Sustainability **2014**, *6*, 7224-7241; doi:10.3390/su6107224

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

Local Perceptions about the Effects of Jatropha (*Jatropha curcas*) and Castor (*Ricinus communis*) Plantations on Households in Ghana and Ethiopia

Joleen A. Timko [1,*], Aklilu Amsalu [2,†], Emmanuel Acheampong [3,†] and Mesfin K. Teferi [4]

[1] Africa Forests Research Initiative on Conservation and Development (AFRICAD), Forestry of Forestry, University of British Columbia, Vancouver, BC V6T-1Z4, Canada

[2] Department of Geography & Environmental Studies, Addis Ababa University, Addis Ababa P.O. Box 150223, Ethiopia; E-Mail: amsalu.aklilu@gmail.com

[3] Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, University Post Office, Kumasi, Ghana; E-Mail: ekachie@yahoo.com

[4] HoA-REC&N (The Horn of Africa Regional Environment Centre and Network), College of Natural Sciences, Graduate Programme Building, Addis Ababa University, 9th Floor, Room 903, Addis Ababa P.O. Box 80773, Ethiopia; E-Mail: mesfink2010@gmail.com

† These authors contributed equally to this work.

* Author to whom correspondence should be addressed; E-Mail: joleen.timko@ubc.ca; Tel.: +1-604-822-6092.

External Editor: Marc A. Rosen

Received: 3 March 2014; in revised form: 10 October 2014 / Accepted: 11 October 2014 / Published: 17 October 2014

Abstract: Biofuel plantations have been hyped as a means to reinvigorate Africa's rural areas. Yet there is still apprehension about the negative environmental and social impacts of large-scale commercial biofuel production around rising food prices, land grabbing, ecological damage, and disruption of rural livelihoods. Given the extent of *Jatropha curcas* production in Ghana and Ethiopia and Castor bean (*Ricinus communis*) in Ethiopia, this paper presents the results of a study that assessed the socio-economic implications of industrial Jatropha plantations on local livelihoods in Ghana, and of industrial Jatropha and Castor plantations on local livelihoods in Ethiopia. This study used primary data collected from 234 households in Ghana and 165 in Ethiopia. The cultivation of Jatropha and Castor has had several important effects on local livelihoods in the study sites, most notably decreases in household landholdings due to the arrival of industrial Jatropha or Castor plantations; and the resulting changes these plantations have caused in household socio-economic status, food security, fallow periods, and fodder availability. We consider how a lack of meaningful consultation between local people, their traditional authorities and the biofuel company managers, along with shortcomings in each country's broader land acquisition process and poor land use information, may have contributed to these overall negative effects on local livelihoods. We conclude by suggesting several ways that emerging biofuel industries could be improved from the perspective of local people and their livelihoods.

Keywords: Jatropha; Castor bean; biofuels; Ethiopia; Ghana

---

1. Introduction

In recent years, biofuels from plant oils have rapidly emerged as a major issue for agricultural development, energy policy, and natural resource management. The growing demand for biofuels is being driven by high oil prices, energy security concerns, and global climate change [1]. Many African countries are faced with a continued dependence on imported oil and increased expenditures due to high oil prices. For example, Tanzania spends some 25 percent of its total foreign exchange earnings on oil imports [2]. These types of scenarios have been an important driving force for biofuels to be considered as alternative energy sources. Growing interest from foreign private investors in establishing biofuel projects, along with growing support from bilateral and multilateral donors for incorporating biofuels into government policies and development plans, have resulted [1,3,4]. African governments are also developing international partnerships with countries that have experience in biofuel development such as Brazil and India, and with the European Union (EU), to transfer biofuel technology to Africa [5]. Enthusiasm by African governments for biofuel development over the past few years has accompanied the hope that agro-fuels would provide new market opportunities and economic benefits. Biofuels are thus presented as a sustainable source of higher income for farmers in Africa and are promoted as a means to improve rural livelihoods, reduce poverty, and stimulate rural development [6].

In spite of the much-touted potential of biofuel plantations to reinvigorate Africa's rural areas through job creation and income generation, the production of biofuels is still a contested issue. This is mainly due to uncertainties regarding the extent of positive environmental and social benefits (e.g., income generation, employment creation, diversification of livelihood strategies) [7], concerns about potentially negative ones (e.g., deforestation and resulting loss of local forest products and services, wildlife displacement, displacement of food production, land grabbing and alienation of farmers from their land), and the manner with which land is acquired for these projects. Linkages between the usage of feedstocks in biofuel production and increases in international food prices have been made [8]. Yet indigenous farming systems, local communities, and the biodiversity they manage are expected to give way to provide the increased fuel needs of the industrialized world [9].

However, many countries do not have in place the legal or procedural mechanisms to protect local rights and take account of local interests, livelihoods, and welfare. Even where legal requirements for community consultation are in place, the involvement of local communities in the negotiation process is not guaranteed. A lack of transparency and of checks and balances in contract negotiations create breeding grounds for corruption and land deals that do not maximize the public interest. Insecure use rights on state-owned land, inaccessible registration procedures, vaguely defined productive use requirements, legislative gaps, and compensation limited to loss of improvements like crops and trees (thus excluding loss of land) all undermine the position of local people [10]. Thus, the political economy of land and biofuel development is seriously contested.

1.1. Assessing the Effects of Industrial Biofuel Plantations in Africa: Jatropha (Jatropha curcas) and Castor (Ricinus communis L)

Africa has become an important target producer of the necessary feedstocks for biofuel production. In particular, land has been acquired for production of Jatropha curcas as a feedstock for biofuel production in Ghana and Ethiopia, and for Castor bean in Ethiopia. Jatropha curcas (herein referred to as Jatropha), commonly called the physic nut, now grows pantropic even though its native range was tropical America [11]. "It is a plant with many attributes, multiple uses and considerable potential" [12] (p. 1). Jatropha has been promoted for its numerous woody by-products such as pruning waste and fruit hulls which could be combusted locally as a fuel source [13], and those by-products of use in micro-industries such as the manufacturing of soaps and candles. Jatropha is thought to help prevent soil erosion by rainwater, reclaim degraded lands, and act as a living fence to exclude browsing animals [11–14]. It is also of great interest to the global biofuel industry as a feedstock. Trends around the world indicate a shift towards Jatropha as a viable and sustainable alternative to traditional biodiesel feedstocks such as palm, soya, *etc*. [15]. It is postulated that over half of the land in Africa is suitable for Jatropha cultivation [16].

In spite of claims promoting Jatropha's attributes, there are many misconceptions, unsubstantiated claims, and research gaps that need to be considered, particularly given the projected expansion of Jatropha cultivation across the tropics. After all, Jatropha "is still a wild plant of which basic agronomic properties are not thoroughly understood" and many of the environmental effects have not yet been investigated [14] (p. 1063). For instance, a number of dubious claims include that Jatropha: will enhance socio-economic development while reclaiming marginal and degraded lands; is drought tolerant; is a high yielding crop; grows well under saline conditions; and does not compete with food production. Indeed, the peer-reviewed literature relating to Jatropha is sparse [17]. Yet there is very little if any evidence to substantiate these types of claims. There is a lack of information about Jatropha's potential yield under sub-optimal and marginal conditions [18–20], as well as about the long-term impacts of large scale Jatropha projects on soil quality and the environment [21]. While the seed yield of individual wild plants has shown great promise, Jatropha has never been grown as a commercial crop. Its long-term response to drought conditions and poor soil fertility is uncertain, and very little is known about its seed and oil yields when grown in relatively dense block plantations.

