the term marginal land may refer to idle, under-utilized, barren, inaccessible, degraded, excess or abandoned land, or land that is occupied by politically and economically marginalized populations (Dale et al., 2000). Bailis and Baka (2011), while acknowledging that no single definition exists for marginal land, indicate that the term describes land that is perceived by outsiders as unused, often governed by common property rights, and of little productive value. They also state that the marginal land designation is applied in a homogenizing way, concealing the wide range of land types, tenure relations, and social–ecological interactions that characterize land falling under the broad category of marginal land.

Milbrandt and Overend (2009), in their study which aims to estimate the extent of marginal land in 19 countries of the Asia-Pacific Economic Corporation (APEC), stated that the term 'marginal land' appears to be used quite loosely without a specific definition. Jonasse (2009) also points out that the terms 'marginal' or 'idle' land are deliberately vague, and that misuse of the terms is enabling massive land allocation to investors who are destroying biodiverse ecosystems and displacing people from their land. Despite the fact that the term marginal land is widely used in the academic literature, it is not supported by a particular definition or research to determine which land falls into this category (James, 2010). Thus, it is crucial to understand what 'marginal' means in order to determine which land is actually 'marginal'. James (2010) emphasizes that use of the term 'marginal land' as a basis for policy making is problematic, even if the term is well understood, because the status of 'marginal' land by definition is relative and changeable depending on the land use type and changes in price or policy. Moreover, land that is marginal for crop production often provides a key subsistence function for poor rural communities (Gopalakrishnan et al., 2011). Thus, defining marginality only in terms of the profitability of agricultural production undermines the importance of this land for poor rural communities and pastoralists, especially in countries like Ethiopia where pastoralism is one of the major sources of livelihoods in dry low land areas. As highlighted in the next section, like the concept of marginal land, the economic viability of commercial jatropha production on marginal land is also highly contentious.

### *The contested claims about the potential of jatropha on marginal land*

Jatropha has received tremendous attention in most African countries and has emerged as one of the most promising feedstock candidates for the production of liquid biofuels, both at the small-scale and large-scale commercial level (Kesava Rao et al., 2012). Hence, the governments of most developing countries who aim to attract foreign investments in biofuels, and those in the developed world, are promoting claims that there is ample 'marginal' land in Africa and that jatropha can be successfully grown on 'marginal' land without affecting food security or the livelihoods of rural communities. Many claims have been made about jatropha as a potential biodiesel crop, and it has been hailed as a 'miracle' crop that can resist drought and grow well on 'marginal' land and help to reclaim degraded land (FAO, 2008). It has also been described as a 'miracle tree' that can alleviate energy crises and generate income in rural areas in developing countries (Trivedi et al., 2012); a unique and ideal biodiesel feedstock candidate that can be grown on 'marginal' land to produce biodiesel without competing for land currently used for crop production (Trivedi et al., 2012; Kesava Rao et al., 2012; Cheng-Yuan et al., 2012; Pandey et al., 2012); 'green gold' which is superior both in terms of the global environment and the economy than any conventional biofuel crops grown in temperate climates (Renner, 2007); and a 'new magic bullet' that can easily cure the complex prevailing problems of energy security, climate change and rural development (Dyson, 2007). Trivedi et al. (2012) describe jatropha as a crop that is becoming a 'poster child' among some proponents of renewable energy, particularly as an oil-bearing, 'drought resistant' tree for marginal land for small farmers. The 2007/08 global food price crisis, which many studies linked to the diversion of food crops such as corn and soybean to biofuels, has further helped jatropha gain priority on the global biofuel agenda of policy makers, NGOs and renewable energy industry leaders. Since then, jatropha has been presented as a biofuel feedstock which does not involve a trade-off between food and fuel by its advocates who have promoted it for extensive plantation on 'marginal' land throughout the world (Pandey et al., 2012).

