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ORIGINAL ARTICLE

Towards a classification of the drivers of jatropha collapse in Ghana elicited from the perceptions of multiple stakeholders

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Abstract

Jatropha for biofuel production created high expectations in Ghana for boosting rural development and national energy security. In the mid-to-late 2000s, large areas were allocated across the country to jatropha investments that eventually collapsed. Jatropha collapse has been prevalent across Africa but few studies have empirically addressed the (a) drivers of jatropha collapse (b) post-collapse impacts, and (c) future acceptability of jatropha. Through household surveys and expert interviews, we capture the perceptions of key stakeholders in Ghana involved in the biofuel sector at the national/regional level and local communities around six collapsed jatropha projects. Key drivers of collapse include the (a) low jatropha productivity, (b) weak business planning, (c) community conflicts, (d) institutional barriers, and (e) civil society opposition. Land-related issues are central to almost all of these drivers of collapse. While there is currently considerable scepticism among stakeholders about the future of the biofuel sector in Ghana (and especially of jatropha), there is still some interest in jatropha as reflected in community surveys and recent government policies. As we could not identify a single dominant driver of jatropha collapse locally or nationally "silver bullet" solutions might not exist. However, improving the land administration system would be a key if the negative past experiences of jatropha boom and bust are to be avoided.

Keywords Biofuels · Jatropha · Collapse · Sustainability · Ghana

Introduction

Biofuels were strongly promoted in the late 2000s in Sub-Saharan Africa (SSA) as a rural development and energy security strategy (Gasparatos et al. 2015). In an effort to reduce the negative effects of biofuel expansion on food security, many national governments promoted the cultivation of non-food feedstocks (mainly jatropha) or combinations of food and non-food crops (Gasparatos et al. 2015; Wendimu 2016).

By the late 2000s, biofuels had drawn widespread criticism in SSA due to their various negative environmental impacts such as land use change, biodiversity loss, greenhouse gas emission, water pollution, and high water demand (Achten and Verchot 2011; Van Eijck et al. 2014; Gasparatos et al. 2015; von Maltitz et al. 2016). Several authors have also highlighted some of the negative socioeconomic impacts of biofuel feedstock production such as low levels of income/employment, generation, food insecurity, and land tenure disputes among others (e.g. German et al. 2013; Van Eijck et al. 2014; Mudombi et al. 2016; Gasparatos et al. 2015; Schoneveld et al. 2011).

Since the early 2010s, with a few exceptions, most of the jatropha projects in SSA collapsed (e.g. von Maltitz et al. 2014; Gasparatos et al. 2015). Some of the main drivers of jatropha collapse in SSA include low productivity in Ethiopia and southern Africa (von Maltitz et al. 2014; Wendimu

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Table 1 Major biofuel policies in Ghana. Source: Adapted from Ahmed et al. (2017a)

Year	Policy direction	Institution
2005	B20 by 2015	National Jatropha Planning Committee
2006	5% gasohol (E5) by 2010, B10 by 2015 (recommended targets)	National Jatropha Planning Committee, Energy Commission
	10% biofuel blending in transport fuel by 2015, 20% by 2020 (final agreed target)	Energy Commission
2007	Commited 1,000,000 ha in 53 districts for jatropha outgrower schemes	National Jatropha Planning Committee
2008	Promotion of large-scale plantations through FDIs	Ghana Investment Promotion Centre
2010	Bioenergy policy with revised targets (10% biofuel blending by 2020, 20% by 2030)	Energy Commission
	Ghana to achieve a net-exporter status for biofuel feedstocks	
	New feedstock options include sugarcane and oil palm	
2011	Renewable Energy Act, 2011 (formal processes of licensing and permitting)	Energy Commission 2011
2012	Draft guideline for large-scale land acquisitions in Ghana	Lands Commission 2012
2015	Draft national sugarcane policy	Ministry of Trade and Industry, 2015

2016), weak planning in Tanzania (Hashim 2014), conflict of interest among local stakeholders in Kenya (Hunsberger 2010), inappropriate business practices in Madagascar (Neimark 2016), lack of innovation in Mozambique (Schut et al. 2011), lack of market development in Zambia (Kunda-Wamuwi et al. 2017), and the general fact that jatropha is an undomesticated crop (Achten et al. 2010a, b). Jatropha collapse has further fuelled the debate about whether biofuel crops can be grown sustainably in Africa, and at the same time have the anticipated energy security and rural development benefits (Hashim 2014; Edrisi et al. 2015).

Ghana, such as other countries in SSA, experienced the rapid rise (Schoneveld 2014), and subsequent negative sustainability impacts and collapse of the jatropha sector (Ahmed et al. 2017a). The first national biofuel target in 2005 was to blend 20% biodiesel (B20) in state vehicles through jatropha outgrower schemes spanning 1,000,000 ha in 53 districts (Brew-Hammond 2009; Ahmed et al. 2017a) (Table 1). Following disappointing results, the government promoted large-scale jatropha production in plantations mainly financed through foreign direct investments (FDI) that allocated hundreds of thousands of hectares across the country (Schoneveld 2014). Overall, 21 large-scale jatropha projects were licensed between 2008 and 2011 on 950,131 ha of land (ActionAid 2012; Ahmed et al. 2017a). This support at the national level reflected, and at the same time reinforced, the expectations for employment generation and rural community development (Nyari 2008; Boamah 2014a).

However, by the early 2010s almost all jatropha projects in Ghana had collapsed (Ahmed et al. 2017a). This raises important questions of (a) why/how this happened, (b) what are the post-collapse sustainability impacts around jatropha plantations, and (c) whether there is still acceptability jatropha in Ghana. However, we currently lack a comprehensive understanding of what drove the collapse of the jatropha sector in Ghana (and more broadly in SSA). Most related studies either report observations/opinions of the authors or a synthesis of the literature (Ahmed et al. 2017a; von Maltitz et al. 2014). In the relatively few papers that have tackled issues around jatropha collapse this was a secondary theme rather than the main focus of the study (and in most cases came from single study sites) (e.g. Boamah 2014a, b; Hashim 2014; Neimark 2016). Furthermore, there is a critical lack of studies on how the perceptions of what drove jatropha collapse can vary between different stakeholders. The literature about the local post-collapse impacts and future acceptability of jatropha (and other biofuel crops) is practically non-existent as most papers have either focused on impacts during the early phases of jatropha projects such as the first 2–3 years after set-up and before collapse (Gasparatos et al. 2015), (for some exceptions see von Maltitz et al. 2016; Mudombi et al. 2016). To the author's best knowledge, no studies have adopted a clear methodological approach to unravel the perceptions of stakeholders across the multiple drivers of jatropha collapse.[1]

The aim of this paper is in twofold. First, it seeks to fill the existing knowledge gaps surrounding the collapse of jatropha projects in SSA, and Ghana in particular. Second, it responds to demands from policymakers and practitioners to extract the key lessons learnt from the collapse of the jatropha sector, as a means of informing future bioenergy policies in Ghana (and possibly elsewhere in SSA).

While jatropha was promoted in several African countries (Gasparatos et al. 2015; von Maltitz et al. 2014), Ghana was

[1] For the purpose of this paper the term "drivers of collapse" refers to the factors that have led to the total halting/failure of jatropha activities nationally and locally. We view underperformance (e.g. lower productivity, economic output) of operational jatropha projects as a different phenomenon (i.e. partial failure), which is outside the scope of this paper.

one of the few countries (alongside Mozambique, Tanzania, Zambia) that was targeted to such a large extent (Schoneveld 2014; Romijn et al. 2014). At the same time, Ghana has very diverse climatic, agro-ecological and socioeconomic conditions. Jatropha production was scattered all over the country ranging from coastal savanna areas in the south, to deciduous forest, transition forest and Guinea savanna areas moving towards the north (Ahmed et al. 2017a) (see Fig. S1, Supplementary Electronic Material). Apart from these agro-ecological differences, the areas that hosted jatropha production had very large differences in land tenure systems and poverty levels, all of which can affect jatropha sustainability (Ahmed et al. 2017a, b). Ghana thus offers a unique opportunity to undertake a comparative analysis of jatropha collapse and post-collapse dynamics in Western Africa, as through careful site selection it is possible to gain a comparative understanding of what drove jatropha collapse in areas with radically different ecological and socioeconomic characteristics (refer to Sect. "Study sites" for site selection).

We use a methodological approach based on Sustainability Science that allows the synthesis of perceptions from different stakeholders such as national/local experts, local key informants, and local communities (Sect. "Methodology"). The key drivers of the collapse of the jatropha sector nationally and locally are identified through expert interviews with national/regional stakeholders and field surveys around six-collapsed jatropha projects (Sect. "Task 1: drivers of jatropha collapse"). Through a rapid sustainability assessment, we identify the perceptions of local communities about sustainability impacts during the operation and following the collapse of each project (Sect. "Task 2: sustainability impacts of collapsed jatropha projects"). Section "Task 3: future acceptability" outlines the future acceptability of biofuel/jatropha projects by local people and the post-collapse local narratives relevant for understanding the biofuel regime in Ghana. Section "Discussion" puts these findings into perspective. It discusses the main lessons learnt from the collapse of the jatropha sector in Ghana, possible interventions that can enhance the sustainability of future biofuel efforts in the country, as well as the limitations of the study and future research directions. Section "Conclusions" outlines the major conclusions of the paper focusing on the importance of reforming the land administration system to avoid similar boom-and-bust cycles in the future.

Methodology

Research approach

Sustainability science can provide a useful framework both to synthesize biofuel knowledge and frame empirical studies (Gasparatos et al. 2013a). For this reason, our methodological approach adopts key principles of sustainability science (Kates et al. 2001; Kates 2011) such as (a) a problem-oriented approach, (b) an ability/approach to link social and ecological systems, (c) an inter- and transdisciplinary focus, and (d) an open mindset to include knowledge from different systems, e.g. scientific knowledge, expert opinion and/or local knowledge.

Regarding (a) we perceive the collapse of jatropha as a key policy question, so we structured this paper around the policy-related questions of "why jatropha projects failed", "what have been their post-collapse impacts", and "is there still acceptability for jatropha investments".

Regarding (b) we studied the collapsed jatropha projects as embedded in the broader social–ecological systems of each study site, interacting both with the natural environment and the socioeconomic structures (e.g. von Maltitz et al. 2016; Oberlack et al. 2016). For this reason, we considered key socioeconomic and environmental impacts of jatropha collapse in each area (Sect. "Task 2: sustainability impacts of collapsed jatropha projects").

Regarding (c) and (d) we capture and elicit the perceptions of different stakeholders such as local communities, practitioners or policymakers related to the jatropha sector. Understanding the perceptions of such stakeholders is essential for understanding issues related to the performance of jatropha projects (e.g. Hunsberger 2010; Arevalo et al. 2014; Rivero et al. 2016; Timko et al. 2016). These stakeholders often have radically different knowledge about jatropha collapse through their personal experiences living in the vicinity of collapsed projects (i.e. local communities, key informants); or working on multiple facets of the Ghanaian biofuel sector (i.e. national/regional experts). We use different analytical tools to elicit the perceptions of the different stakeholders such as qualitative analysis of expert interviews and statistical analysis of household surveys. We deem all perceptions of stakeholders involved or affected by biofuel investments as credible, as we do not wish to treat any actor/stakeholder as having a priority over the others. This is justified as we wish to capture the wealth of different perceptions rather than rank them. Such multi-stakeholder approaches that elicit the plurality of stakeholder perceptions have been used to study other industrial crop systems such as oil palm (Moreno-Penaranda et al. 2015). Selected stakeholders were identified through an extensive policy and institutional analysis of the biofuel sector in Ghana (Ahmed et al. 2017a).