Castor bean, *Ricinus communis*, belongs to the Euphorbiaceae, or spurge, family. It grows wild and is generally considered as merely a weed or as a shade-giving agent for more sensitive low growing cash crops. It is a warm-season plant indigenous to eastern Africa and probably originated in Ethiopia [22–24]. Castor can survive under rather dry conditions because of its very strong root system, its resistance to loss, and its ability to withstand substantial water stress. As a peasant crop in the warmer regions of the world, castor can be grown almost anywhere if land is available, and this is perhaps its greatest virtue—it is an adaptable cash crop that can be easily cultivated on well drained soils in frost-free seasons [25]. One of the reasons that castor plants have become so successful is their extremely viable seed that germinates readily in a variety of soils. More often castor is inter-planted with crops, sown round the borders and margins of fields on areas unsuitable for other crops [26,27]. Castor has the highest viscosity and highest density of all oils [22]. It has numerous industrial uses, namely for the production of paints and varnishes, nylon type synthetic polymers, resins and lubricants, cosmetics, textile dyeing, insecticides, in the leather industry, and for medicinal purposes as a laxative. The leaves of the castor plants have also been used for feeding silkworms and cattle, as human food (where fresh green food is scarce), and the branches and stem can be used for the production of low-grade paper as well as for fuel. Castor is selected as a good alternative for biofuel crop in Ethiopia due to its high crop yield per hectare, high oil content per kg of seed (over 50% oil content), and tolerance to moisture stress. It is also an excellent rotation crop for maize, sorghum, pulses and horticultural crops; hence, production should be encouraged as the return is also much higher than for maize and sorghum [28].

1.2. Study Rationale

Ghana and Ethiopia have demonstrated a willingness to pursue industrial biofuel projects despite the lack of evidence about the benefits of such projects and plants. Given the local perceptions about the effects of such projects, it is an opportune time to more carefully assess how these projects can impact local livelihoods, both positively and negatively. This paper utilizes criteria and indicators from an analytical framework [6] to present the results of a comparative study that assessed several important effects of industrial Jatropha plantations on local livelihoods in Ghana [29], and of industrial Jatropha and Castor plantations on local livelihoods in Ethiopia [30]. The framework was developed in two stages: first, a comprehensive review of the relevant published and gray literature focused specifically on Jatropha, and drawing on more general biofuel-related literature where necessary, deductively identified a broad list of potential socio-economic impacts of industrial biofuel projects, and second, the framework was inductively refined through in-depth case study investigation of Jatropha projects in Ghana and Ethiopia [6].

These two countries were ideal locations in which to situate such a study given their recent experiences with industrial biofuel plantations in general, and with Jatropha and Castor in particular. At the time of fieldwork, there were at least seventeen commercial biofuel developments [31] in Ghana, thirteen of which focused primarily on the cultivation of Jatropha. In Ethiopia, vast amounts of land have been deemed suitable for biofuel development, and Jatropha has gained priority as an alternative energy source. Since the completion of fieldwork, most of the lands acquired for Jatropha and/or Castor plantations in Ghana and Ethiopia have been abandoned by the companies, and converted into other uses, mainly commercial cultivation of food crops. In spite of this, the abandoned lands remain off-limits to local use and the negative effects on local livelihoods persist.

This paper is divided into four sections. Following this introduction, a characterization of the study sites and the methods used for data collection are presented. The results section utilizes several criteria and indicators to present the data regarding important effects of industrial Jatropha plantations on local livelihoods in Ghana [29], and of industrial Jatropha and Castor plantations on local livelihoods in Ethiopia. In particular, we include changes in household landholdings, socio-economic status, food security, fallow periods, and fodder availability from the Ghanaian and Ethiopian study sites. The fourth and final section of the paper discusses the results in more detail, and reflects on how a lack of meaningful consultation between local people, their traditional authorities and the biofuel company managers, along with shortcomings in each country's broader land acquisition process and poor land use information, may have contributed to these overall negative effects on local livelihoods. We conclude by suggesting several ways that emerging biofuel industries could be improved from the perspective of local people and their livelihoods.

2. Methods

2.1. Description and Selection of Study Sites

Purposive sampling enabled us to select case study sites where the impacts of large-scale production of Jatropha and Castor on farmers' livelihoods would be expected, such as those areas immediately bordering and thus affected by land being used for Jatropha cultivation. Using expert advice from the Environmental Protection Agency (EPA) of Ghana, the study was conducted in 11 communities spanning the major agro-ecological zones and political divisions across Ghana—Lolito and Adidome in the Volta Region; Old Akrade in the Eastern Region; Kobre, Bredie-Camp, Kadelso and Ahenekom in the Brong Ahafo Region; Agogo in the Ashanti Region; and Kpachaa, Kusawgu, and Diare in the Northern Region (Figure 1). In Ethiopia, the study was conducted in three sites located in two regional states: Bordede and Fedis in Oromia Region, and Mancha in the Southern Nations, Nationalities and Peoples Regional State (SNNPRS) (Figure 2). The main livelihood in all of these study sites is agriculture, mainly rain-fed cultivation, and livestock rearing. Table 1 presents the general site characteristics of each of the study sites.

Table 1. General characteristics and companies in study sites.

Study Site Name	Number of Household Questionnaires Administered	Number of Expert Interviews/Focus Group Discussions (FGDs)	Type of Biofuel Feedstock	Biofuel Company
		Ghana		
Adidome	12	2/11	Jatropha	Galton Agro Ltd.
Agogo	30	4/7	Jatropha	ScanFarm (formally ScanFuel)
Ahenekom	5	2/8	Jatropha	Savannah Black Farming and Farm Mgt Ltd
Bredie Camp	-	4/11	Jatropha	Kimminic Corporation
Diare	-	2/0	Jatropha	Integrated Tamale Fruit Company (ITFC)
Kadelso	52	4/0	Jatropha	Jatropha Africa
Kobre	50	3/9	Jatropha	Kimminic Corporation
Kpachaa	50	1/0	Jatropha	Biofuel Africa
Kusawgu	-	2/0	Jatropha	Biofuel Africa
Lolito	35	2/13	Jatropha	Biofuel Africa
Old Akrade	-	1/5	Jatropha	Annuamom Industries

Table 1. *Cont.*

Study Site Name	Number of Household Questionnaires Administered	Number of Expert Interviews/Focus Group Discussions (FGDs)	Type of Biofuel Feedstock	Biofuel Company
Ethiopia				
Bordede	52	5/3	Jatropha	Imami/New-Age Bio-Tech
Fedis	50	7/3	Castor bean	Flora Eco-Power
Mancha	63	6/3	Jatropha; Castor bean	Sun Biofuel; Global Energy

Figure 1. Map depicting the approximate location of the Ghanaian study sites in relation to the capital city of Accra.