The claims about jatropha as a 'miracle' crop have inspired oil companies and companies investing in renewable energy to invest in large-scale jatropha plantations in Africa, Asia and Latin America (Green Car Congress, 2009). Although the positive claims made about jatropha have led to the establishment of many large-scale jatropha plantation projects all over the world, mainly in the global South, the crop has so far failed to prove the associated claims in reality. Many recent studies argue that most of the claims made about jatropha are unproven (e.g. Ariza-Montobbio et al., 2010). A study conducted in Mozambique by JA and UNAC (2009) concluded that the dominant arguments about jatropha as a food-security safe biofuel crop, a source of additional farm income for rural farmers, and a potential driver of rural development, were misinformed at best and dangerous at worst. D1 Oils, one of the major players in the biofuel industry, also concluded, based on their own research and experience with jatropha, that the claims being made about the crop, including that it can grow under marginal conditions, is pest and disease resistant, and does not require fertilizer, are simply not true (Volckaert, 2009). Volckaert (2009) emphasizes that jatropha is not a 'miracle' crop as it needs proper management, proper genetic selection and commercial cultivar development and conventional crop inputs just like any other cultivated crop. Based on his study conducted in Mozambique to assess the potential of jatropha as a biodiesel feedstock, Benge (2006) articulated his concerns about the unfounded claims of jatropha by relating it to the old saying, 'there is no free lunch'. He argued that, although Jatropha may look promising as a tree/shrub for marginal land, without added nutrients, moisture and improved germplasm, marginal yields can be expected. Behera et al. (2010) also state that the production of jatropha on marginal land for biofuel without the use of large inputs has recently created a hype of attention, resulting in the planting of huge areas of jatropha in Asia, Africa, and Latin America. Many other earlier studies conducted in Africa and India, where jatropha has been vigorously promoted, also suggest that although jatropha can survive on land with low nutrients and moisture, it needs sufficient nutrients and irrigation to be profitable on a large-scale commercial level (Endelevu Energy, 2009; Gerbens-Leenes et al., 2009; Milbrandt and Overend, 2009; Ariza-Montobbio et al., 2010). However, when jatropha is produced by small-scale farmers or in a joint venture with companies based on outgrower scheme model and if certain production circumstances are met, some studies suggest that biodiesel production from jatropha could be financially viable (e.g. Bryant and Romijn, 2014). The finding of a study by Mogaka et al. (2010) indicates that jatropha production is profitable for small-scale farmers only if the plant is grown in hedges.

## Results

### *Procedures of land identification for biofuel investments*

Before proceeding to the main factors that led to the termination of jatropha projects, this section provides the analysis, based on the semi-structured interviews, of how the so-called 'marginal' land leased to biofuel investors are identified and quantified in Ethiopia. This study finds that there is no agreed upon national or regional procedure for the identification and quantification of marginal land or any other land for large-scale agriculture in Ethiopia. The main criterion used for the identification of 'marginal' land in the country is its potential to support agricultural crop production. The government officials interviewed claim that the land allocated for biofuel production, mainly jatropha, cannot support any other agricultural crops because of its low moisture content or due to poor soil quality. The second criterion used is the land that is identified as marginal has no current users.

The quantification of marginal land also takes two forms: estimation based on satellite images and ground level estimation. The land data available at the national level is primarily based on mere estimation from the satellite images taken by the federal mapping agencies and remote sensing experts working in the different institutions. The results of the interview indicate that the data available at regional levels are of better quality than the national level data because they are estimated by the respective district level agricultural officers, development agents and village officials who have better knowledge about the land availability in the area. Land quantification in this case involves riding a motorcycle or driving a vehicle around the field which also leaves much space for measurement error. Although it has been argued by government officials that the use of remote sensing technologies in combination with on ground verification of remote measurements is suitable for the identification and quantification of 'marginal' land allocated to investors for biofuels projects, the experiences so far suggest that these techniques are very inaccurate.