Data collection and analysis

We collected data between 1 and 21 September 2015, with supplementary data collected in February–March 2016. We used a combination of techniques to capture the three

Table 2 Summary of data collection mechanisms

Task	Topic	Scale	Data collection	Respondents	Respondents
1	Drivers of collapse (Sect. ""Task 1: drivers of jatropha collapse")	National	Expert interviews	21	National/regional experts involved in biofuel activities in Ghana. Selected based on the institutional analysis by Ahmed et al. (2017a)
		Local	Key informant interviews	10	Four local chiefs, two opinion leaders, Four former plantation managers
			Household surveys	201	Local households selected randomly in each community
2	Post-collapse sustainability impacts (Sect. "Task 2: sustainability impacts of collapsed jatropha projects")	Local	Household surveys	201	Local households selected randomly in each community
3	Future acceptability of jatropha/biofuels (Sect. "Task 3: future acceptability")	Local	Household surveys	201	Local households selected randomly in each community

pertinent questions related to the collapse of jatropha projects (Table 2):

(a) what are the drivers of the collapse of the jatropha sector (as a whole) and of the six selected projects in particular? (Task 1)
(b) what are the sustainability impacts of collapsed jatropha projects on local communities? (Task 2)
(c) what is the acceptability of jatropha (or other biofuel feedstocks) in areas around collapsed jatropha projects? (Task 3)

For Task 1, we conducted 21 expert interviews to understand the drivers of jatropha collapse in Ghana as a whole (Table 2). Stakeholders were identified through an extensive policy and institutional analysis (Ahmed et al. 2017a). The site-specific drivers of jatropha collapse were extracted from key informant interviews in each study site and open-ended questions in a household survey ($N=201$) (see Table S1 in Supplementary Electronic Material for a list of interviewed stakeholders).

The interviews and open-ended questions were transcribed and then analysed with *Atlas.ti* to identify the emerging patterns. Responses regarding the drivers of collapse are grouped across two tiers of aggregation and visualised as network diagrams. These first-tier drivers of collapse were subsequently grouped into five second-tier drivers of collapse that reflect the four major elements of the concept of "biofuel complex" (Borras et al. 2010): crops, institutions, land, and stakeholders.

For Task 2, household survey respondents ($N=201$) were asked to rate their perception for each sustainability impact for two time intervals ("during the operation" and "after the collapse" of each project) using the following Likert-type scale (see von Maltitz et al. 2016): increased significantly, increased moderately, remained the same, decreased moderately and decreased significantly.

For each sustainability impact category and time interval, the response with the highest frequency was used. The deeper the colour in each cell the higher the prevalence of the response among community members. The higher the prevalence of an answer, the higher the consensus about the specific sustainability impact within the community (see Supplementary Electronic Material for more details on methodology and disaggregated data, Table S3).

For Task 3, respondents stated their willingness to accept another jatropha project and/or other biofuel crops (e.g. sugarcane, oil palm) in their community. Responses for future acceptability were expressed as frequencies (see Supplementary Electronic Material for more details on methodology and disaggregated data, Table S3-S7).

Study sites

Study sites (Fig. 1) were selected after documenting jatropha investments in Ghana by (a) geographical location and ecological zone (b) ownership type (i.e. foreign-led, joint venture), and (c) verified land size (Ahmed et al. 2017a). To allow for some level of variation, study sites reflect different geographical/agro-ecological settings, different countries of origin of investors, represented a mix of FDIs and joint ventures with Ghanaian companies, and were located in districts with different incidences of poverty (Table 3). Selected sites reflect a cross-section of project/area characteristics that can influence jatropha impact and collapse as identified in the literature both for Ghana (e.g. Ahmed et al. 2017a) and elsewhere in Africa (e.g. Gasparatos et al. 2015).

All selected projects started their operation after 2005 when the first national biofuel targets were adopted (Table 1), and collapsed by 2012, operating on average for 4.5 years. In terms of size, land acquisitions ranged between 2300 and 120,000 ha, with actual cultivated land ranging between 202 and 5000 ha. Local chiefs and middlemen mediated the land acquisition processes in all study sites,

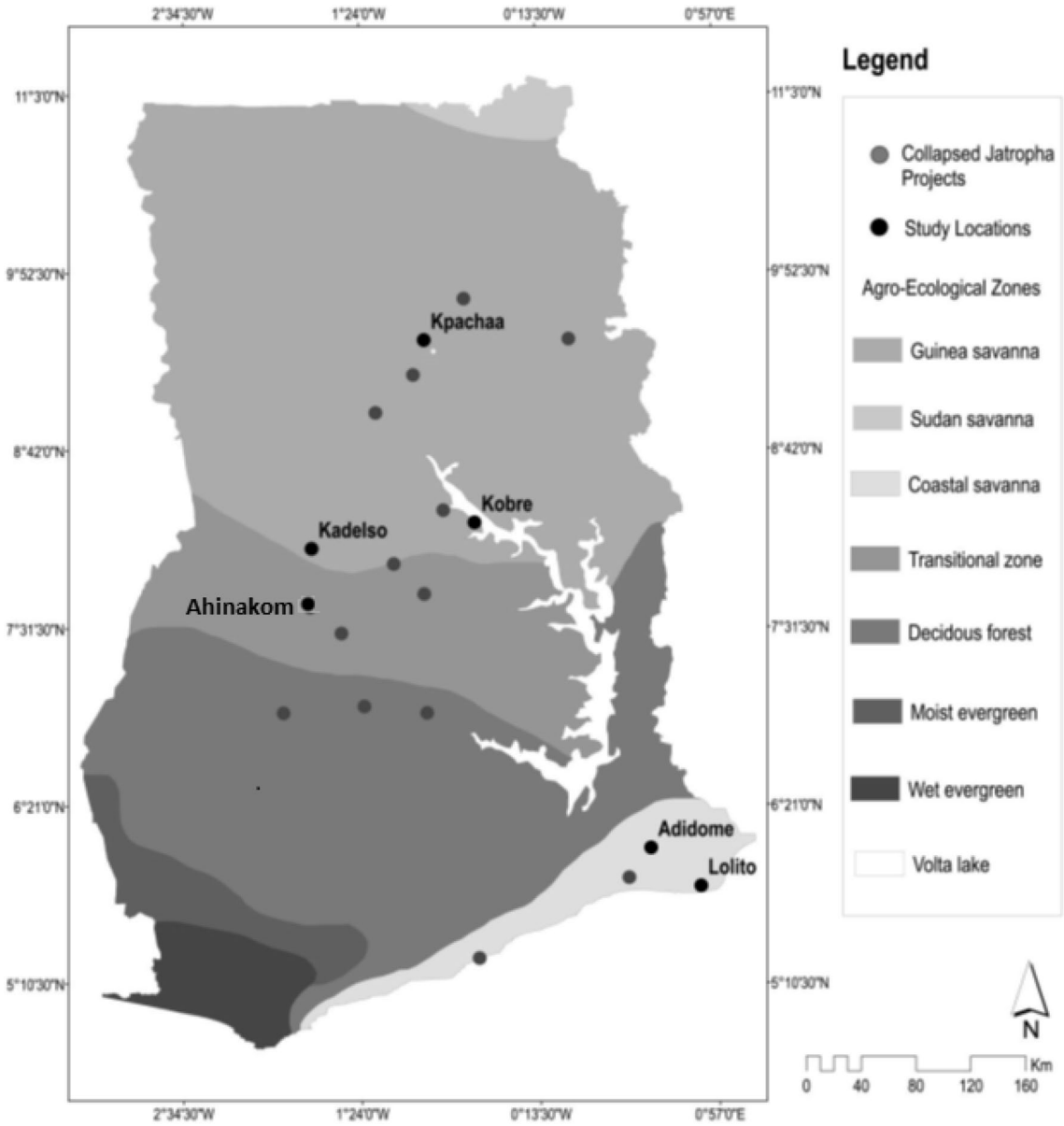

Fig. 1 Location of collapsed jatropha projects and study sites in Ghana

often without any meaningful local consultation, community participation or adequate compensation (Ahmed et al. 2016; 2017a).

Geographically, Kpachaa is in the Northern Region (Mion District) with a relatively high incidence of extreme poverty (35%) (Ghana Statistical Service 2015). Kobre, Kadelso, and Ahinakom are located in the Brong-Ahafo Region (Pru, North Kintampo and South Kintampo Districts, respectively) in the transitional forest zone. The incidence of poverty is 36, 42 and 45% for Pru, North Kintampo, and South Kintampo Districts, respectively (Ghana Statistical Service 2014, 2015). Finally, Lolito and Adidome (South and North Tongu Districts, respectively) are in the coastal savannah zone of the Volta Region and have high extreme poverty incidence of 46 and 42%, respectively (Ghana Statistical Service 2015).

Household survey samples varied between communities, ranging between $N = 29$–40 (Table 3). We aimed to capture at least 15% of households in each community.

Table 3 Characteristics of collapsed projects in each study site. Source (Ghana Statistical Service 2014, 2015; Ahmed et al. 2017a)

	Kpachaa	Kadelso	Kobre	Ahinakom	Adidome	Lolito
Administrative region	Northern	Brong Ahafo	Brong Ahafo	Brong Ahafo	Volta	Volta
Investor name	BioFuel Africa	Jatropha Africa	Kimminic Corporation	Savannah Black Farming	Galton Agro Ltd	BioFuel Africa
Investor origin	Norway	UK/Ghana	Canada/Ghana	United States	Israel	Norway
Year of start	2006	2007	2007	2007	2008	2007
Year of collapse	2011	2012	2012	2011	2012	2011
Land acquired/sold (ha)	10,696	120,000	50,000	4000	100,000	2300
Land cultivated with jatropha (ha)	1000	5,000	1050	202	325	1500
Ecological zone	Guinea savannah	Guinea savannah	Transitional forest	Transitional forest	Deciduous forest	Deciduous forest
Previous land use	Cropland, woodland	Cropland, woodland	Cropland, woodland	Cropland, woodland	Cropland, woodland	Flood plains
Water management	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed
Average temperature (°C)	14–40	24–30	27–40	24–30	16–30	14–28
Soil type	Voltarian sandstone	Voltarian sandstone	alluvial soils	Laterite and some ochrosols	Dahomeyan Acidic Gneiss	Coarse textured alluvial
Annual rainfall (mm)	750–1050	950–1200	800–1400	1400–1800	1000–1200	900–1100
Incidence of poverty in study districts (%)	35.3	35.9	41.9	44.7	46.0	41.7
Land acquisition process						
Responsible for allocating land to investors	Chief	Chief	Chief	Chief	Chief	Chief
Consultation with local community	No	No	Yes	Yes	No	No
Compensation	Only to few households	Only to few households	Only to few households	Only to few households	No	No
Land title type	Lease	Lease	Lease	Lease	Lease	Lease
Number of surveys	37	31	29	30	40	33
Surveys as fraction of local community (%)	33	16	8	30	19	16

As of 2014, households in Ghana with an annual income below GH 1314 (US$328) are considered poor, and extremely poor when they earn below GH 792 (US$198) (Ghana Statistical Service 2015)

Results

Task 1: drivers of jatropha collapse

Government organisations

Government organisations comprehend the drivers of jatropha collapse in terms of institutional yardsticks and mismatches between the promises made by companies and what actually materialised. The Lands Commission (the main land administration organisation in Ghana) perceives that jatropha collapse was driven by three weaknesses in land administration (Fig. 2; Table 4). First, the international interest in jatropha investments created a new space for large-scale land acquisitions, which were not subject to any regulatory framework, at the time of the biofuel boom there was no guideline for large-scale acquisitions in Ghana. Second, because the Lands Commission did not have the capacity to address such acquisitions, many investors took the opportunity of the existing lack of oversight (largely reinforced by the lack of a land ownership database in Ghana) to gain access to large tracts of land.