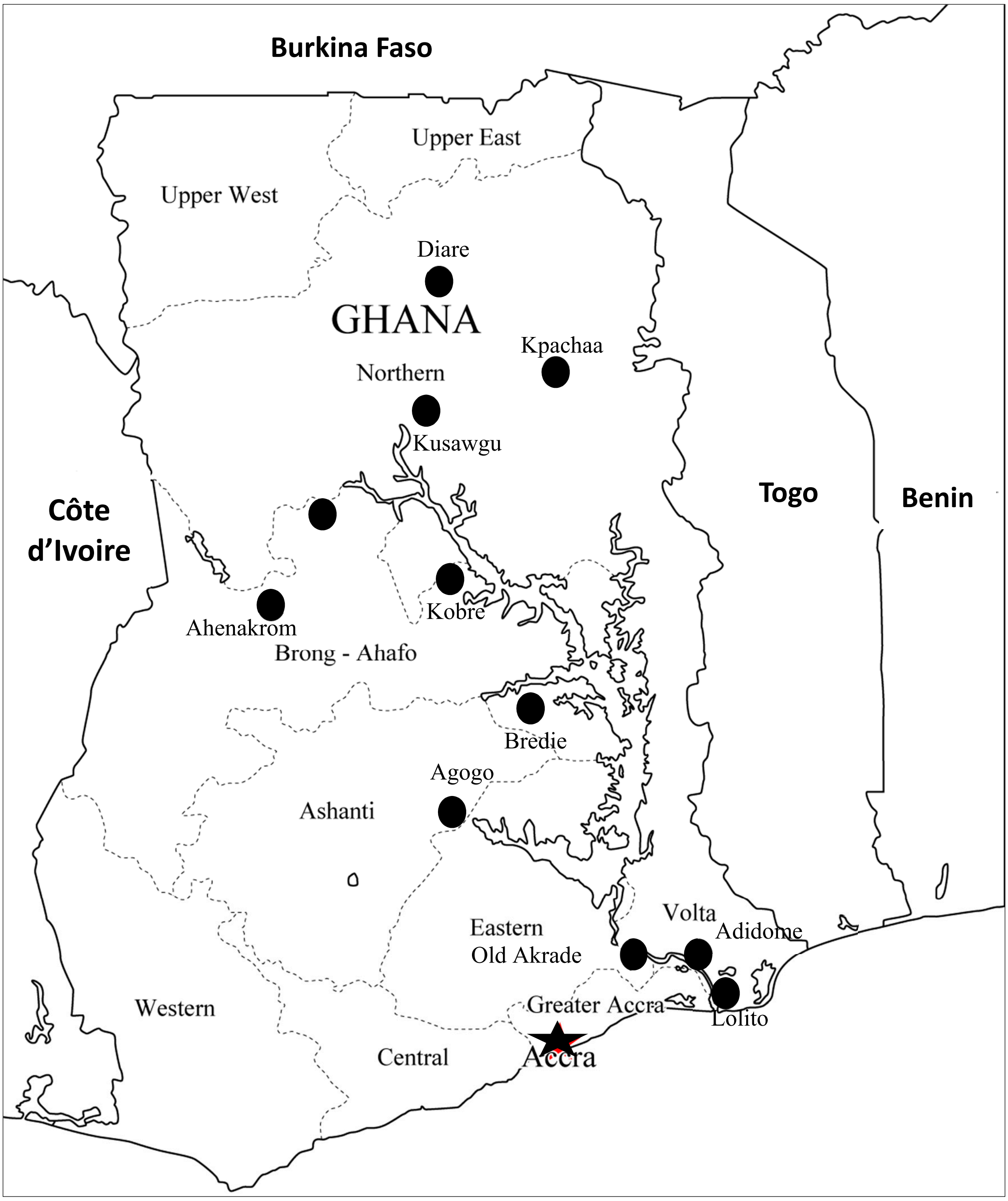
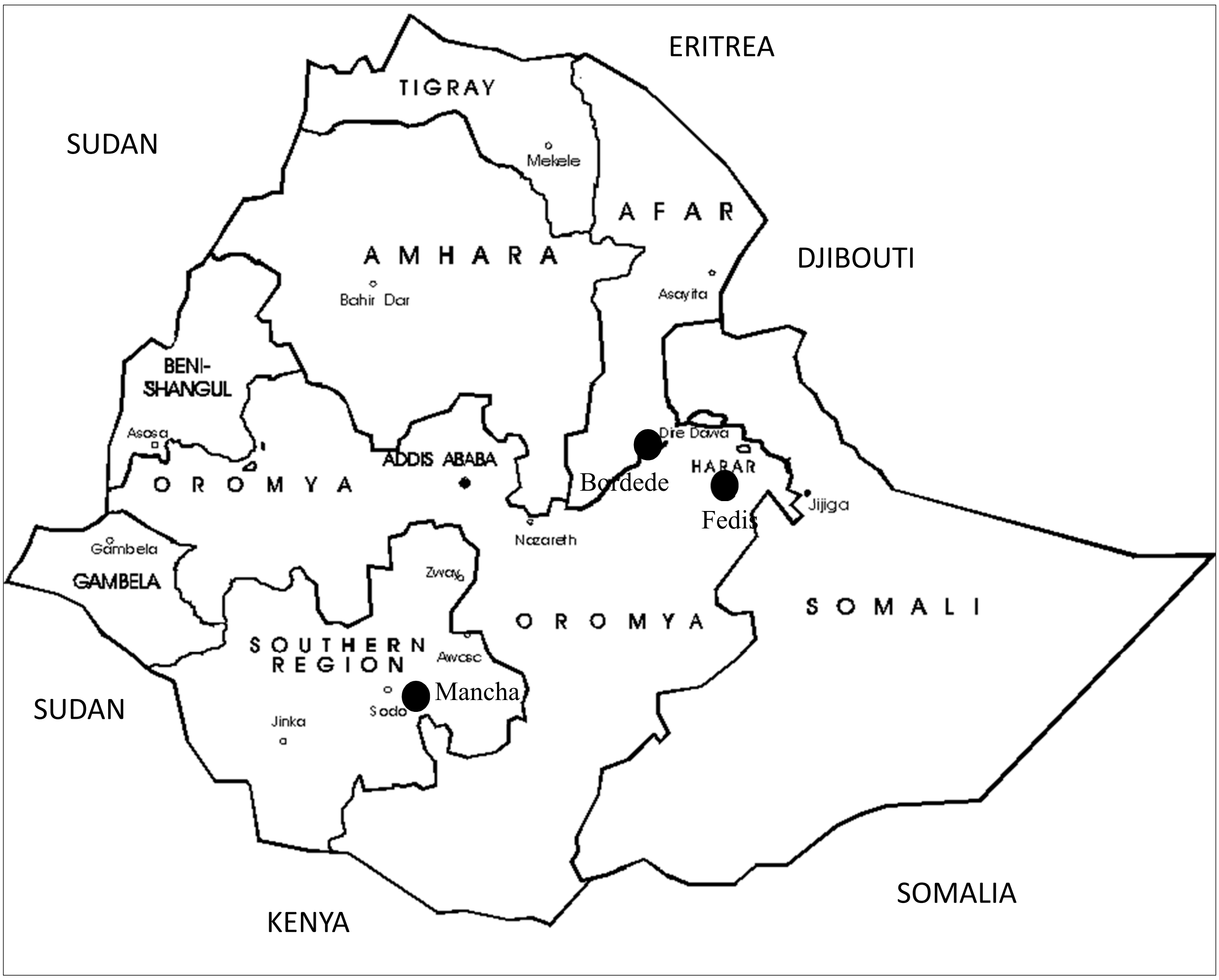


Figure 2. Map depicting the approximate location of the Ethiopian study sites in relation to the capital city of Addis Ababa.