The semi-structured interviews with experts revealed that some of the satellite images used are quite old and thus are of less practical use as the area may have undergone major changes since the images were taken. Furthermore, the experts interviewed indicated that the accuracy of the information from the satellite images is highly dependent on the skills and expertise of the professionals in reading and interpreting the satellite images. An expert at the Ethiopia Agricultural Investment Directorate stated that the inaccuracy of land measurement procedures currently in use is the main source of disputes between new incoming investors and previous land users due to the discrepancies between what is recorded in the national land 'bank' as 'free' available land for investment and what is actually available on the ground. One classic example of the inaccuracy of these methods is the case of a German biofuel company, Flora Eco Power, which was given 13,000 ha of what was considered 'marginal' land for the production of castor oil for biodiesel in the East Harerge district of Oromia region. However, about 87% of the land was later found to be part of the Babile Elephant Sanctuary (African Biodiversity Network et al., 2010), while the remainder was being used by local communities. Although the land was allotted to the company on the grounds that it was 'marginal' and not being used by anyone at the time, the company faced opposition to the implementation of its project. Shortly after the company started to clear the land of forest, opposition came from the Ethiopian Wild Life Society, local communities and environmental NGOs, which finally led to the relocation of the project to a nearby area covered by acacia trees. While the Ethiopian government's biofuel strategy document and the government officials interviewed at the Ethiopian Agricultural Directorate claimed that the land allocated to the large-scale jatropha plantation had no current users and was incapable of producing agricultural crops, the experience on the ground as described below indicates that these claims are mostly untrue. Previous studies such as Rachel and Dana (2012) have also pointed out that, although modern remote sensing technologies are used for determining the availability of 'marginal' land, their use has serious limitations for two main reasons: people frequently have uses for the land that are not reflected in land use datasets, e.g. land may have social and cultural value, and a remote classification of marginality is incapable of capturing the changing nature of land use. The next section examines the main reasons behind the failure of Emami Biotech's and other similar large-scale jatropha projects in Ethiopia based on the semi-structured interviews, focus group discussions, field observations and information from secondary sources.

*Key factors behind the failure of large-scale jatropha projects*

*Poor agronomic performance*

Despite the claims made about the potential of jatropha as a biofuel feedstock, the jatropha plantation projects that have been initiated in Ethiopia to date have not realized the claims that drove the 'jatropha euphoria'. An analysis of the Emami Biotech case revealed that the poor agronomic performance of its jatropha plantation was one of the main reasons for the closing down of the company's large-scale jatropha operation. Seedling survival rate, vegetative growth, and yield are the main indicators for evaluating the agronomic performance of jatropha. The survival rate of jatropha at the Emami Biotech farm was 77.7% (Feto, 2011) which is very similar to the study by Ariza-Montobbio and Lele (2010) who report an 80% survival rate under rain-fed conditions. However, although the Emami jatropha plantation had a reasonable survival rate, it was observed during the farm visit that the jatropha vegetative growth rate was extremely low. In addition to the very stunted vegetative growth, the branching pattern was also very poor. Researchers working on jatropha agronomy and breeding at the Melkassa Agricultural Research Centre, who also followed up the jatropha growth performance on Emami's large-scale jatropha plantation farm, described the vegetative growth performance of jatropha on the farm as very poor. Even though the company did not harvest any yield before it abandoned its jatropha farm, the researchers at Melkassa Agricultural Research predicated that only a very low yield could be expected from a plantation with such stunted growth and poor branching pattern.

Two main factors contributed to the poor agronomic performance of Emami Biotech's jatropha plantation. The first was moisture stress as the investment project was located in a lowland area where the amount of annual rainfall is minimal and erratic (less than 750 mm per annum). According to the results of the interviews with the local community, Emami Biotech had tried to develop a series of farm ponds, mini dams and gully plugging to harvest and store water from flash floods for use in irrigation during the dry period. Since the harvested surface water was insufficient to irrigate the whole field during the long dry period, the company also conducted a hydro-geological assessment of ground water, which was also found to be uneconomical because of the great depth of the underground water in the area.

The second crucial factor that led to the poor performance of jatropha was the fact that the company used untested planting material. The plants were propagated from seeds despite the fact that jatropha is strongly heterozygotic and the propagation of high yielding and high quality genotypes requires clonal or tissue culture techniques (Sarathum et al., 2011). The company used seeds collected from different parts of the country where jatropha grows naturally, and imported seeds from India. However, an evaluation of the agronomic performance and commercial viability of the planting material was not conducted under the existing local soil and climatic conditions. Breeding and agronomic research on jatropha in Ethiopia is very scarce, and only a few research centres, such as Melaksa Agricultural Research Centre and Wendo Genet Forestry Research Centre, have recently started jatropha germplasm selection trials. Melkassa Agricultural Research Centre has conducted a jatropha germplasm selection trial at the Miesso research station, which is around 50 km from the Emami Biotech jatropha plantation in Bordede. During the field work, it was observed that the vegetative growth performance of jatropha on experimental plots (under rain-fed condition) was not very good. Since the results of the experimental trial have not yet been published, it was not possible to obtain yield and other agronomic data from the research station. Behera et al. (2010) confirm that the selection of basic planting material is a crucial step and a tree which has an annual yield above 2 kg dry seeds and a seed oil content which is higher than 30% by weight can be considered a good source of planting material. Behera et al. (2010) have also admitted that sufficient information about the nutrient needs and water requirements of jatropha in different ecosystems is still lacking even in India, where a lot of research has been conducted on the plant.