Fig. 2 Drivers of collapse as expressed by national and regional stakeholders

Thirdly, the definition of marginal land, the identification of such marginal lands, and the establishment of jatropha on such lands was not entirely possible. This is because it is difficult, if not impossible, to identify such continuous parcels of 'marginal' land at the scale necessary to develop large-scale plantations that span thousands of hectares. In reality, most jatropha projects engulfed agricultural land, settlement areas and/or forest/woodland, which ignited conflicts between companies and local communities (Ahmed et al. 2017b). Such conflicts largely emanated from the lack of national agro-ecological zoning and land use planning to demarcate and apportion areas suitable for different land uses.

However, at the regional level, Lands Commission offices comprehend jatropha collapse differently. For the Northern Region Lands Commission, the major driver was land litigation that was initiated due to the illicit activities of chiefs (Fig. 2). In many cases, chiefs played a crucial role in land acquisition processes often lacking accountability and transparency in disclosing information of the land

Table 4 Summary of national drivers of jatropha collapse

Category	Stakeholder	First-tier drivers	Second-tier drivers
National government organisations	Energy Commission	Inadequate research	Poor land administration
		Low employment	Weak business planning
		Institutional arrangements and support	
	Lands Commission	Lack of land information bank	Poor land administration
		Lack of agro-ecological zoning	Civil society campaigns
		Community conflicts	
	Town and Country Planning Department	Shifting of strategies of companies from jatropha to food crops	Weak business planning-
		Use of marginal lands	Lack of funding
	Environmental Protection Agency	Marginal lands	Low productivity of the crop
	Ministry of Food and Agriculture	Marginal lands	Low productivity of the crop
Local government agencies	Regional Lands Commission	Land litigation	Poor land administration
		Little experience growing jatropha	
		Malpractices of chiefs	
		Lack of M&E for FDIs	
		Low compensation	
	Regional Environmental Protection Agency	Land litigation	Poor land administration
		Use of marginal lands	Low productivity of the crop
	Regional Ministry of Food and Agriculture	No local programmes	Poor land administration
		Marginal land	
		Poor institutional support	Low productivity of the crop
Civil society organisations	Civil Society Coalition on Land	Lack of community participation	Civil society campaigns
		Low employment benefits for locals	Poor land administration
		Institutional arrangements/support	Weak business planning
		No need assessments	Lack of funding
		Non-payment of salaries	
	ActionAid Ghana	Human right abuses	Civil society campaigns
		Inappropriate community entry	
		Inadequate research	
		Low compensation	
	Oxfam Ghana	Inadequate research	Civil society campaigns
		Ignorance of chiefs	Weak business planning
		Use of marginal lands	
	Agricultural Workers Union (AWU)	Non-payment of salaries	Civil society campaigns
		Malpractices of chiefs-	
		Low compensation for land by companies	
Private sector	Smart Oil Ltd	Mismanagement	Civil society campaigns
		Human rights abuses	Weak business planning
		Lack of research	
		Negative perceptions	Lack of funding
	CEHRT	Human rights abuses	Civil society campaigns
		Donor funding withdrawal	

deals to local communities. When the affected communities got informed that chiefs had taken money (and did not give them their compensation), it usually led to agitations from those affected. According to the Brong Ahafo Region Lands Commission, the central issue was violations in land acquisition processes and the inability of investors to meet local community expectations on employment and income. In addition, the Environmental Protection Agency (EPA) and

the Volta Region Lands Commission indicate that the major driver of jatropha collapse was the decision to grow jatropha on marginal lands, which led to low oilseed productivity. From EPA's perspective, most investors did not undertake proper business planning and research about the crop and the appropriate agronomic practices.

The Energy Commission is the major non-decentralised government agency in the biofuel sector. Expert interviews suggested three main drivers of collapse. The first relates to the lack of institutional support for investors. The government planned to create an enabling environment in terms of tax incentives and opportunities for domestic bank loans. However, this was never implemented despite many companies calling for government support to enable them to access domestic loans following donor withdrawal (especially, during the 2008 financial crisis). The second driver relates to inadequate research from investors on appropriate crop varieties, while the third was the push to grow jatropha on marginal lands. Both drivers eventually curtailed business profitability as observed in the specific case studies described below.

Similarly, the Town and Country Planning Department (TCPD), an organisation responsible for land use planning, suggested that the promotion of jatropha on marginal lands took a toll on crop yields and contributed to project collapse. Another driver was the shifting business strategies of some investors. Cases were cited of companies shifting their operations from large-scale jatropha production to food crops or other endeavours after promising jobs and income to local communities. These unmet expectations led to, in some cases, social conflicts as described see below.

Civil society organisations (CSOs)

CSOs perceive jatropha collapse mainly based on the widespread abuse of human rights[2] that created a snowballing effect towards CSO campaigns, community conflicts and funding withdrawal from donors (Fig. 2; Table 4). Actually, several CSOs cite that human rights abuses catalysed their involvement in aggressive campaigns to halt biofuel activities. This motivation is also driven by their perception that biofuel activities had ignited land grabbing and land dispossession, with little or no compensation to local communities. In fact, the interviewed CSOs inadvertently see land dispossession as the major source of human rights abuse in communities around jatropha projects. However, there are some differences between CSOs on how they framed their advocacy activities.

The Civil Society Coalition on Land (CICOL) frames their argument around the lack of formal land acquisition processes that created the pre-conditions for human rights abuse. Oxfam rather points to the illicit activities of local institutions such as chieftaincy as the sources of abuses, and the lack of agronomic research and investor experience that curtailed the social and economic viability of projects. These created a leeway for Oxfam's entry in campaigns against jatropha expansion as it became apparent to the organization that the lack of viability would give rise to a series of unanticipated negative impacts. ActionAid points to the mismatch between the promises made by companies and the observed localized impacts that directly affected the local livelihood and human rights (see the case of Kpachaa below).

The Agricultural Works Union (AWU) of the Trades Union Congress, a labour union, cites the inadequate and or non-payment of plantation workers' salaries as the main drivers of collapse, which led to local agitations (see the case of Kobre below). Furthermore, AWU was of the view that there was no local monitoring and evaluation of foreign direct invests (FDIs) by the very organisation that gave them the license to operate (i.e. the Ghana Investment Promotion Centre). This lack of monitoring led to several problems following the bad performance of jatropha companies such as labour unrest and youth agitation, which could have been resolved at the early stages of the project cycle.

Private sector

Given the almost complete state of collapse of the jatropha sector by the time of this research, it was difficult to identify the former senior personnel of these defunct jatropha companies. At the time of fieldwork (September 2015), Smart Oil Ltd was the only operational jatropha project in Ghana. The company identified three major drivers for collapse. The first relates to the lack of agronomic research on crop varieties and land suitability (Fig. 2; Table 4). The hype that jatropha could grow well on marginal lands was based on little research but still influenced many companies to seek such land without doing site-specific research. To make matters worse, many companies used unproven feedstock, recording low productivity that ultimately prevented their economic viability. Most defunct companies used jatropha varieties that were imported, and whose performance in terms of yields was far lower than expected.

The second driver was the mismanagement of funds and the illicit practices of some farm managers. For example, in Kadelso and Kobre project, managers misused funds by not accounting properly and overpaying workers for work not done (Sect. "Local communities in case study sites").

[2] In the context of large-scale acquisitions for biofuel development in Ghana, CSOs view human rights abuse as the violation of a bundle of local communities' rights, including customary land rights, rights to livelihoods and rights to information or prior informed consent (e.g. ActionAid, 2012).

These attest to the weak business planning and management practices from the side of the investors.

The third driver was the hostility of some media and CSOs for jatropha expansion. The general perception, especially, among CSOs, was that 'biofuel is bad' due to the human rights abuses discussed above. This led some CSOs to launch aggressive campaigns, which ultimately led to youth mobilization in some communities (e.g. street demonstrations, vandalization of plantations), effectively stopping some jatropha projects.

The Centre for Environment and Health Research and Training (CEHRT) is a private entity that undertook several environmental impact assessments (EIAs) for jatropha companies in Ghana. Interviews with CEHRT indicate that following the EIAs, there were incidents of human rights abuses in some plantations, as many mitigation measures specified in the various EIA reports, as well as the promises made by companies during community fora, did not materialise. These were eventually used by CSOs to fuel their negative advocacy, and in some instances, precipitated the withdrawal of funding from investors.

Local communities in case study sites

This section draws on perceptions from key informant interviews (e.g. local chiefs, opinion leaders, and former jatropha company personnel) and household surveys with local communities to identify the local drivers of collapse in each study site.

In Adidome, the major driver of collapse for Galton Agro Ltd was land litigation. The litigation process was initiated by two competing families on who was the rightful owner of the land given to Galton Agro Ltd, and essentially, who must receive the compensation (Table 5; Fig. 3). According to the respondents, the Chief of Fievie gave out the land to the company, but the chief of New Bakpa contested it. He claimed that Galton Agro Ltd acquired falsely the land because the wrong person gave it out and received the compensation. After several court cases pursued by the people of New Bakpa and some intervention by the Central Tongu District Assembly, Galton Agro Ltd decided to sign a new contract with the Chief and people of New Bakpa but was reluctant to pay the second compensation. Following the lack of compensation, conflicts between the youth and the company led to vandalisation of the plantation, and subsequently, a court injunction to halt the project. As of September 2015, the case was still in court and Galton Agro Ltd had long ceased its operations.

The Adidome's case highlights three critical issues. First, is the lack of a centralized land information system that can help investors identify the rightful owners. The second is the role of chiefs and local communities in initiating unrest and halting biofuel projects due to compensation disagreements. The third is the failure of the company to negotiate for fairer compensation with local communities. Aside these land-related issues, former plantation workers indicated that jatropha yields were also too low to ensure the long-term viability of the company. This can partly explain the