2.2. Data Collection and Analysis

This study used primary data collected by employing a household questionnaire survey. The questionnaires were administered to 399 households, 234 in Ghana and 165 in Ethiopia (not all respondents answered each question; the number of responses are identified as appropriate in the results section). Because of rural sensitivities in Ghana, initial contact with the respondents was negotiated with the assistance of community administrators such as the Assemblyman or Unit Committee Chairman who provided the initial list of possible respondents. Subsequent respondents were selected by purposive and/or snowball sampling. In Ethiopia, the respondents were selected by employing a systematic random sampling technique from a list of farmers obtained from the respective Kebele administrations and who had been participating in the Jatropha/Castor plantations or who were affected by Jatropha cultivation.

Ghanaian respondents were residents in the communities who were affected by Jatropha cultivation—either company workers or people who lost land to the company. Ethiopian respondents were residents in communities affected by either or both Jatropha or Castor cultivation (approximately 60% of Ethiopian respondents were affected by Jatropha while 40% were affected by Castor). Trained enumerators administered the questionnaires one-on-one with respondents and the responses were entered directly into the spaces provided. Various local dialects were used in the Ghanaian study sites, as appropriate. In Ethiopia, the interviews were carried out in two local languages, Amharic and Afan Oromo, depending on location of the study areas. The questionnaire included questions pertaining to the socio-demographic profile of the household, household resources and farming practices, livelihood conditions before and after the introduction of biofuel plantations, and existing and potential conflicts related to natural resources use in general and biofuel development in particular. Focus group discussions were held with selected members of the community in each study site in order to generate more elaborate opinions, feelings and experiences on the socio-economic impacts of Jatropha cultivation. In Ethiopia, two focus groups, one mixed gender group and the other females only, were carried out in each site. In Ghana, each focus group consisted of participants of the same gender and age range. In both Ghana and Ethiopia, all focus groups consisted of an average of eight individual participants composed of individuals of different age and socio-economic status. Several key informant interviews were conducted at various sites with leaders including village chiefs and elders, local government representatives such the Assemblyman and Unit Committee Members; and other people with knowledge of Jatropha issues.

Our interviews were exploratory in nature; they were not meant to be inferential, but rather to provide insight into the experiences of local people affected by large-scale biofuel projects (in this case, Jatropha and Castor). The responses obtained through the administration of questionnaires were assigned numerical codes and SPSS was used to summarize and analyze the data. Because we were looking for commonalities rather than divergences, simple descriptive statistics and frequencies were generated. Cross tabulations of relevant variables were also done to reveal patterns and relationships. The qualitative information collected from the focus group discussions was carefully coded and thematically analyzed. An analytical framework developed elsewhere [6] deductively analyzed the literature in this domain to identify key criteria for assessing the impacts of biofuel projects on rural livelihoods. We utilized several criteria from that framework to assess the perceived socio-economic effects arising from the biofuel projects in our study sites.

3. Results

The cultivation of Jatropha and Castor has affected local respondents in the Ghanaian and Ethiopian study sites in both positive and negative ways. We explored these effects using two criteria and their associated indicators to frame the discussion: (1) Negative effects of biofuel projects on local landholdings and land use are minimized; and (2) Household- and community-level socio-economic effects are addressed [6]. These two criteria were written in such a way as to indicate the desired state.

3.1. Negative Effects of Biofuel Projects on Local Landholdings and Land Use Are Minimized

The most direct and immediate impacts of Jatropha and Castor cultivation relates to land loss. Loss of rights over customary or traditional lands, and the way this has negatively affected local villagers' livelihoods is a major concern for local communities in both Ghana and Ethiopia. In Ghana, just over half (54.3%) of the 234 respondents reported that they have lost land to Jatropha investments. For example, in Agogo in the Ashanti Region, most farmers reported that contrary to the belief that Jatropha does well on marginal lands and that it was these lands given over for Jatropha cultivation, the land actually given to the company (formerly ScanFuel Ltd., now ScanFarm Ghana Ltd (Agogo, Ghana)) was productive or fertile land which was being used to cultivate crops such as maize, yam, plantain, and even cocoa. The respondents claim that this has forced them to move to marginal lands which are unproductive or infertile. Respondents reported that they lost between 1 and 1000 acres (with a mean of 55.5 acres) to Jatropha cultivation. The majority (69.7%) of the 109 respondents who answered this question reported that they lost up to 10 acres, 7.3% lost between 11 and 20 acres while another 7.3% lost more than 100 acres (Table 2). Of the eight people that lost more than 100 acres of land, two people lost 850 acres each, while one person reports having lost as many as 1000 acres.

Table 2. Size of land lost by households to Jatropha investments in Ghanaian study sites.

Size of Land Lost (Acres)	Number of Respondents	Percent of Respondents
0–10	76	69.7
11–20	8	7.3
21–30	4	3.7
31–40	3	2.8
41–50	3	2.8
51–60	1	0.9
61–70	2	1.8
71–80	2	1.8
81–90	1	0.9
91–100	1	0.9
>100	8	7.3
Total	109	99.9

While the landholding system in Ethiopia is quite different to the one in Ghana, local respondents have shared similar experiences regarding land loss. In Ethiopia, most of the plantations have been carried out on arable land, grazing areas, forest land and woodlands. Farmers only have land use rights on small tracts of land, less than two hectares on average, on which they are currently cultivating. In our study sites, the government presumed that all the communal lands were waste land and leased them to investors without consideration of the socio-economic and cultural benefits that the communities were earning from such lands. This is partly because official classifications of marginal and waste land are often based on limited environmental parameters (e.g., precipitation, slope, soil nutrient levels) rather than assessments of actual land use in practice [17]. Likewise, uncertainty is exacerbated by the overlapping and improper classification of common land, waste land and pasture [32]. Our study found that farmers lost approximately 32% from their small tracts of land. The average land holding size decreased to 1.5 ha from 2.2 ha and the average cultivated land decreased from 1.73 to 1.25 ha after the plantations were established. At a site level, lands lost to plantations were nearly 10,000 hectares in Bordede, and 5000 hectares in each of Fedis and Mancha.

3.2. Household- and Community-Level Socio-Economic Effects Are Addressed

While local respondents acknowledge that the biofuel plantations have created local employment, several other anticipated benefits, including the provisioning of schools or clinics, have not been realized. The decreases in household landholdings due to the arrival of industrial Jatropha or Castor plantations (discussed above) are perceived by local respondents to be the main force that has precipitated several other important changes in their livelihoods, including household socio-economic status, food security, fallow periods, and fodder availability. These are discussed in more detail below.

3.2.1. Local- and Community-Level Benefits from Biofuel Plantations

The majority of respondents in both Ghana and Ethiopia perceive that local employment opportunities have been created by the biofuel plantations (Table 3). In Ghana, 42% of the 234 respondents interviewed reported that they personally worked for Jatropha plantations; the majority (78%) of these reported working full time while 22% indicated that they worked on a part-time basis. Those not working for Jatropha plantations reported that, because the Jatropha companies took their land without their consent and without compensation, they could not justifiably work for them. Other broader benefits that local people anticipated receiving from the plantations, including infrastructure such as schools, medical clinics and roads, do not appear to have materialized (Table 3).

Table 3. Perceptions of local- and community-level benefits from biofuel plantations.