The interviews with former project staff and a review of secondary sources revealed that similar factors (i.e. moisture stress, use of locally collected germplasms and unsuitable soil condition) have led to the collapse of Sun Biofuel's jatropha projects both in Metekel and Wolaita Zones in Ethiopia. In 2006, Sun Biofuels was granted 80,000 ha of land with a lease period of 50 years at price of 25 birr/ha/year (less than $2 at the time) in the Metekel Zone of the Benishangul Gumz region for jatropha plantation (Lakew and Shiferwa, 2008). After clearing 60 ha of forest land and planting some of the cleared land with jatropha seedlings, the company ceased operations due to the unsuitability of the soil for jatropha plantations (Lakew and Shiferwa, 2008). The problem in this project was that the soil was a heavy black soil that suffered from deep cracks during the dry season which meant that most of the jatropha seedlings dried out, making it extremely difficult to establish a farm. In the same year, Sun Biofuels was given 5000 ha of pasture land that was considered 'marginal' by government officials to establish a jatropha plantation in the Wolaita district in Southern Ethiopia. According to the study conducted jointly by the African Biodiversity Network, the Ethiopian Society for Consumer Protection and the Giga Foundation (2010) and interviews with previous project staff members, Sun Biofuels abandoned its large-scale jatropha plantation in the Wolaita district in 2009 after 3 years of unsuccessful growing seasons, mentioning low rainfall and poor soil quality as the main reasons for the company's failure to produce a sufficient harvest from the jatropha plantation.

Based on an evaluation of jatropha performance under different agro-ecologies, Behera et al. (2010) concluded that irrigation is one of the critical inputs for jatropha cultivation in dry areas, especially during its initial establishment. Based on data from an experimental farm in Tanzania, Segerstedt and Bobert (2013) also conclude that high jatropha yields are crucial for economic feasibility, which can only be achieved on good soils with high levels of inputs. The poor performance of jatropha under low moisture and poor soil conditions came as a surprise both to investors and governments who believed that jatropha could be grown commercially on marginal land.

*Conflict over the land*

This study reveals that securing uncontested access to land is crucial for the successful implementation and sustainability of large-scale biofuel projects. The Emami jatropha project is located in a neighbourhood where there is historical conflict between two ethnic groups (Afar and Oromo) over grazing land. The communities in the project area are mainly pastoralists and very few of them are engaged in mixed crop-livestock activities. A large-tract of land is located along the border of the two regions (Afar and Oromia) which was used as a conflict buffer zone between the two ethnic groups. However, due to the increasing scarcity of grazing land in the area caused by the expansion of large-scale private and government farms in the middle Awash area, competition for grazing land is increasing and is aggravating armed conflict between the two ethnic groups. Historically, the conflict between the two ethnic groups has been sporadic and mainly limited to the dry season, but now the conflicts are becoming more frequent even in the rainy season due to the gradual decline in grazing land. It is in this area, within the Oromia region, that Emami Biotech received 11,000 ha of land for its projects. While the Emami project was perceived to put pressure on grazing land in the Miesso district of the Oromia region, the expansion of large-scale private and government cotton farms is putting pressure on the grazing land in the Afar region.