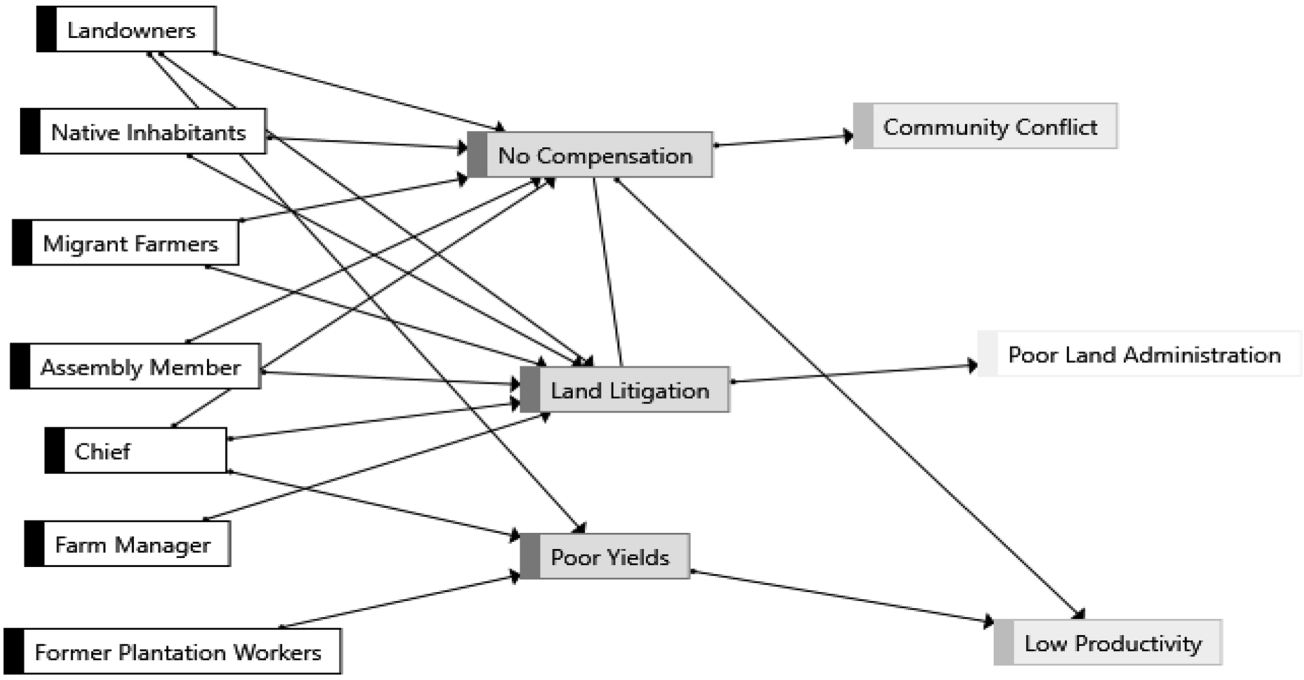

Fig. 3 Drivers of collapse for Galton Agro Ltd (Adidome)

Table 5 Summary of local drivers of jatropha collapse

Community	First-tier drivers	Second-tier drivers
Adidome (Galton Agro Ltd)	Land litigation	Poor land administration
	Lack of compensation	Community conflict
	Poor yields	Low productivity of the crop
Ahinakom (Savannah Black Farming and Farm Mgt Ltd)	Inadequate oil	Low productivity of the crop
	Mismanagement of funds	Weak business planning and funding
	Marginal land	
	Jatropha variety	
	Bad farming practices	
Kadelso (Jatropha Africa)	Mismanagement of funds	Low productivity of the crop
	Non-payment of salaries	Poor land administration
	Lack of policy implementation	Weak business planning and lack of funding
	Investor (in)experience	
	Weak leadership	
	Discovery of crude oil	
	Lack of transparency	
	Marginal lands	
Kobre (Kimminic Corporation)	Mismanagement of funds	Weak business planning and lack of funding
	Investor (in)experience	
	Non-payment of salaries	Low productivity
	Lack of community participation	
	Poor community entry	
	Lack of competent personnel	
	Donor fund withdrawal	
Lolito (BioFuel Africa)	Community agitation	Community conflict
	Low economic returns	Weak business planning and lack of funding
	No employment for natives	
	Mismanagement of funds	Low productivity of the crop
	Poor yields	
	Marginal land	
	Lack of community support	
	Investor (in)experience	
	Crop variety	
	Non-payment of salaries	
Kpachaa (BioFuel Africa)	No compensation	Community conflict
	Conflict of interest	Civil society campaigns
	Human right abuses	Weak business planning and lack of funding
	Non-payment of salaries	Low productivity of the crop
	Community agitation,	
	No community participation	
	Mismanagement of funds	
	Investor (in)experience	
	Marginal land	
	Inadequate research	

reluctance of Galton Agro Ltd to pay a second compensation to the chief and people of New Bakpa.

Savannah Black in Ahinakom represents one of the instances of jatropha collapse due to poor site selection and agronomic practices (Table 5; Fig. 4). Local community respondents suggest that the plantation was located on marginal land and employed poor farming practices (e.g. low fertiliser use). After a series of harvests the obtained seed yields and extracted oil were much lower than initially expected. Community respondents mentioned that after

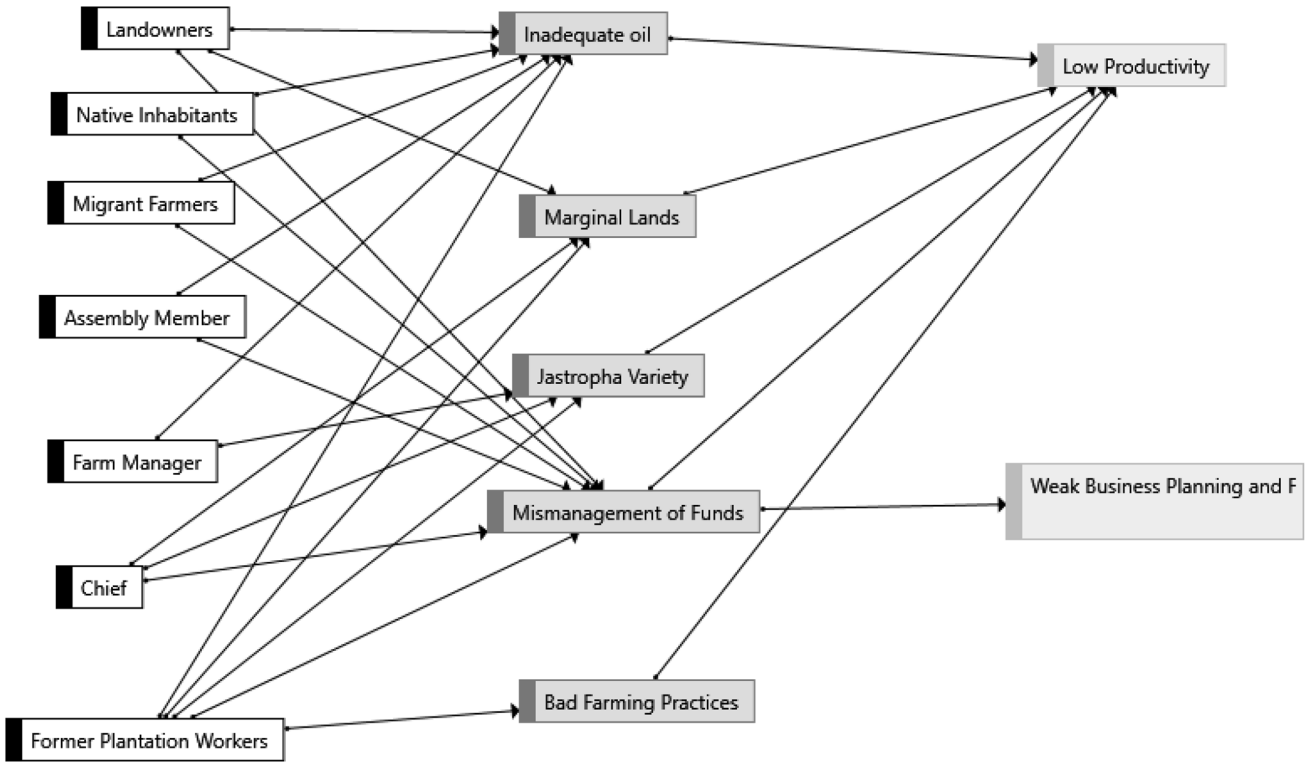

Fig. 4 Drivers of collapse for Savannah Black Ltd (Ahinakom)

these poor harvests the company and plantation employees informed the community that it is not possible to break even, so the termination of operations was imminent.

The case of Jatropha Africa in Kadelso is rather unique, as there does not seem to be a wide consensus about what caused project collapse (Table 5; Fig. 5). The only area where there seems to be agreement is the mismanagement of funds. Most respondents blame the company for using an illiterate and untrained person as the farm manager responsible for paying salaries, and implementing and supervising daily plantation activities. According to the respondents, the farm manager had no formal education and knowledge of financial management and jatropha agronomy. Former workers suggested that even when they were informed that their salaries had been transferred, the farm manager refused to pay them. Strategically, the farm manager had closed the community–company interface, such that even though plantation workers had requested the investors to directly address their grievances on multiple occasions, there was no response. Though the motivation of the investors for choosing such an inappropriate manager is unclear, most respondents believe he got the job because his brother (who lived in Accra) facilitated the company's land acquisition processes with the chief. To keep the land, the company was compelled to retain him because of the links he has. If this was actually the case, this is a typical example of how the local elites used knowledge and networking with chiefs to make investors commit to issues they are unwilling to do that can be deleterious to the investment in the long run.

However, interviews with the former farm manager suggested that the discovery of crude oil in Ghana in 2008 (Ahmed et al. 2017a) was the key reason why Jatropha Africa was demotivated to continue jatropha production in that area. He also indicated that the lack of institutional support in terms of assisting with domestic loans and tax incentives also contributed to the collapse. While the case of Jatropha Africa suggests very weak planning practices, it also highlights that the community–investor interface is important in getting feedback for the investors to understand actual activities on the ground and respond properly.

For Kimminic Corporation operating in Kobre, the lack of investor experience, fund mismanagement, and non-payment of salaries stand out as the major drivers of collapse (Table 4; Fig. 6). Most people in the community cite illicit activities of managers in terms of paying wages for work not done. According to former plantation workers, during the early plantation phases, they were marked for 5 h' work, even though they worked for 1 h, and upon payment, the managers would take the extra 4 h' wage. Plantation workers currently serving as security personnel for the abandoned machinery indicate that another important driver was the inexperience of the investor with jatropha production. They

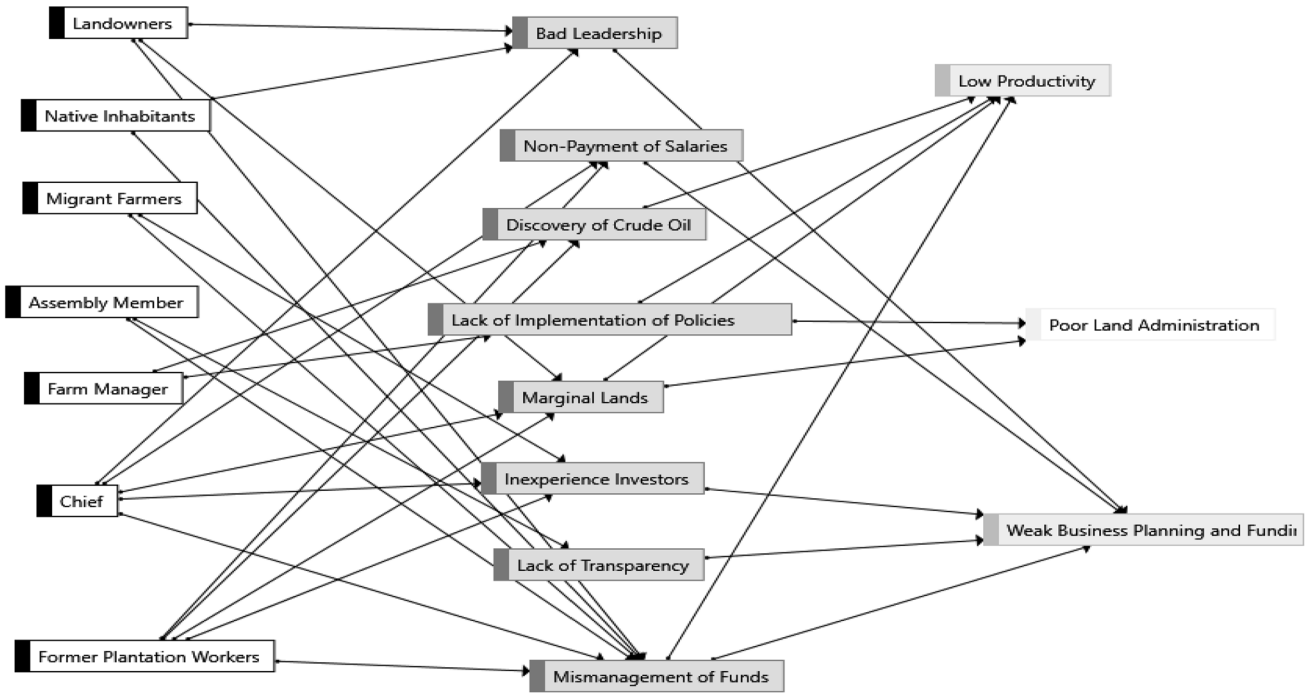

Fig. 5 Drivers of collapse for Jatropha Africa (Kadelso)