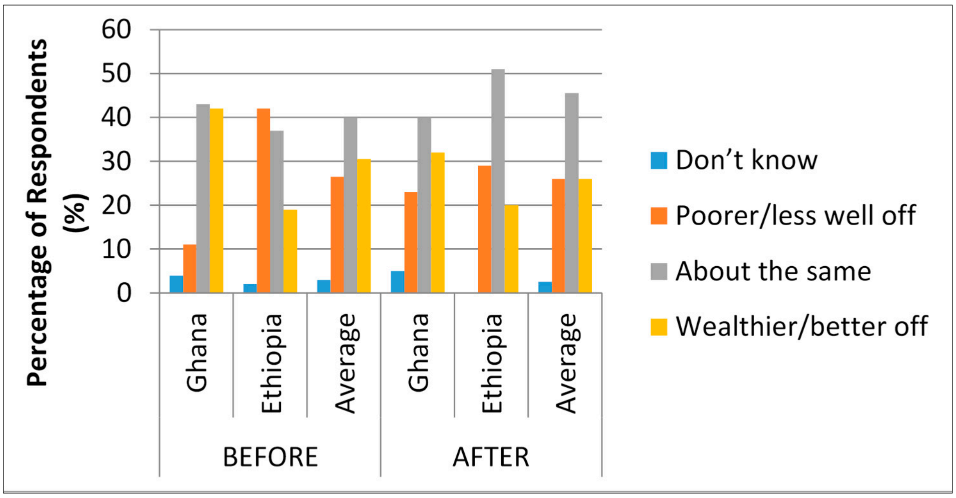
Benefit	Ghana		Ethiopia	
	Yes	No	Yes	No
Plantation created employment	155	79	53	19
The company built schools	2	232	1	71
The company built medical clinics	11	223	-	-
The company provided water wells or boreholes	34	200	16	56
The company provided/maintained local roads	1	233	2	70

3.2.2. Changes in Household Economic Status

The economic status of households in the study communities were assessed by asking respondents whether they considered their households to be poorer, wealthier or the same as their neighbors both before and after Jatropha and Castor plantations were established in their localities. This is an important line of inquiry as people are concerned about their subjective well-being, that is, people are poor if they feel poor and cannot maintain the average standard of living in the society in which they live [33]. Despite the fact that most respondents acknowledged that employment had been created through the plantations (Table 3), it is not clear if and how this benefit has reached the respondents' own households. There are differences in the data between the two countries, with Ghanaian respondents generally feeling that their household economic status has decreased since the Jatropha plantations were established, while Ethiopian respondents felt more positive about their household economic status after the industrial biofuel plantations were established (Figure 3).

In Ghana, it appears that respondents felt economically worse off after the introduction of Jatropha. Fewer people felt like they were wealthier or better off than their neighbors, and more people felt poorer than their neighbors, after Jatropha plantations were established than before. Approximately 42% of the respondents reported that they were wealthier or better off than their neighbors before Jatropha plantations were established, while 32% indicated the same after plantations were established. Of the total, 43% and 41% said that they were the same as their neighbors before and after Jatropha plantations were established, respectively. Additionally 11% indicated that they were poorer or less well off than their neighbors before Jatropha plantations were established, while 23% maintained that their households were poorer than their neighbors after Jatropha was established. The majority of the respondents attributed the decline of their living standards to Jatropha plantations which have taken vast areas of land.

Figure 3. Perceived household economic status before and after the establishment of industrial Jatropha and Castor plantations.



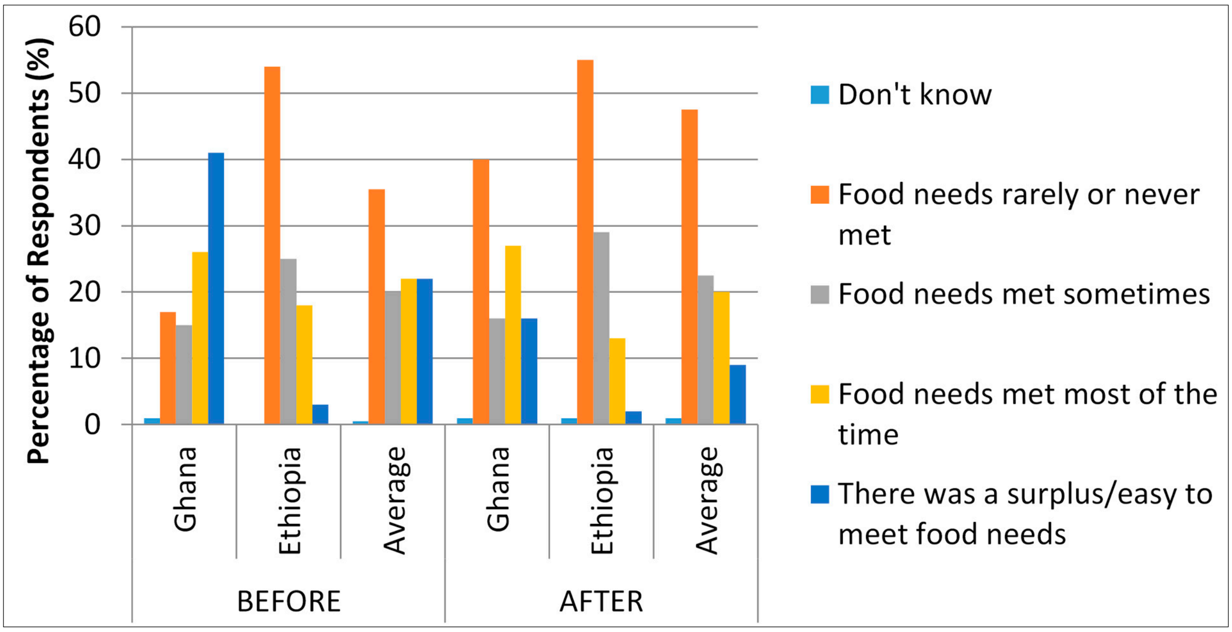
In Ethiopia, it would appear that respondents generally felt economically better off after the introduction of Jatropha and Castor. More people felt like they were of a similar economic status to their neighbors, and fewer people indicated that they were poorer or less well off than their neighbors, after the plantations were established than before. Approximately 19% and 20% of respondents reported that they were wealthier or better off than neighbors before and after the plantations were established, respectively. Thirty seven percent reported they were the same as their neighbors before the plantations were established, as compared to 51% feeling the same after. Also, 42% indicated that they were poorer or less well off than their neighbors before the plantation, while 29% stated that their households were poorer than their neighbors after the plantations were established. The balance of respondents in each country's findings was unsure of how they compared with their neighbors.

3.2.3. Local Food Security is Enhanced

The effects of Jatropha and Castor cultivation on local food production and security manifest mainly through the loss of land. As a result of land loss, households resort to reducing the area they have under cultivation and increasing cropping intensity—thus shortening the fallow period. Not only do these trends reduce immediate household income levels and food security, but are also likely to lead to land degradation and loss of soil fertility over time.

In terms of food security, the respondents were asked to recall the ease with which they were able to meet their food needs before and after Jatropha and Castor plantations were established in their regions. Overall, 22% of respondents reported there being a food surplus before the plantations were established, while only 9% reported this after the plantations were established (Figure 4). Likewise, the number of respondents reporting that their food needs were rarely or never fully met rose from 36% before plantations were established to 48% after plantations were established.

Figure 4. Perceived household food security before and after the establishment of industrial Jatropha and Castor plantations.