Since all land in Ethiopia is officially owned by the state, the users of the land that was allocated to the Emami jatropha project were not consulted and they were not part of the negotiation process, so they had to accept the top-down decision made by the government to lease the land. Although the government strongly argued that the land allocated to Emami Biotech was 'marginal', free from inhabitants and unsuitable for agricultural crop production, it was communal and was mainly used for livestock grazing. Moreover, the land was used for income generating activities, mainly the sale of charcoal and fire wood. The creation of employment opportunities and the development of infrastructure such as schools, rural health stations and water wells were used to convince the communities that were negatively affected to accept the project, which was going to be implemented anyway. However, the communities were not informed about the time frame within which the promises made by the company would materialize. As one of the key informants who used to work for the Emami project explained, after project implementation, the local community started to ask for the promises made by the company. According to the information from the agricultural office of Miesso district that monitors the investment, the company created temporary jobs for about 160 people during the initial phase of the project for land clearing, land preparation and the planting of jatropha seedlings, though the number of employees was significantly reduced once jatropha planting had been completed. The company's inability to generate sufficient jobs that could engage the majority of affected people, and the urgency of the community to obtain the promised infrastructure finally led to a conflict between the company management and the previous land users, which consequently created a sense of insecurity among the project staff who had to work and live in the area. A key informant, who wanted to remain anonymous, explained that unknown groups from the local community had made several attempts to attack the project staff and the company's project manager. The project finally came to an end due to the disappointing performance of jatropha and the insecurity among the project staff in the area due to conflict over the unmet promises.

*Other causes for the failure or lack of implementation of biofuel projects*

As well as the poor agronomic performance of jatropha and conflict over the land, other factors also contributed to the failure of the jatropha projects. These include: (i) lack of an appropriate feasibility study including soil tests and adaptation trials and investors' very limited knowledge and experience of the agronomic requirements of jatropha under different agro-ecological zones; (ii) under-capitalization of new companies entering the biofuel business; (iii) falling crude oil prices and most developed countries' withdrawal from providing incentives and subsidies for biofuels that made biofuels less profitable; (vi) the world economic downturn following the financial crisis and the international politics of biofuels (i.e. campaign against biofuels due to their perceived negative impact on food security and environment)—which made it difficult to find funding for biofuel projects, and; (v) more challenges than expected to implementation (i.e. most investors underestimated the challenges of establishing large-scale farms). An expert at the Ethiopian Investment Agency said that the strategy of most biofuel investors is to first acquire a large tract of land and then use land possession as a means to raise funding. However, if an investor fails to find funding, the planned projects will fail. While many biofuel companies in the country have formally terminated their projects and left the country, others had their investment licenses revoked by the government due to failure to commence implementation of their projects. According to the information from the semi-structured interviews, some of the biofuel projects have changed the name of their companies and investment plans to invest in other crops.

## Discussion

The problems with large scale jatropha plantation as observed in Ethiopia may have much in common with earlier policies in the region, in particular with the East African Groundnut Scheme which, as will be outlined below, is a classic example of disastrous programme failure.

The global fats and oils shortage that occurred following World War II led to the initiation of the East African groundnut scheme in Tanganyika (the present day Tanzania) in 1946 by the British Government (Hogendorn and Scott, 1981; Rizzo, 2006). The initial proposal to establish mechanized large-scale groundnut production came from Samuel Franks, the Managing Director of the African United Company (AUC), a subsidiary of Unilever, a multi-national giant that supplied about three-quarters of the margarine consumed in Western Europe and two-thirds of soaps utilized in the UK and its colonies. Samuel Franks, following his visit to Tanganyika, suggested to the British Minister of Food a scheme to grow groundnut on 1.3 million ha in the 'empty spaces' of East Africa to fulfil Britain's critical shortage of oils and fats (Kauzeni et al., 1993). The general idea was accepted by the Minister, although several questions remained unanswered (Kauzeni et al., 1993). The plan was approved by the British government in December 1946, and the implementation of the project began in February 1947 with desperate urgency. The scheme was expected to produce 600,000 tonnes of peanuts by the fifth year and the total cost of the project was estimated to be £24 million. After 5 years, the outcome of the scheme was, in practice, a total failure. While the targets for the scheme were reduced year after year, its cost was progressively adjusted upwards. When the project was shut down in 1951, over £36 million had been spent, while the scheme had imported more groundnuts as a seed than it actually produced (Kauzeni et al., 1993). According to Rizzo (2006), the East African Groundnut Scheme in Tanganyika is probably the most dramatic and most cited failure of the ambitions of the late British colonial development projects in Africa.