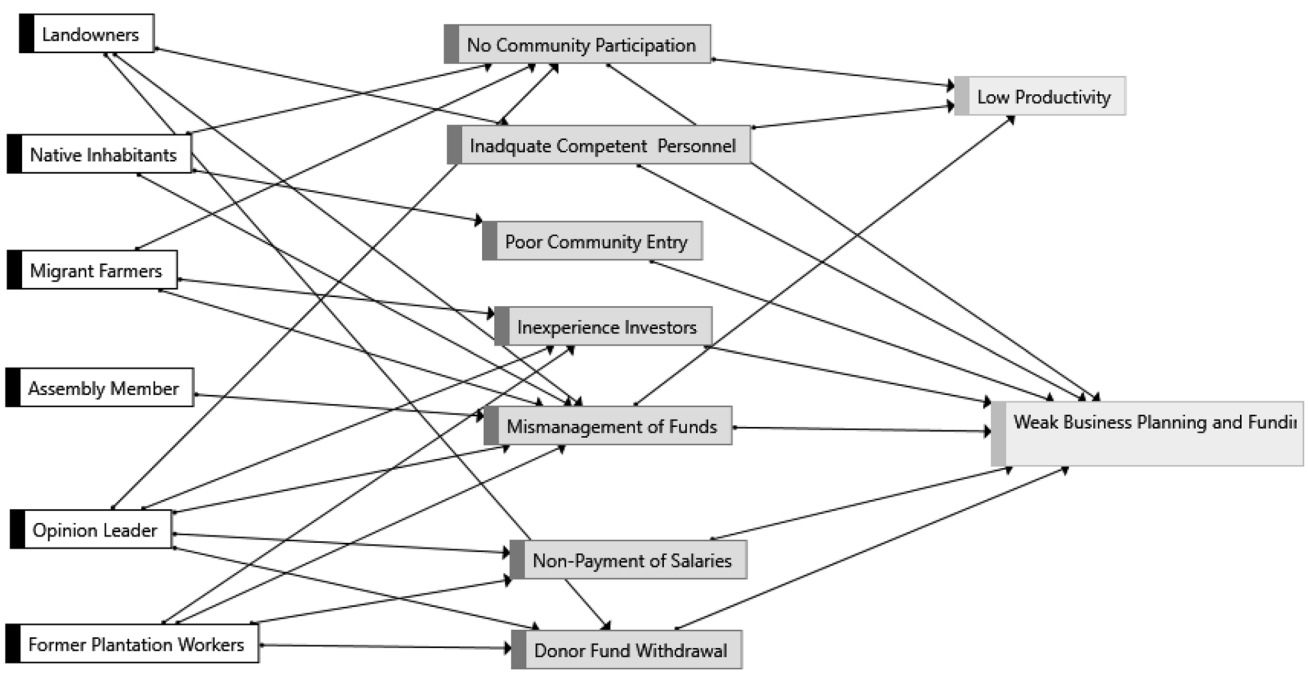

Fig. 6 Drivers of collapse for Kimminic Corporation (Kobre)

suggested that the company was rapidly expanding the plantation size without having a clear idea of how to manage it. As a result, operating costs surpassed the economic returns by a wide margin, as the trees were still not matured enough to give any immediate economic returns.

Furthermore, Kimminic was the only biofuel company in Ghana that acquired equipment to build an oil extraction/

processing facility in Kobre. A large sum of money was used to procure the equipment (which now lies abandoned) creating a shortage of operating funds to manage the plantation. At one stage, the company could no longer even pay its workers. Members of the local community blame the company for not establishing a proper community–investor interface for monitoring and evaluating the activities. These reflect weak business planning and management. It becomes obvious that investor experience (or the lack of it) is very critical for the viability of a jatropha project. In 2012, when the company folded up, salaries and local conflicts were still outstanding.

Finally, the cases of BioFuel Africa which operated in Kpachaa and Lolito show how the same company faced different challenges in the two areas and was ill-prepared to deal with them (Table 4; Figs. 7, 8). The first of BioFuel Africa's plantation was established in Lolito on a supposedly marginal land (flood plain). The land was acquired through the intervention of an urban elite from the community and registered in his name. He then later subleased it to BioFuel Africa without consultation with the community and landowners. When the company started operating, there were a series of community agitations for not employing locals and at the same time for not compensating the landowners. BioFuel Africa, however, insisted that it had paid compensation through the elite, which the community never received. Added to this, the crop also did not meet BioFuel Africa's yield expectation.

Subsequently, BioFuel Africa moved to Kpachaa in Northern Region, again facing problems related to land compensation. However, in this case, the problems emerged from the illicit activities of the chief, whom the local people blame for receiving the compensation but never allocating it to the affected people. Local residents sued the chief and the company in the high courts. In this case, the challenges of forceful acquisition of the land, and the large-scale clearing of land that denied the people of access to non-timber forest product (NTFPs) emerged. CSOs picked this as a manifestation of human rights abuse and land dispossession in a particularly poor and underdeveloped area, launching campaigns to halt the project. ActionAid Ghana was actively involved providing resources, mobilizing youth, and political support against the project. This influenced the project donors from Norway to withdraw their funding. In this sense, Kpachaa represents a situation where CSOs used crisis narratives to justify their interventions to halt jatropha activities. Both cases (Lolito and Kpachaa) suggest that social acceptance is very important for the successful operation of a biofuel project. It is also an example of how activities of chiefs and the elites can have serious

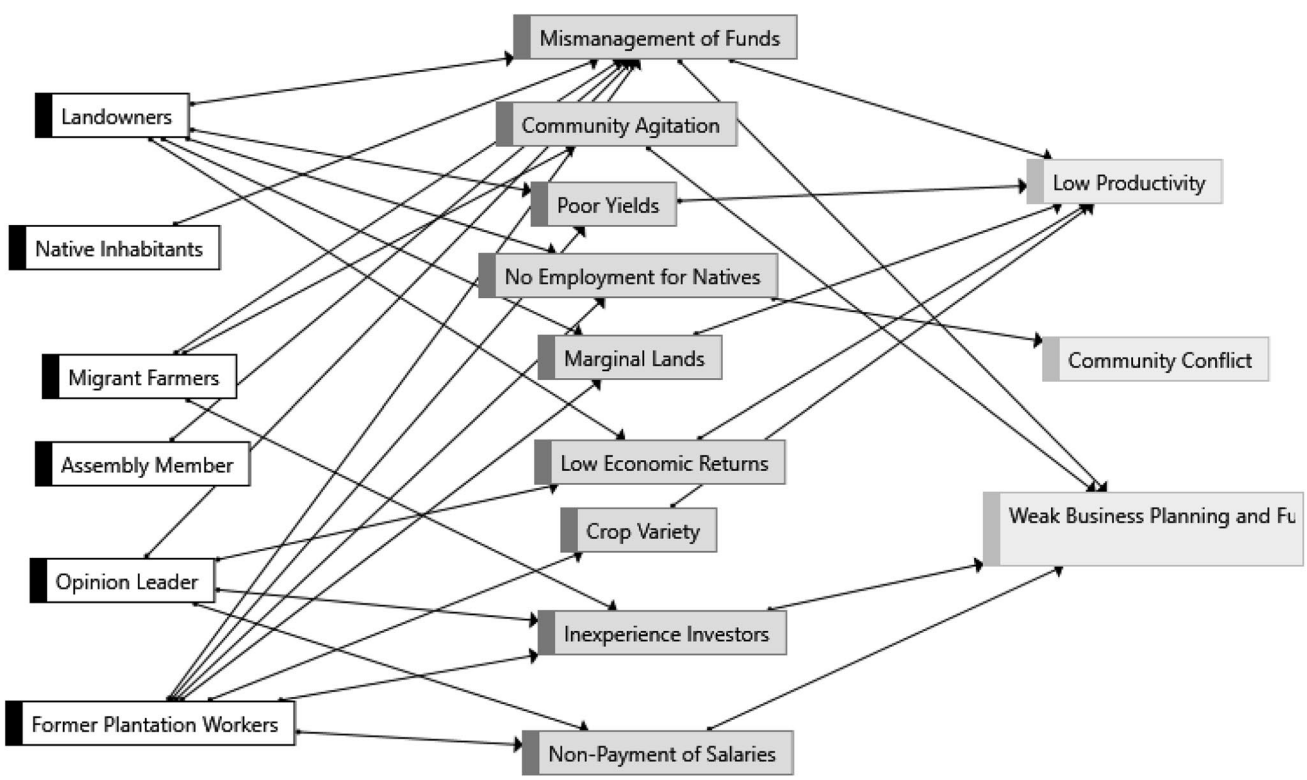

Fig. 7 Drivers of collapse for BioFuel Africa (Lolito)

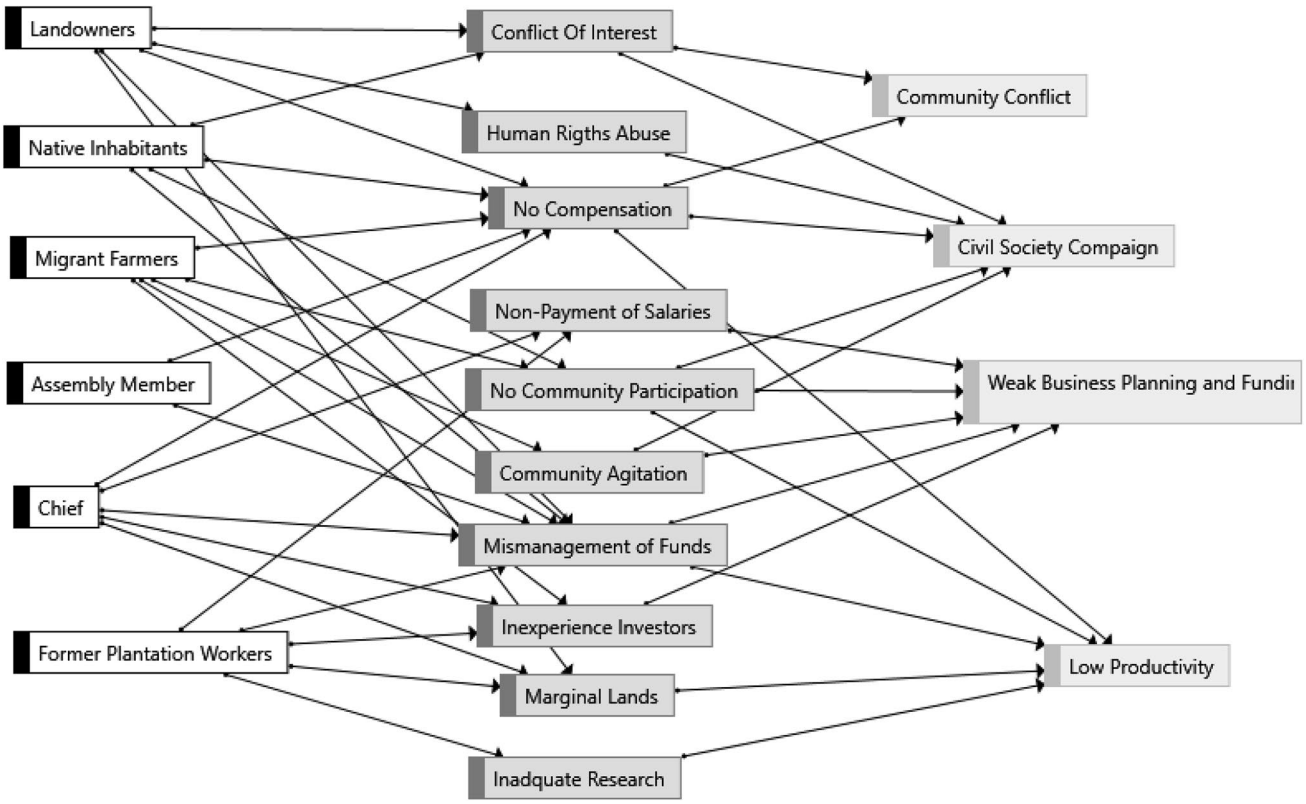

Fig. 8 Drivers of collapse for BioFuel Africa (Kpachaa)

ramifications for project collapse if they are not accountable or transparent. However, the investors also have to be blamed for not learning from their earlier mistakes in Lolito and resolving them in Kpachaa.