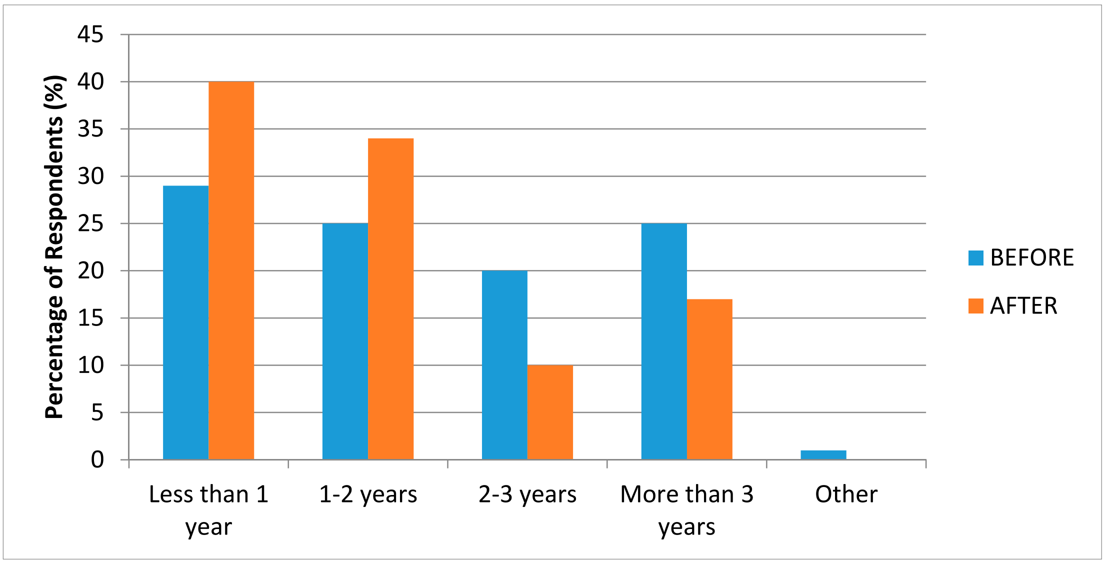


Before the Jatropha plantations were established in the Ghanaian study sites, 41% of respondents recall there being a food surplus, 26% recall their food needs were met most of the time, 15% recall their food needs were met sometimes, while 17% recall their food needs were rarely or never fully met. After Jatropha cultivation began, only 16% reported that there was a food surplus or that it was easy to meet food needs, 27% reported that they were able to meet their food needs most of the time, 16% said their food needs were met sometimes, while 40% reported their food needs were rarely or never fully met. Before Jatropha and Castor plantations were established in the Ethiopian study sites, only 3% of respondents recall there was a food surplus, 18% recall their food needs were met most of the time, 25% report their food needs were met sometimes, while nearly 54% remember that their food needs were rarely or never fully met. After Jatropha and Castor cultivation began, 2% report there was a food surplus or that it was easy to meet food needs, 13% report that they were able to meet their food needs most of the time, 29% said they were sometimes able to meet their food needs, while 55% reported their food needs were rarely or never fully met as there was not enough food.

3.2.4. Changes in Fallow Periods in Ghana

In the Ghanaian study sites, the loss of land by households has affected the length of time that farmers are able to leave their land to fallow (Figure 5). Over 46% of the 144 respondents reported that they fallowed their land for more than two years before Jatropha was cultivated in their localities. Only 26% reported doing the same after the introduction of Jatropha. More respondents (~40%) fallowed their land for less than one year after Jatropha was established as compared to those (~29%) who did so before Jatropha was established.

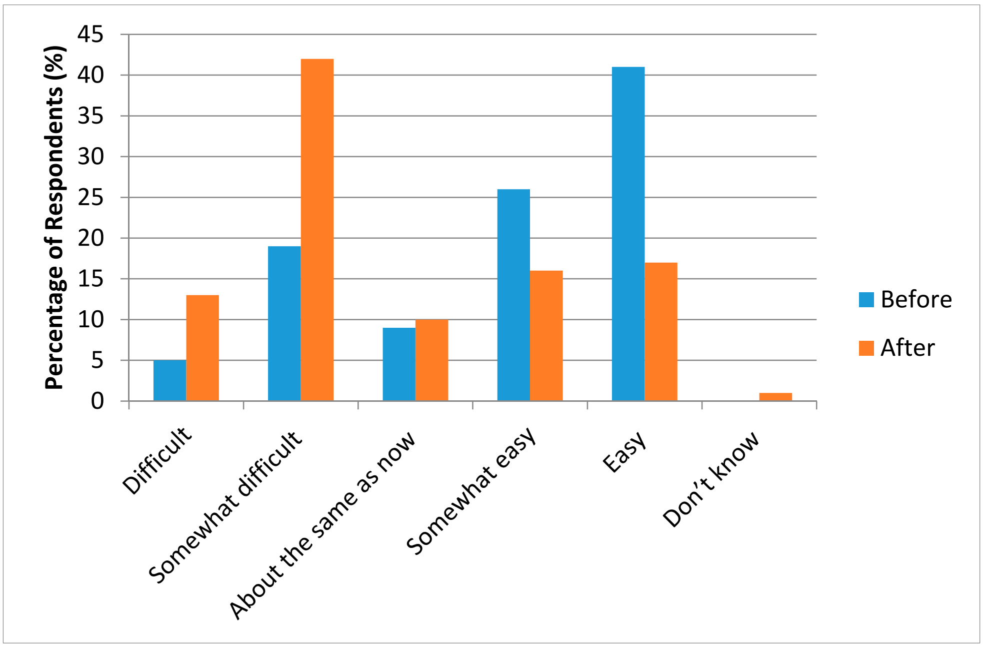
Figure 5. Changes in fallow pattern in the Ghanaian study sites before and after the establishment of industrial Jatropha plantations.



3.2.5. Changes in Fodder Availability in Ethiopia

In all of the Ethiopian study sites, the main sources of fodder for livestock were communal grazing areas. Farmers would also graze their livestock on crop residues and grasses on fallow land. However, with the amount of fodder obtained from crop residues and fallow land limited, communal grazing areas constitute the most important sources of fodder. Nearly 67% of respondents assert that it was easy to get fodder for their livestock before the introduction of Jatropha and Castor plantations (Figure 6). This dropped to about 34% after the introduction of the industrial biofuels. In addition, the plantations have restricted grazing space and livestock mobility in all the three sites.

Figure 6. Changes in fodder availability in the Ethiopian study sites before and after the establishment of industrial Jatropha and Castor plantations.



4. Discussion

This paper has presented the results of a study that assessed the perceived effects of industrial Jatropha plantations on local livelihoods in Ghana, and of industrial Jatropha and Castor plantations on local livelihoods in Ethiopia. In the introduction, we noted that the production of biofuels is still contested due to uncertainties surrounding positive environmental and social benefits, concerns about potentially negative impacts, and the manner with which land is acquired for these projects. Our results substantiate these concerns. Our respondents' skepticism about the positive benefits of large-scale biofuel investments is warranted; while local respondents acknowledge that the biofuel plantations have created local employment, several other anticipated benefits, including the provisioning of schools or clinics or roads, have not materialized. Likewise, concerns about potentially negative effects were also founded as the cultivation of Jatropha and Castor led to decreases in household landholdings which further precipitated negative impacts on household socio-economic status, food security, fallow periods, and fodder availability. Lastly, a lack of consultation characterized the manner in which land was acquired for these projects and could be considered one of the most important reasons that the biofuel projects in our study sites were not successful. This is discussed in further detail below.