There are many similarities between the failed late-colonial East African groundnut scheme and the present day jatropha projects in Africa. Among the main similarities are: (i) while large-scale jatropha production is being promoted by the narrative of the use of 'marginal' land, an 'empty' land narrative was used by the post-colonial British government to confiscate land from its users. Neither narrative examines whether there are insuperable objections from the point of view of native land users; (ii) the selling point, both for the jatropha projects and the East African groundnut scheme, was that the projects would bring development to Africa, though the main aim was to look for a solution to the problems that countries in Europe faced at home; (iii) the sense of urgency with which the projects were initiated in both cases; very superficial feasibility studies were conducted, mainly areal mapping, and large-scale projects were initiated without pilot testing, and; (iv) assumptions that the existing conditions such as soil conditions, temperature, and precipitation would be suitable for the crops under consideration without the existence of any credible scientific evidence to support these claims.

Given the above mentioned similarities, historically, severe overcentralization of farm management by the colonial power, inappropriate technology (i.e. a mismatch between local conditions and the equipment needed to do the job of, for instance, land clearing), and in general, a severe underestimation of complex logistical problems were the main reasons for the failure of large-scale farming particularly those involving public-corporations. For private large-scale farms, low or very low investment capitalization was the main reason for their failure. The majority of these factors also play a great role in the failure of current large-scale jatropha plantations. The fact that similar factors which led to the drastic failure of, for instance, the East African ground nut schemes more than six decades ago are also responsible for the present-day failure of large-scale biofuel projects in general, and jatropha in particular, shows that investors and developing countries' governments which support these projects have not learnt from past failures. Although it would be very interesting to examine the institutional, power dynamics and behavioural pattern that prevented learning from past failures, this endeavour is beyond the scope of this paper.

## Conclusion

The most important conclusion that can be drawn from this study is that the claim that jatropha can be commercially grown for biodiesel on marginal land is an unproven argument which has played a major role in the failure of jatropha projects in Ethiopia. The findings of this study suggest that sufficient moisture and appropriate selection of planting material are crucial for the commercial level economic viability of jatropha projects. This research also reveals that securing uncontested access to land is essential for the successful implementation and sustainability of large-scale biofuels projects. Furthermore, as revealed by this study, the current practice of determining land marginality for jatropha production based only on its potential for crop production has serious limitations as it fails to recognize the complex reality of previous land uses, which provide key livelihood options for rural communities and low-income groups. The jatropha projects were promoted without sufficient scientific knowledge of the crop and its agronomic practices. Thus, promoting large-scale investments in jatropha may discourage any future investments in the crop, while it may also lead to financial loss for actual investments. Nonetheless, as jatropha is still a wild plant with high heterozygosity, its domestication and the development of appropriate technologies (e.g. the selection of high yielding varieties; improved water, nutrient, and pest management; pruning; taproot development at cutting plants; seedling production of high performance clones through in-vitro culture; customizable root development) may considerably improve its performance on 'marginal' land in the future (Hegele, 2012). However, for the time being, the potential for profitable jatropha production on 'marginal' land in Ethiopia is not a reality, but a myth.

## Acknowledgments

This research was funded by the Danish Ministry of Foreign Affairs (11-118-DIIS). The financial support from the ministry is greatly appreciated. The author is grateful to Peter Gibbon, Arne Henningsen, Margaret Skutsch, and Martin Hegele for their valuable comments on earlier drafts of this paper. The authors take full responsibility for any remaining errors.