It is worth mentioning that despite the key differences between the six projects discussed above, some common themes emerge (Figures S2–S3, Supplementary Electronic Material). In addition, each community has some elements of drivers linked to those identified at the national level. In particular, landowners generally bring up issues related to inappropriate compensation and weak business planning as the main drivers of local jatropha collapse. Settler farmers also highlight issues of compensation, but focus particularly on the non-payment of salaries for those working in plantations, and how this led to community conflicts. Local inhabitants emphasize community conflicts from the illicit activities of chiefs as key drivers of collapse, while assembly members blame the poor investor–community interface, land administration, and weak business planning. Former plantation workers generally emphasize the weak business planning, lack of funding and low productivity of the crop. Finally, former plantation managers generally focus on CSO opposition, weak business planning, and lack of funding and low productivity of the jatropha varieties used.

Task 2: sustainability impacts of collapsed jatropha projects

A second important issue surrounding the collapse of jatropha projects is their post-collapse issues. Results of the household survey suggest that during their operational phase, plantations produced significant economic benefits to the local communities through job creation and income opportunities (Fig. 9). However, following project collapse, more than 70% of respondents from these study communities reported significant decreases in jobs and household income, especially, from low-income households who earn below the annual average of GH¢ 1314 (US$ 328). Similarly, out of the 98 households that reported declining household income, 72% are households who depend significantly on agriculture and were former plantation workers. From a gender perspective, out of the 98 respondents that reported a significant decrease in household income, 32% are women. In Ahinakom, out of 31 respondents who reported a significant decrease in household incomes, 55% are women. Out of this number, approximately 20% are female household heads who were formerly employed in the plantation. This shows that, aside from the impacts with high degree consensus (over 80% respondents) in Fig. 9, there are differences between different social groups such as women,

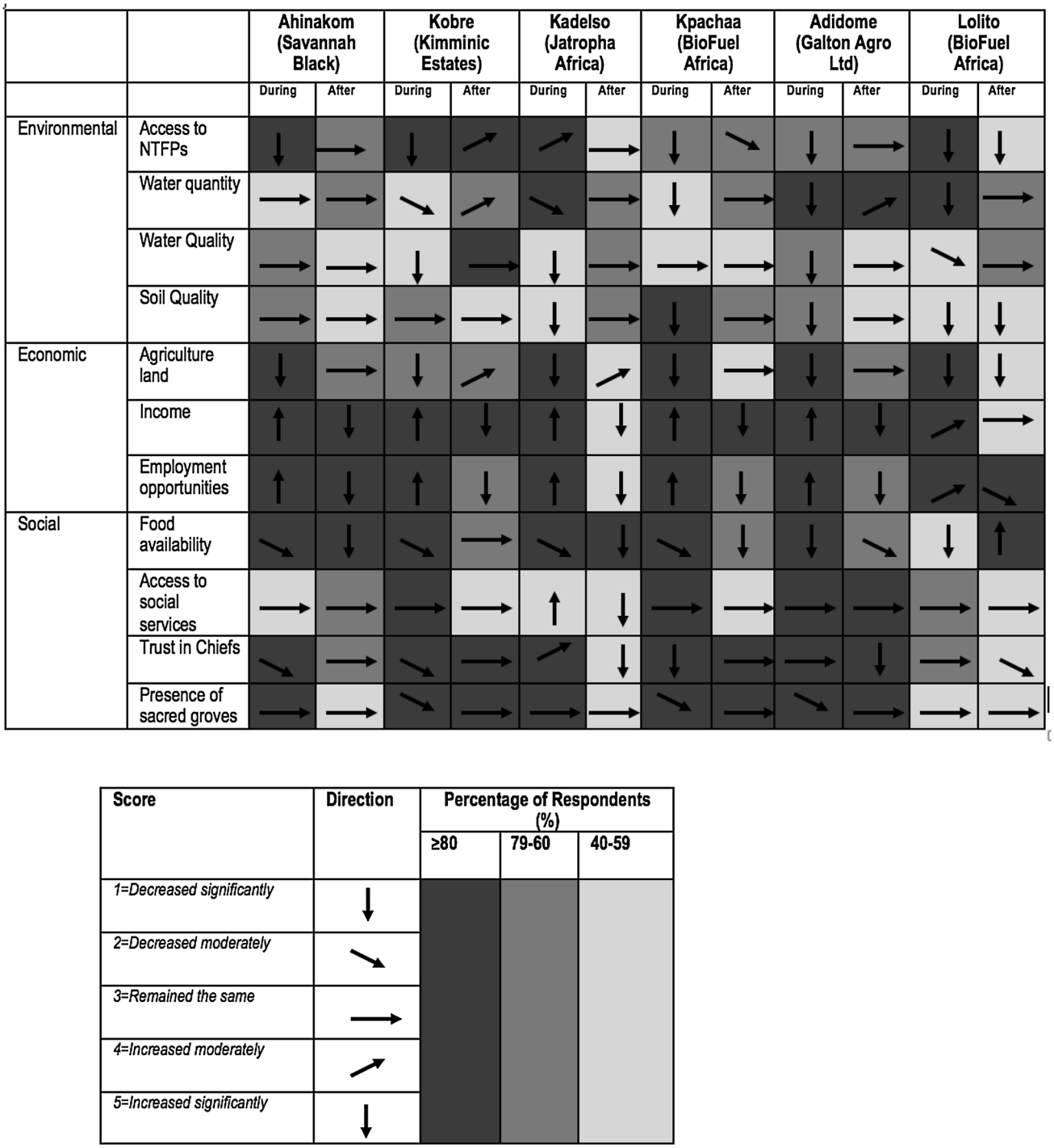

Fig. 9 Socioeconomic and environmental impacts in study sites during the operation and after the collapse of study projects

owners, local inhabitants, plantation managers, and former plantation workers.

On the other hand, food availability and access to some environmental resources, especially, NTFPs, declined during the operation of the jatropha projects due to the extensive landscape modification that had been undertaken and the subsequent restricted access to the land (Fig. 9). For a deeper exploration of these dynamics, refer to Ahmed et al. (2017b). After project collapse, the communities in Kobre and Kadelso have reportedly "re-gained access" to the land through encroachment. In Kpachaa, Adidome, Ahinakom, and Lolito, the access of local communities to the land is still

restricted despite the projects having collapsed several years ago. For the case of Lotito, access is even further restricted as the land rights are transferred to a new company for rice cultivation which reinforced deprivation from NTFPs in the area. Those communities that regained access to the converted land indicated they experience negative trends related to food production. However, in Lolito, though access by local people is restricted, there is a significant perception of an increase in access to food (mainly rice) as the new company, a Brazilian company, has further transformed the land for rice cultivation.

While for most impacts there is consensus (i.e. deeper colours in Fig. 9), at the same time, there is less consensus among respondents for some important impacts. For example, in the cases of Kadelso and Lolito, there is little consensus regarding the impacts of jatropha projects on NTFPs, access to social services and sacred groves after the collapse. This is because access to former plantation land and other amenities after collapse varied among affected people, with some people encroaching the land while others not. A similar lack of consensus is observed in most communities for soil and water quality both during operation and after the collapse. Disaggregated results for all sustainability impacts are included in Table S3 in Supplementary Electronic Material (impacts with little consensus are highlighted for each site).

Task 3: future acceptability

Despite project collapse, 132 respondents (66%) across all study areas are still willing to accept another jatropha project in their community and 146 respondents (73%) are willing to accept another biofuel crop (Table 6). However, there are some differences between communities. For example, the people of Ahinakom, Kadelso, and Adidome are overwhelmingly positive about the prospects of another jatropha project due to expectations of employment and income. The drivers of collapse in these areas were in most cases not related to the local community (see Sect. "Local communities in case study sites", Figs. 3, 4, 5). On the other hand, respondents at Kobre, Lolito, and Kpachaa are much more sceptical about the prospects of another jatropha project due to their experiences of land dispossessions, lack (or low) compensation and lower employment benefits than what was initially expected, which often led to community conflicts (Sect. "Local communities in case study sites"–"Task 2: sustainability impacts of collapsed jatropha projects", Figs. 6, 7, 8).

Within the specific sub-groups, 63% of all landowners are not willing to accept another jatropha project, possibly due to fears of land dispossession. This is particularly prevalent in areas such as Kpachaa where all landowners surveyed are not willing to accept another jatropha project. Conversely, 72 and 63% of settler and local farmers, respectively, are willing to accept another jatropha project in their community due to the expectations of employment generation. In addition, 77% of all former plantation workers, including in Kpachaa where the project was highly controversial, are willing to accept another jatropha project. From a gender perspective, in Ahinakom, out of those who will accept another jatropha project, 57% are females and mostly female household heads that worked formerly for Savannah Black Farming and Farm Management Ltd. The farm area in Ahinakom was within the community, so women were hired for planting and harvesting jatropha.

With the exception of Kpachaa, all surveyed communities were mostly willing to accept another industrial crop (including biofuel feedstock) (Table 5). As expected, the major reasons include expectations of employment and income. However, due to the particular locations, climatic conditions and existing cropping knowledge the preferred crop varies across communities. For example, the respondents from Adidome and Lolito are more willing to accept sugarcane because they have the current cropping knowledge and suitable land.

Whereas in some cases there is large willingness to accept, there are equally some varied opinions among the different study groups (e.g. migrants, natives, landowners, former plantation workers). In Kpachaa, Kadelso, and

Table 6 Acceptability of future jatropha and other biofuel crops in each study site

Community	Future acceptability of jatropha				Future acceptability of other biofuel/industrial crop			
	Yes		No		Yes		No	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Ahinakom	35	95	2	5	24	65	13	35
Kobre	12	39	19	61	18	58	13	42
Kadelso	26	90	3	10	21	72	8	28
Kpachaa	12	40	18	60	14	47	16	54
Adidome	39	98	1	2	39	98	1	2
Lolito	8	24	26	76	30	88	4	12

Kobre, there is less willingness from landowners to accept jatropha because most of them had experienced land dispossession and were not compensated properly (Sect. "Local communities in case study sites"). However, migrant farmers and ordinary native people have relatively high willingness to accept jatropha in all communities. For former plantation workers, there are mixed responses within communities, i.e. there is a high willingness in Adidome, Kadelso, and Ahinakom but low willingness in Kpachaa, Lolito and Kobre (see disaggregated data in Tables S4–S5, Supplementary Electronic Material).