In our study sties, three underlying and interconnected factors appear to have contributed to the establishment of Jatropha and Castor plantations in ways that did not necessarily contribute positively to local livelihoods were: a lack of meaningful consultation between local people, their traditional/local authorities and the biofuel company managers prior to the dissemination of land to the biofuel companies; shortcomings in each country's broader land acquisition process; and the poor availability of reliable and accurate land use information upon which land use decisions have been made.

Local respondents in both Ghana and Ethiopia report that no or little consultation occurred between themselves, the biofuel companies, and the Chief/traditional authority before their lands were taken up for biofuel plantations. Although the procedures of leasing out land for such purposes in both countries require consultation with local communities and their active participation in land delineation, the local communities in our study areas barely participated in the process. In Ghana, a majority of respondents noted that they were not consulted by the Jatropha companies or the Chief/traditional authority before their lands were taken up for Jatropha plantations. Likewise in Ethiopia, a majority of respondents reported that they did not know about the biofuel projects until "experts" from the local administration arrived to measure the land in their area. Only then were local people told that the land was being given to an investor.

Although the procedures of leasing out land for such purposes in both countries requires consultation with local communities and their active participation in land delineation, the local communities in the study sites barely participated in the entire process. This behooves us to question each country's broader land acquisition processes and land use policies as the rapid expansion of biofuels is likely to generate increased conflict over land rights and utilization [34]. In Ghana, approximately 80% of lands are customary lands belonging to local communities where chiefs are the custodians of these lands. The chiefs, as the traditional authority, are the ultimate owners of the lands and can in reality transfer land to Jatropha companies without the consent of the local farmers who occupied the land. Indeed, this is what happened in most of our study sites. The majority of local respondents presented a scathing indictment of the land acquisition process, labelling it "disrespectful", "a blatant abuse of power with sturdy control of resources", "non-transparent", and a "denial of sources of livelihoods of the rural poor by the Companies and more importantly the traditional authorities". Customary lands account for almost eighty percent of lands in Ghana, and the wholesale alienation of customary lands for plantation agriculture infringes on customary land rights. Traditional councils, typically comprised of a paramount chief and village elders, are bestowed with the sole authority to negotiate and approve the allocation of customary land [35]. Despite these statutory land arrangements, customary land users often lack documented rights to land and are therefore often at the mercy of the traditional council's capacity and will to act in accordance with their fiduciary responsibilities. In our Ghanaian study sites, the majority of respondents were farmers who lost their lands as a result of insecurity of tenure coupled with their powerlessness in confronting the custodians during the process of the acquisition of the lands for Jatropha cultivation and weaknesses in negotiating for the corresponding compensations.

In Ethiopia, land and all natural resources belong to the State, with it acting as a custodian for the country's people. As such, land cannot be sold or otherwise alienated or mortgaged. However, since land is by law State property, the government has the right to transfer land to any investor, and to pay compensation only if individuals have legal use right over the land at the moment of transfer. A lack of sound guidelines and explicit standards in Ethiopia for land allocations and sustainable land use is often identified as a major challenge to advancing large-scale biofuel investments as the land use plans required by Ethiopian law have not yet been developed and are not currently available in any of the regional states. Accordingly, the allocation of land for large-scale biofuel investments is not made on already classified land, but actually on land that is considered "unutilized" by other users in the vicinity. This rather unclear process has led many of our respondents to blame the haphazard, nontransparent, and unregulated process with which land deals and land acquisitions are made, and for their lack of participation in large-scale land acquisitions. This partly emanates from the government's assumption that the lands being considered for biofuel investments are "free" and "unutilized", and that the utilization of these lands for biofuel plantations would not affect local livelihoods. These in fact are wholly inaccurate terms, not to mention incorrect assumptions. These lands are neither "free" nor "unutilized". The lands that were given out to investors for Jatropha and Castor plantations in our Ethiopian sites were actively used by the local communities, mainly for communal grazing and shifting cultivation. One of the attractions of Africa for the biofuels industry is the perception that there are vast areas of unused or underutilized land, which can be readily given over to grow biofuel feedstocks. It is also argued that much of this so called unused land is marginal for other forms of agricultural production, and therefore its use for cultivation of biofuels does not amount to the displacement of food crops [36].

The results emerging from the Ghanaian and Ethiopian cases illuminate several ways that the emerging biofuel industries could be improved from the perspective of local people and their livelihoods. These include:

- comprehensive land inventories, and the development of sound guidelines and explicit standards for land allocations and sustainable land use, would appropriately identify potential areas for biofuel development;
- instituting and operationalising a biofuel policy to guide the acquisition of land for large-scale biofuel plantations would help to protect the vulnerable and the poor from land alienation; and
- clear and mandatory consultation procedures to ensure that customary land users have an inalienable voice in land negotiations.

Unfortunately, at this time our data points to mostly negative livelihood impacts arising from the industrial plantations of Jatropha and Castor. Astute policy development and its standardized implementation is required to ensure that the disproportionate costs of the emerging biofuel industries in both Ghana and Ethiopia do not continue to fall on local people. If done properly, the burgeoning industry could be developed in ways that minimize challenges and take advantage of the opportunities so that win-win outcomes in terms of land sovereignty, food security for the poor, energy security, and economic development are possible.

Acknowledgments

This research has been generously funded by the *Conflict and Cooperation over Natural Resources in Developing Countries* (CoCooN) programme of the Netherlands Organisation for Scientific Research (NWO).

Author Contributions

The four authors of this paper have worked collaboratively since 2010 on a Jatropha-related research project funded by the *Conflict and Cooperation over Natural Resources in Developing Countries* (CoCooN) programme of the Netherlands Organisation for Scientific Research (NWO). Through this project, country reports for Ghana and Ethiopia were prepared. Each of the coauthors on this paper authored one or both of those country reports. This paper synthesizes those two country reports in an effort to compare and contrast the experiences of both countries with Jatropha-related investment, and draws upon another paper published by Timko. All four authors have reviewed and commented on this manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References and Notes

1. Sulle, E.; Nelson, F. *Biofuels, Land Access and Rural Livelihoods in Tanzania*; IIED: London, UK, 2009.
2. Molony, T.; Smith, J. Biofuels, Food Security and Africa. *Afr. Aff.* **2010**, *109*, 489–498.
3. Bassey, N. Agrofuels: The corporate plunder of Africa. *Third World Resur.* **2009**, *223*, 21–26.
4. Bassey, N. The Agrofuels Debate in Africa: Challenges and Opportunities. In Proceedings of the Ecological Agriculture: Mitigating Climate Change, Providing Food Security and Self-Reliance for Rural Livelihoods in Africa Conference, Addis Ababa, Ethiopia, 26–28 November 2008.
5. Tsegaye, W.; Glantz, M.H. *Biofuels in Africa: A Path Way to Development*, Occasional Paper No. 43; International Research Center for Energy and Economic Development: Boulder, CO, USA, 2009.