## References

African Biodiversity Network, the Ethiopian Society for Consumer Protection, the GIGA Foundation. Biofuels: a failure for Africa. Ethiopia: Addis Ababa; 2010.
Ariza-Montobbio P, Lele S. Jatropha plantations for biodiesel in Tamil Nadu, India: viability, livelihood trade-offs, and latent conflict. Ecol Econ 2010;70:189–95.
Ariza-Montobbio P, Lele S, Kallis G, Martinez- Alier J. The political ecology of Jatropha plantations for biodiesel in Tamil Nadu, India. J Peasant Stud 2010;37(4):875–97.
Bailis R, Baka J. Constructing sustainable biofuels: governance of the emerging biofuel economy. Ann Assoc Am Geogr 2011;101(4):827–38.
Behera K, Srivastava P, Tripathi R, Singh JP, Singh N. Evaluation of plant performance of *Jatropha curcas* L. under different agro-practices for optimizing biomass—a case study. J Biomass Bioenergy 2010;34(1):30–41.
Benge M. Assessment of the potential of *Jatropha curcas*, (biodiesel tree,) for energy production and other uses in developing countries. Agroforestry Office, USAID; 2006.
Borras S, David F, Sofía S. The politics of agrofuels and mega-land and water deals: insights from the ProCana case, Mozambique. Rev Afr Polit Econ 2011;38(128):215–34.
Bossio D, Erkossa T, Dile Y, McCartney M, Killiches F, Hoff H. Water implications of foreign direct investment in Ethiopia's agricultural sector. J Water Altern 2012;5(2):223–42.
Bryant S, Romijn H. Not quite the end for Jatropha? Assessing the financial viability of biodiesel production from Jatropha in Tanzania. Energy Sustain Dev 2014;23:212–9.
Cheng-Yuan Y, Zhen F, Bo L, Yun-feng. Review and prospects of Jatropha biodiesel industry in China. J Renewable Sustainable Energy Rev 2012;16(2012):2178–90.
Cotula L, Oya C, Codjoe E, Eid A, Kakraba-Ampeh M, Keeley J, et al. Testing claims about large land deals in Africa: findings from a multi-country study. J Dev Stud 2014;50:903–25.
Dale H, Brown S, Haeuber A, Hobbs N, Huntly N, Naiman R, et al. Ecological principles and guidelines for managing the use of land. Ecol Appl 2000;10:639–70.
Dyson T. The new magic bullet. The palm beach letter, Daily Wealth; 2007 [http://www.dailywealth.com/994/The-New-Magic-Bullet, retrieved 02-08-2012].
Endelevu Energy. Jatropha Reality Check: a field assessment of the agronomic and economic viability of Jatropha and other oilseed crops in Kenya. Nairobi, Kenya: World Agroforestry Centre and Kenya Forestry Research Institute; 2009.
Ethiopian Biofuels Development Directorate. Assessment of biofuels projects status in Ethiopia (Amharic version); 2011.
EU Directive. Directive 2009/28/EC of The European Parliament and of The Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Off J Eur Union 2009;140:16–47. [L 140/16].
Feto A. Energy, greenhouse gas and economic assessment of biodiesel production from jatropha: the case of eastern and north eastern Ethiopia [MSc thesis] Ethiopia: Haramaya University; 2011.
Gerbens-Leenes W, Hoekstra Y, van der Meer H. The water footprint of bioenergy. Proc Natl Acad Sci U S A 2009;106(25):10219–23.
German L, Schoneveld G, Gumbo D. The local social and environmental impacts of smallholder-based biofuel investments in Zambia. Ecol Soc 2011;16(4):12.
Gopalakrishnan G, Cristina Negri M, Snyder W. A novel framework to classify marginal land for sustainable biomass feedstock production. J nviron Qual 2011;40(5):1593–600.
Green Car Congress. BP and D1 oils from joint venture to develop jatropha biodiesel feedstock. Energy, technologies, issues and policies for sustainable mobility; 2009 [http://www.greencarcongress.com/2007/06/bp-and-d1-oils-.html, retrieved, 02-08-2012].
Hegele, M. (2012), University of Hohenheim, Germany, personal communication in November 2012.
Hogendorn S, Scott M. The East African groundnut scheme: lessons of large-scale agricultural failure. J Afr Econ Hist 1981;10(1981):81–115.
International Fund for Agricultural Development (IFAD). Opportunities for rural poor people: How the poor can benefit from this emerging opportunity. Paper prepared for the round table organized during the thirty-first session of IFAD's governing council. Prepared by Vineet Raswant, Nancy Hart and Monica Romano; 2008.
James L. Theory and identification of marginal land and factors determining land use change. Paper provided by Michigan State University, Department of Agricultural, Food, and Resource Economics in its series Graduate Research Masters Degree Plan B Papers with number 98203; 2010.