Discussion

A typology of the drivers of jatropha collapse in Ghana

The previous sections outlined a large variety of unique drivers that have influenced jatropha collapse in Ghana, both at the national and local levels. We aggregate the numerous first-tier drivers (Tables 4, 5; Figs. 2, 3, 4, 5, 6, 7, 8) in five second-tier drivers, which we refer for the remainder of the text as the overarching drivers of collapse:

(a) low jatropha productivity;
(b) weak business planning and lack of funding;
(c) community conflicts (catalysed by illicit activities of chiefs/elite and agitation of youth);
(d) poor land administration and other institutional barriers;
(e) civil society opposition.

Studies in other African countries have identified similar drivers of jatropha collapse/failure such as land litigation, market/funding constraints, bad project planning, low yields and CSO opposition (Schut et al. 2011; Hashim 2014; von Maltitz et al. 2014; Wendimu 2016; Neimark 2016; Slingerland and Schut 2014).

In more detail, the collapse of many jatropha projects (and the sector as a whole), primarily, reflects the poor performance of jatropha as a crop and/or of the varieties used, largely because basic agronomic aspects of jatropha were unknown. This manifested in low productivity, which curtailed the economic viability and long-term viability of several projects. Locating plantations on marginal land without the appropriate agronomic knowledge took a further toll on yields and economic returns (see also Ahmed et al. 2017b). For example, at Ahinakom (Savannah Black and Farm Management Ltd project), the decision of the investor to locate the plantation on land not suitable for food production was blamed for the poor yields and low oil content (Fig. 4). In this respect, while locating jatropha plantations on marginal land has been a powerful and persuasive argument to overcome food–fuel competition in SSA, it also put investments at risk of low productivity and economic viability (Wendimu 2016; Ahmed et al. 2017b). The widespread expectation across SSA that jatropha can perform well on marginal land also possibly prevented, to an extent, the building of the agronomic knowledge necessary for successfully growing the crop in semi-arid areas of the continent (Iiyama *et al*. 2013).

The inexperience of investors/companies with the jatropha, weak business practices and lack of funding reinforced low jatropha productivity (see above) and further catalysed the collapse of several projects. According to the perceptions of some respondents, the investors often lacked a long-term vision and tended to prioritise short-term profit. Weak business practices are usually reflected in the unrealistic business plans that overestimated yields, promoted the rapid expansion of plantations without considering initial low returns-on-investment, and over-employed workers/managerial personnel, precipitating, thus, high operational costs. Weak business planning is also reflected by the lack of investor experience with jatropha agronomy, lack of research/trials, mismanagement of funds and wrong site selection (see also Schoneveld and German 2013; Ahmed et al. 2017a).

Lack of funding further reinforced weak business practices and accelerated the collapse of some projects. While many jatropha projects in Africa were initiated before the economic crisis of 2008, they were not fully operational until well after it. Funding was often withdrawn from jatropha investments on the wake of the economic crisis requiring projects to become economically viable in much less time than initially planned (Slingerland and Schut 2014; von Maltitz et al. 2014), preventing the much-needed experimentation with the crop. Whereas some companies such as Kimminic ran out of funds due to overspending and mismanagement, others such as BioFuel Africa had their funding withdrawn by investors due to the reported cases of human rights abuses. Such financial setbacks further prevented companies from fulfilling some of their promises to local communities, including low employment generation and unpaid salaries to plantation workers. Escalating dissatisfaction in local communities stemming from weak business planning acted synergistically to incite community conflicts and civil society campaigns.

Local communities also contributed to project collapse, especially through the unconstructive involvement of chiefs and local elites, and the agitation of youth such as the deceitful role chiefs played in Adidome (Sect. "Local communities in case study sites"). In Kpachaa, the initial refusal of chiefs to disclose information on the size of land allocated and the compensation received led to distrust, lack of transparency

and accountability. When the people became aware of the chief receiving money without giving compensation, youth and CSO agitation worsened the situation (see below). For more on the negative role chiefs have played during land acquisitions in Ghana refer to (Boamah 2014b; Campion and Acheampong 2014; Schoneveld and German 2013). All this evidence questions whether the actual motivation of chiefs was to safeguard land or enrich themselves through illicit means (Kwoyiga 2012; Ahmed et al. 2016; Boamah 2014b).

Land litigations (e.g. in Adidome) reflect the weak land policy and administration system of Ghana. The government is responsible for implementing appropriate policies to regulate the biofuel sector and create structures for fair and transparent land acquisitions. Local and national respondents evoked numerous challenges related to land administration in Ghana that eventually contributed to the collapse of biofuel projects (Table 4; Fig. 2). These include (a) weak site selection due to lack of agro-ecological zoning, (b) lack of a harmonized regulatory framework for land acquisitions, (c) disputes over land ownership and rightful compensations, (d) lack of land ownership data to inform investor decisions. Some of these challenges manifested in our study sites, as for example seen in the double sale of land and the repetitive requests for compensation in Adidome (Galton Agro Ltd) (Sect. "Local communities in case study sites"). The way that the poor land administration system affected project collapse is most likely reinforced by the illicit activities of chiefs operating within this problematic system (see above).

Surprisingly, the lack of market development for biofuels (and co-products) did not come up as a driver of collapse, despite having been identified as a major driver in other studies (e.g. von Maltitz et al. 2014; Schut et al. 2011). We hypothesize that this is due to two reasons. First, we were unable to interview more representatives from the private sector (especially the investors of the collapsed projects), as it is extremely difficult to track senior personnel following project collapse. Second, all study companies collapsed within the first or second harvest and had no opportunity to explore the markets for their products. This is true for almost all jatropha projects in Ghana (Ahmed et al. 2017a), so it might be the case that the interviewed stakeholders were not confronted by how market constraints can affect jatropha projects, and drive their collapse.

Civil society opposition contributed to the collapse of BioFuel Africa in Kpachaa and Lolito. CSOs operating in Ghana raised concerns over land dispossession, food insecurity and loss of livelihood to frame their advocacy messages against jatropha and mobilize human, financial, and political resources (Nyari 2008; ActionAid; Ghana 2012). In Kpachaa, ActionAid and the Regional Advisory and Information Network Systems (RAINS) further branded BioFuel Africa operations not only as land grabbing but also as a new form of colonialism (Nyari 2008; ActionAid; Ghana 2012). This choice of highly emotive words eventually gained ground, further mobilizing the local community to halt the project. Studies have reported how the negative publicity from CSOs has been a critical driver of project collapse in Ghana and elsewhere in Africa (e.g. Schoneveld 2014). Whereas we cannot judge the legitimacy of these practices and whether the specific advocacy messages were in the interest of the local communities, the fact remains that some CSOs openly opposed biofuel investments in Ghana and actively contributed to their collapse.

Key lessons learnt for informing future biofuel/bioenergy efforts in Ghana

Despite the negative consequences of the collapse of the jatropha sector, there is still interest across Africa to promote renewable energy pathways based on bioenergy (REN21 2016). However, whilst research is advancing across the world, the practicalities are fraught with challenges as witnessed in the boom-and-bust cycle of jatropha in Ghana and many other African countries (Sect. "Introduction"). Currently, new jatropha varieties are being developed suggesting that there is still some interest in the crop (Prakash et al. 2016). In Ghana, there is still a high willingness to promote industrial crops that can be used as biofuel feedstock as reflected in the draft of the National Sugar Policy (Ministry of Trade and Industry 2016), the Oil Palm Master Plan (MASDAR 2011), the reopening of the Komenda sugar factory and the current development of land banks for investors. Conscious of the specific characteristics of Ghana and the six study sites, we attempt to extract some of the key lessons learnt from the recent jatropha boom-and-bust cycle as a means of informing any future efforts to revive the biofuel/bioenergy sector in the country and elsewhere in Africa (whether based on jatropha) (Table 7).

First, it is important to note why biofuel feedstock production was so strongly promoted in Ghana, both nationally and locally. The major leeway to forge local support for biofuel feedstock investments (mainly jatropha-related) in Africa, was the optimism that biofuel feedstock production could have significant positive sustainability impacts related to economic/rural development and energy security (Gasparatos et al. 2013b, 2015). In Ghana, this manifested particularly with the hope to revive the agrarian system through the generation of jobs and income in poor rural areas (Boamah 2014b; Ahmed et al. 2017a). Indeed, several jatropha projects either consciously targeted, or geographically coincided with, areas desperately needing rural development interventions to boost socioeconomic conditions given the high incidence of poverty. For example, in all six districts where our study sites are located, the incidence of extreme poverty is above 35% (Table 2). Our results suggest that local communities were generally optimistic that jatropha investments would bring better employment and income

Table 7 Key findings/suggestions for each stakeholder group

Stakeholder group	General findings
Local communities	Greater consensus on direct livelihood impacts (i.e. employment, income) than other sustainability impacts (e.g. water availability/quality, soil quality)
	Post-collapse impacts often depend on whether the local communities gained access to former plantation land through legal means or encroachment
	Low future acceptability of jatropha investments in communities where the reasons of project collapse are related to social conflicts from land dispossession and lack of compensation due to the unconstructive role of chiefs (i.e. Lolito, Kpachaa)
	High future acceptability in communities where the reasons of failure are not directly related to the local communities, e.g. bad business planning or CSO opposition in Kobre
Policymakers (i.e. government agencies)	Due consideration must be given to addressing the challenges and reforming the land administration if there will be a national interest in further expanding biofuels through large-scale commercial agriculture projects
	Proper national interpretation of marginal and delineation of areas suitable for biofuels projects through detailed land use planning and classification are important for biofuel sustainability
Companies	Prior detailed research and planning are necessary for future investors in biofuel sector before undertaking their investments
	A proper community–company interface is necessary for companies in getting social support and this must be enhanced
CSOs	Wider consultation between CSOs and policymakers on the biofuel policy making an adoption could have addressed some of the negative reportage from the side of CSOs
	CSOs are good at utilising crisis narratives in mobilizing social support from propagating their pre-existing advocacy messages
Chiefs	Transparency on the part of chiefs to their people is necessary for building trust for successful implementation of biofuel projects
	It is imperative to delineate between chiefs and local people on the rightful recipients of land compensations

opportunities, and eventually reduce poverty. This optimism about the expected benefits from jatropha or other biofuel crop investments is still strong in some of our study sites despite jatropha's collapse (Sect. "Task 3: future acceptability"). While it is surprising that some local communities are still willing to support jatropha or other bioenergy investments by giving out their land, this willingness should be understood in the context of low development levels in these rural areas. Other studies in SSA found similar levels and reasons of acceptability for jatropha (Hashim 2014).

Second, all jatropha projects had some significant negative sustainability impacts during their operation, and sometimes after their collapse (Sect. "Task 2: sustainability impacts of collapsed jatropha projects"). While the type and magnitude of these impacts depend on the specific site characteristics, it can be argued that these impacts ran contrary to the initial optimism and support for jatropha. Negative sustainability impacts included land dispossession in Kpachaa, non-payment of salaries in Kobre and Kadelso, land litigation in Adidome, low employment in Lolito and low oil yields in Ahinakom to name just a few. In some cases, the very driver of support of biofuel feedstock production (i.e. employment and income generation) turned out to be a driver of collapse and community agitation if it did not materialise as expected. Project collapse possibly reinforced rural poverty and power asymmetries in some study sites such as Kpachaa considering the responses of poor households (Sect. "Task 2: sustainability impacts of collapsed jatropha projects"). In this respect, it can be argued that the studied jatropha projects, in reality, represented a risk rather than an opportunity to promote sustainable rural development and household resilience through the diversification of rural livelihoods. This questions the assertion that large-scale biofuel feedstock production can have a positive impact to the rural poor in agrarian societies in SSA and whether biofuel feedstocks can be produced sustainably in SSA (Arndt et al. 2011; van Eijck et al. 2014; Favretto et al. 2014). While it is possible to have positive impacts (Fig. 9), it is important to develop biofuel feedstock projects in a way to minimise the expected negative trade-off and the chances of project collapse. Ensuring the viability and sustainability of biofuel investments can ensure that while land is converted to biofuels/bioenergy the expected positive benefits will manifest.