6. Timko, J.A. An Analytical Framework for Assessing the Impacts of *Jatropha Curcas* on Local Livelihoods. In *Conflict and Cooperation over Natural Resources in the Global South: Conceptual Approaches*; Bavinck, M., Pellegrini, L., Mostert, E., Eds.; CRC Press; Taylor and Francis Group: Boca Raton, FL, USA, 2014; pp. 173–191.
7. Skutsch, M.; de los Rios, E.; Solis, S.; Riegelhaupt, E.; Hinojosa, D.; Gerfert, S.; Gao, Y.; Masera, O. Jatropha in Mexico: Environmental and social impacts of an incipient biofuel program. *Ecol. Soc.* **2011**, *16*, 11, doi:10.5751/ES-04448-160411.
8. Ewing, M.; Msangi, S. Biofuels production in developing countries: Assessing tradeoffs in welfare and food security. *Environ. Sci. Policy* **2009**, *12*, 520–528.
9. Birega, G. Agrofuels Beyond the Hype: Lessons and Experiences from other Countries. In *Agrofuel Development in Ethiopia: Rhetoric, Reality and Recommendations*; Heckett, T., Aklilu, N., Eds.; Forum for Environment: Addis Ababa, Ethiopia, 2008; pp. 67–82.
10. Cotula, L.; Dyer, N.; Vermeulen, S. *Fuelling Exclusion? The Biofuels Boom and Poor People's Access to Land*; IIED: London, UK, 2008.
11. Achten, W.M.; Mathijs, E.; Verchot, L.; Singh, V.; Aerts, R.; Muys, B. Jatropha biodiesel fuelling sustainability? *Biofuels Bioprod. Biorefin.* **2007**, *1*, 283–291.
12. Openshaw, K. A review of *Jatropha curcas*: An oil plant of unfulfilled promise. *Biomass Bioenerg.* **2000**, *19*, 1–15.
13. Achten, W.M.; Maes, W.H.; Aerts, R.; Verchot, L.V.; Trabucco, A.; Mathijs, E.; Singh, V.P.; Muys, B. *Jatropha*: From global hype to local opportunity. *J. Arid Environ.* **2010**, *74*, 164–165.
14. Achten, W.M.J.; Verchot, L.; Franken, Y.J.; Mathijs, E.; Singh, V.P.; Aerts, R.; Muys, B. *Jatropha* bio-diesel production and use. *Biomass Bioenerg.* **2008**, *32*, 1063–1084.
15. KnowGenix. Sustainable Biodiesel Feedstock: Jatropha: A Strategic Option. In Proceedings of the Jatropha World Conference, Jakarta, Indonesia, 23–24 January 2008.
16. Jingura, R.M.; Matengaifa, R.; Musademba, D.; Musiyiwa, K. Characterisation of land types and agro-ecological conditions for production of Jatropha as a feedstock for biofuels in Zimbabwe. *Biomass Bioenerg.* **2011**, *35*, 2080–2086.
17. Findlater, K.M.; Kandlikar, M. Land use and second-generation biofuel feedstocks: The unconsidered impacts of *Jatropha* biodiesel in Rajasthan, India. *Energy Policy* **2011**, *39*, 3404–3413.
18. Brittaine, R.; Lutaladio, N. *Jatropha: A Smallholder Bioenergy Crop. The Potential for Pro-Poor Development*; FAO: Rome, Italy, 2010.
19. Jongschaap, R.; Corre, W.; Bindraban, P.S.; Brandenburg, W.A. *Claims and Facts on Jatropha curcas L: Global Jatropha curcas Evaluation, Breeding and Propagation Programme*; Report 158; Plant Research International: Wageningen, The Netherlands, 2007.
20. Ariza-Montobbio, P.; Lele, S. Jatropha plantations for biodiesel in Tamil Nadu, India: Viability, livelihood trade-offs, and latent conflict. *Ecol. Econ.* **2010**, *70*, 189–195.
21. Weyerhauser, H.; Tennigkeit, T.; Yufang, S.; Kahrl, F. *Biofuels in China: An Analysis of the Opportunities and Challenges of Jatropha Curcas in Southwest China*; ICRAF Working Paper Number 53; ICRAF: Beijing, China, 2007.
22. United Nations Industrial Development Organization (UNIDO). *Castor Oil Production and Processing*; United Nations: New York, NY, USA, 1974.

23. Onwueme, I.C.; Sinha, T.D. *Field Crop Production in Tropical Africa, Principals and Practice*; Technical Center for Agricultural and Rural Co-operation: Wageningen, The Netherlands, 1991.
24. Desai, B.B. *Seeds Handbook: Biology, Production, Processing and Storage*; Marcel Decker: New York, NY, USA, 2004.
25. Atsmon, D. Castor. In *Oil Crops of the World: Their Breeding and Utilization*; Robbelen, G., Downey, R.K., Ashri, A., Eds.; McGraw-Hill: New York, NY, USA, 1989; pp. 438–447.
26. Seegeler, C.J.P. *Oil Plants in Ethiopia: Their Taxonomy and Agricultural Significance*; Agricultural Research Reports, Issue 921; Center for Agricultural Publishing and Documentation: Wageningen, The Netherlands, 1983.
27. Anderson, G.Q.A.; Haskins, L.R.; Nelson, S.H. The Effects of Bioenergy Crops on Farmland Birds in the UK: A Review of Current Knowledge and Future Predictions. In *Biomass and Agriculture: Sustainability, Markets and Policies*; Parries, K., Point, T., Eds.; OECD: Paris, France, 2004; pp. 199–218.
28. Alemaw, G.; Alamayehu, N. *Highland Oilcrops: A Two-Decade Research Experience in Ethiopia*; Research Report No. 30; Institute of Agricultural Research: Addis Ababa, Ethiopia, 1997.
29. Antwi-Bediako, R. (RECA, Accra, Ghana); Acheampong, E. (KNUST, Kumasi, Ghana); Campion, B. (KNUST, Kumasi, Ghana); Eworyi, S. (RECA, Accra, Ghana); Timko, J. (AFRICAD, Vancouver, BC, Canada); Hoogland, M. (Both Ends, Amsterdam, The Netherlands). Assessing the Socio-Economic Implications of Industrial Biofuel Plantations: Repercussions of *Jatropha curcas* on Rural Land Use Alienation and Conflict Escalation in Ghana. Unpublished work, 2012.
30. Amsalu, A. (Addis Ababa University, Addis Ababa, Ethiopia); Teferi, M.K. (HoA-REC&N, Addis Ababa, Ethiopia); Antwi-Bediako, R. (RECA, Accra, Ghana); Timko, J. (AFRICAD, Vancouver, BC, Canada); Hoogland, M. (Both Ends, Amsterdam, The Netherlands). Assessing the Socio-Economic Implications of Industrial Biofuel Plantations: Repercussions of Jatropha curcas on Rural Land Use Alienation and Conflict Escalation in Ethiopia, Country Report. Unpublished work, 2012.
31. Schoneveld, G.C.; German, L.A.; Nutakor, E. Land-based investments for rural development? A grounded analysis of the local impacts of biofuel feedstock plantations in Ghana. *Ecol. Soc.* **2011**, *16*, 10.
32. Agoramoorthy, G.; Hsu, M.J.; Chaudhary, S.; Shieh, P.-C. Can biofuel crops alleviate tribal poverty in India's drylands? *Appl. Energy* **2009**, *86*, S118–S124.
33. Galbraith, J.K. *The Affluent Society*; Houghton Mifflin Harcourt: Boston, MA, USA, 1984.
34. Peskett, L.; Slater, R.; Stevens, C.; Dufey, A. *Biofuels, Agriculture and Poverty Reduction*; Natural Resource Perspectives 107; Overseas Development Institute (ODI): London, UK, 2007.
35. Government of Ghana. *Administration of Lands Act, 1962*; Government of Ghana: Accra, Ghana, 1962.
36. Cotula, L.; Vermeulen, S.; Leonard, R.; Keeley, J. *Land Grab or Development Opportunity? Agricultural Investment and International Land Deals in Africa*; FAO, IIED and IFAD: London, UK; Rome, Italy, 2009.