Jonasse R. Agrofuels in the Americas. Oakland: Institute for Food and Development Policy. A Food First Books; 2009.
Justica Ambiental and Uniao Nacional de Cammponeses (JA and UNAC). Jatropha! A socio – economic pitfall for Mozambique. Report prepared from SWISSAID; 2009 [Accessed at: http://www.open.ac.uk/technology/mozambique/sites/www.open.ac.uk.technology.mozambique/files/pics/d131620.pdf].
Kauzeni A, Kikula I, Mohamed S, Lyimo J. Land use planning and resource assessment in Tanzania: a case study. IIED environmental planning issues no. 3 and IRA research paper no. 35; 1993.
Kesava Rao R, Wani P, Singh P, Srinivas K, Srinivasa Rao Ch. Water requirement and use by Jatropha curcas in a semi-arid tropical location. J Biomass Bioenergy 2012;39(2012):175–81.
Lakew H, Shiferwa Y. In: Mahiber Melka, editor. Rapid assessment of biofuels development status in Ethiopia and proceedings of the national workshop on environmental impact assessment and biofuels. Addis Ababa, Ethiopia: MELCA Mahiber; 2008.
Land Matrix. The online public land deals database. http://landportal.info/landmatrix, 2012. [accessed 01 May 2012].
Makki F, Geisler C. Development by dispossession: land grabbing as new enclosures in contemporary Ethiopia. Paper presented at the International Conference on Global Land Grabbing, Institute of Development Studies and Future Agricultures Consortium. Brighton, UK: University of Sussex; 2011 [6-8 April 2011].
Milbrandt A, Overend R. Assessment of biomass resources from marginal land in APEC economies. Report prepared for the Asia-Pacific Economic Cooperation Energy Working Group under EWG 11/2008A. APEC; 2009.
Mogaka V, Ehrensperger A, Iiyama M, Birtel M, Heim E, Gmuender S. Understanding the underlying mechanisms of recent *Jatropha curcas* L. adoption by smallholders in Kenya: a rural livelihood assessment in Bondo, Kibwezi, and Kwale districts. Energy Sustain Dev 2010;18:9–15.
MoME (Ministry of Mines and Energy). Biofuel development and utilization strategy. Addis Ababa: The Federal Democratic Republic of Ethiopia; 2007.
Pandey Ch, Singh Kr, Singh Sh, Kumar A, Singh B, Singh R. *Jatropha curcas*: a potential biofuel plant for sustainable environmental development. J Renewable Sustainable Energy Rev 2012;16(2012):2870–83.
Peterson G, Galbraith J. The concept of marginal land. Am J Agric Econ 1932;14(2):295.
Principles for Responsible Agricultural Investment (PRAI). Principles for responsible agricultural investment that respects rights, livelihoods and resources. A discussion note prepared by FAO, IFAD, UNCTAD and the World Bank Group to contribute to an ongoing global dialogue; 2010.
Rachel A, Dana M. Marginal land: the role of remote sensing in constructing landcapes for agrofuel development. J Peasant Stud 2012;39(2):403–22.
Rahmato D. Land to investors: large-scale land transfer in Ethiopia. Forum of Social Studies (FSS) Addis Ababa, FSS Policy Debate Series No.1; 2011.
Renner R. Green gold in a shrub. Sci Am 2007;296(6):20–3.
Rizzo M. What was left of the groundnut scheme? Development disaster and the labour market in Southern Tanganyika 1946–1952. J Agrar Chang 2006;6(2):205–38.
Sarathum S, Hegele M, Wünsche J. Micropropagation of *Jatropha curcas* L. Acta Horticulturae, 923. ISHS; 2011. p. 65–72. [http://www.actahort.org/books/923/923_8.htm].
Schut M, Slingerland M, Locke A. Biofuels development in Mozambique. Update and analysis of policy, potential and reality. J Energy Policy 2010;38(2010):5151–6.
Segerstedt A, Bobert J. Revising the potential of large-scale Jatropha oil production in Tanzania: an economic land evaluation assessment. Energy Policy 2013;57:491–505.
The Financial Express. Emami's strength lies in diversified investment. The Resource Centre; 2009.
The State of Food and Agriculture (FAO). Biofuels: prospects risks and opportunities services. Rome: Food and agriculture organization of the united nations; 2008.
Trivedi S, Gaudani H, Gupta M, Gupta N, Patil P, Gupta G, et al. Establishment of Agrobacterium-mediated genetic transformation in *Jatropha curcas* L. Int J Agric Sci 2012;1(2):11–20.
UN-Energy. Sustainable bioenergy: a framework for decision makers. New York: United Nations; 2007 [Available at http://www.fao.org/docrep/010/].
Volckaert V. *Jatropha curcas*: beyond the myth of the miracle crop. Regional Manager Africa—D1 Oils Plant Science, power point presentation; 2009.
World Bank. Rising global interest in farmland. Can it yield sustainable and equitable benefit. The World Bank; 2010.