Third, our study suggests that multiple drivers and stakeholders contributed to the collapse of the jatropha system, both nationally and locally, i.e. state institutions, CSOs, local communities, companies and the crop itself. Furthermore, these drivers and stakeholders often acted synergistically making it difficult to unpack the actual effects of individual drivers/stakeholders responsible for the demise of the jatropha sector. For this reason, in our opinion, there is not a "silver bullet" to ensure the viability and sustainability of the biofuel sector, and especially the jatropha sector. An understanding of how the different drivers manifested is important

when designing policies to promote bioenergy to reduce the risks of project collapse or underperformance in the future.

Fourth, when viewed critically the drivers of collapse and the themes emerging from the expert interviews and community surveys, it becomes obvious that the central issue for the collapse revolves, one way or another, around the land. For example, the poor performance of jatropha is often the result of locating jatropha projects on marginal lands, which has a lot to do with (lack of) land use zoning and providing permits to exploit such lands. Community conflicts in most study sites emanated from the unsatisfactory compensation that local communities received for the land they gave to investors, the way land was given away and/or land rights dispossession. This reflects poor land administration in terms of proper guidelines for land acquisition and compensation. CSOs became active in some study sites because of the human rights violations and negative impacts related to the above land-related issues.

In this respect, land administration is a major crosscutting issue that can have ramifications for all the other drivers of collapse, see also (German et al. 2013; Hashim 2014) for the centrality of land administration systems. The lack of guidelines for large-scale acquisitions during the biofuel boom (Ahmed et al. 2017a) influenced most investors to use the customary routes of land administration, which can be susceptible to foreign powers and create a space for illicit activities (German et al. 2013; Campion and Acheampong 2014). In a reactive response, the government of Ghana in 2012 drafted guidelines for large-scale land acquisitions. However, by the time this regulation was enforced in 2015 virtually all jatropha projects had collapsed (Ahmed et al. 2017a). As a result, strengthening land policy needs to be a pre-condition if jatropha (or other biofuel crops) are to be promoted further in Ghana and other parts of SSA. The current guidelines for large-scale land acquisitions fall short of addressing diverse policy needs. For the companies, this includes the re-examination of the marginal land discourse (Ahmed et al. 2017b), as well as reducing the complexities in land registration and how companies can gain access to reliable land information. Government agencies can contribute to such activities by promoting agro-ecological zoning for agriculture investments that demarcate places for different agricultural uses based on a set of criteria that go beyond food crop production suitability *per se*, as currently used to identify marginal lands (Ahmed et al. 2017b). Furthermore, land compensation processes must also be improved as they are now curtailed by the lack of explicit definitions of who are the rightful recipients of land compensation, and how such compensations are to be determined (Kidido et al. 2015). In the absence of this, local communities including chiefs need to chart a path that creates transparency and accountability in land deals through wider community participation during project planning and land acquisition.

Lessons learnt and implications for sustainability science

Jatropha is only one of the different industrial crops that are heavily promoted across Africa for production in large-scale plantations (Schoneveld 2014; Wiggins et al. 2015). For example, sugarcane and oil palm have been gaining significant attention in Africa in the past decades as means of spurring economic growth and boosting rural development (e.g. Hess et al. 2016; Dubb et al. 2017; Orday et al. 2017). Considering the ongoing expansion of these crops, it is important to understand what factors might affect their performance to establish whether they fulfil their development potential. While some socioeconomic impacts might require several years to manifest, the collapse of such investments can have immediate negative effects for local communities.

Using a combination of different qualitative and quantitative tools, this study focused on the collapse of such an industrial crop in Ghana. Through its highly transdisciplinary research approach that aimed to elicit the perceptions of different stakeholders and integrate their diverse knowledge, this study adopted key tenets of sustainability science (Sect. "Research approach"). We believe that such research approaches rooted in sustainability science can offer a flexible lens to allow identify the possible (under)performance of large-scale industrial crop expansion in different parts of Africa. Given the focus on eliciting perspectives rather than quantifying impacts (Sect. "Caveats and future research directions"), the approach used in this paper can provide a quick and relatively inexpensive "reality check" about the status and performance of industrial crop initiatives, both at the national and the local levels.

It is worth mentioning that jatropha has undergone a very unique trajectory that is not observed for other industrial crops in Africa (i.e. rapid expansion of an undomesticated crop, which was followed by a swift collapse). This means that it is not possible to generalize several of the findings of this study for other industrial crops in Africa (or elsewhere in the world). However, two key findings can be generalized to some extent, as they do not relate so much to the crop itself (or the agro-ecological settings where it was promoted), as much as the rules and institutions that governed the large-scale investments.

The first has to do with the central role that the land governance system plays for establishing foreign-led large-scale investments. The way these projects were obtained access to land and were established locally, dictates to a large extent their local impacts and possibility of (under) performance. This study shows that the land administration system was not ready to tackle the surge in foreign-led large-scale land acquisitions spearheaded by jatropha (Sect. "Key lessons learnt for informing future biofuel/bioenergy efforts in Ghana"). While similar processes are

followed for agro-industrial investments for other crops (e.g. oil palm), the collapse of the jatropha sector made painfully visible the substantial shortcoming and bad operationalization of the land governance system. Elements that need to be reconsidered in other regions of SSA that experience industrial crop expansion include:

(f) what should be the maximum amount of land allocated;
(g) what constitutes marginal land;
(h) how to link investors and local communities;
(i) what should be the role of chiefs in such processes;
(j) how to identify who should receive compensation and how to share this compensation among rightful recipients.

The second lesson learnt relates to the (lack of) participation of local communities in the planning of large-scale land acquisitions. None of the local communities were consulted properly during the early development phases of all study projects. We believe that meaningful participation during project planning and implementation could have resolved some of the grievances related to the inappropriate transfer of land and lack of compensation. This could have reduced the risk of project collapse. That said, it is important to strengthen EIA processes, as they are often the only stage of the project cycle that community voices can be heard (Ahmed et al. 2016; 2017b). From a sustainability science perspective, top-down and bottom-up transdisciplinary processes for co-designing and implementing such projects can enhance their legitimacy among local communities, and possibly their long-term viability and sustainability (Ahmed et al. 2016; Schut et al. 2014).

Caveats and future research directions

Despite the rich findings reported above, our study has three significant caveats. First, it was not possible to interview investors (see also Sect. "Key lessons learnt for informing future biofuel/bioenergy efforts in Ghana"). Investors are a key stakeholder group in the Ghanaian biofuel sector (Ahmed et al. 2017a), and thus their perceptions are important for understanding the collapse of the sector. All jatropha investments in this study were foreign-led (Sect. "Data collection and analysis") (as most in the country), which mean that the senior management was also mostly foreign. Despite efforts to locate and contact the senior managers of the collapsed investments, we did not receive any answer as most had left Ghana following project collapse.

Second, the rapid appraisal approach employed in this study captures perception about changes in impacts (e.g. income levels), rather than quantifying the impact levels before and after collapse (see Supplementary Electronic Material for more details). We chose this approach based as the initiation and collapse of each project was 7–9 years and 3–4 years, respectively, before fieldwork (Sect. "Study sites", Table 3). Capturing highly quantitative information (e.g. income, crop yields, natural resource use) over such timescales inserts high uncertainties due to the inaccurate recollection of respondents (von Maltitz et al. 2016). While a more quantitative approach would have been ideal to understand better the post-collapse impacts, we believe that this is practically impossible due to the absence of detailed baseline studies before the establishment of the jatropha projects.

Third, it is practically impossible to unpack the effect of each individual driver on the collapse of each specific project, let alone the sector as a whole. As suggested by the expert interviews and household surveys (Sect. "Task 1: Drivers of jatropha collapse"), the different drivers of collapse are strongly interlinked. For example, crop failure is often blamed on the poor planning and lack of research from the part of the investors. On the other hand, the private sector suggests that some poor business practices such as the circumnavigation of the weak land administration system were due to the low institutional support that investors received from the government of Ghana, which in turn did not "allow" them to operate within a properly regulated institutional landscape. This means that while our study can offer a glimpse of all factors that affected jatropha collapse, it cannot differentiate between their relative importance. This is not the least an outcome of the "blame game", in which the different actors descended by indicating other aspects of the biofuel complex as responsible for the collapse of the sector (Borras et al. 2010).

Future studies should use empirical approaches to understand the drivers of collapse and post-collapse impacts of jatropha in other African countries that experienced large jatropha promotion. Furthermore, there is very scant knowledge about the local post-collapse dynamics. For example, we need critical studies on emerging post-collapse issues such as who owns the land and who should have access to land (i.e. land rights) in areas of jatropha collapse. Due to gaps in the land administration systems, land rights have remained "in limbo" following the collapse of several jatropha projects. Whereas local communities are demanding land rights to be formally returned, the *modus operandus* in doing so is not explicit in the national legislation and the exit strategies of companies. Most companies still hold the land rights and are rebranding themselves as other commercial agriculture activities (e.g. rice cultivation) but the legality of such practices is not clear-cut and needs to be further investigated. Another research gaps relate to the ecological restoration of abandoned jatropha plantations. With hundreds of thousands of hectares of abandoned jatropha plantations across Africa, there are several unresolved questions such

as whether/how ecological restoration is to be pursued and who is responsible.

Conclusions

This paper discussed issues surrounding jatropha collapse in Ghana such as the (a) drivers of collapse, (b) post-collapse impacts, and (c) acceptability of future biofuel ventures. Understanding these aspects of the recent jatropha, boom-and-bust cycle can provide valuable information to inform which policy and practice domains must be strengthened to improve the sustainability of future biofuel investments.

Expert interviews with national, regional and local stakeholders identified several drivers that contributed to the collapse of the jatropha sector in Ghana. While many of these drivers are context-specific, we can group them into five overarching categories: (a) civil society opposition, (b) low crop productivity, (c) community conflicts, (d) poor land administration and other institutional barriers, and (e) weak business planning and lack of funding. Local stakeholders cite, among others, low crop productivity and weak business planning/lack of funding as the main drivers. National and regional stakeholders identified poor land administration, weak business planning and civil society opposition as the dominant drivers of collapse. However, it is difficult to differentiate the relative contribution of each driver to the collapse of each project, let alone the sector as a whole.

The willingness to accept another jatropha project in areas that experienced collapse varies between sites and geographical contexts. Social conflicts emerge as the main determinant of social acceptability of future biofuel investments, as communities that experienced severe social conflicts are less likely to accept new jatropha/biofuel investments.

Our results suggest that any action to promote jatropha (or any other biofuel crop for that matter) must reconsider the entire biofuel complex. This is because several of the drivers of collapse acted in tandem and synergistically. Given the centrality of land in practically all five drivers of collapse, it is imperative to improve the land administration system. Developing clear guidelines of who is the rightful landowner, recipient of compensation, and how compensation is to be given, are only some of the issues to be tackled before broad political support could be given to a new wave of large-scale land acquisition for biofuel production in Ghana.

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