The rise and fall of foreign private investment in the jatropha biofuel value chain in Ghana

Nygaard, Ivan; Bolwig, Simon

Published in:
Environmental Science & Policy

Link to article, DOI:
[10.1016/j.envsci.2017.08.007](https://doi.org/10.1016/j.envsci.2017.08.007)

Publication date:
2018

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):
Nygaard, I., & Bolwig, S. (2018). The rise and fall of foreign private investment in the jatropha biofuel value chain in Ghana. *Environmental Science & Policy*, 84, 224-234. <https://doi.org/10.1016/j.envsci.2017.08.007>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

The rise and fall of foreign private investment in the jatropha biofuel value chain in Ghana

1 Introduction

Since the turn of the millennium, *Jatropha curcas* has emerged as a promising opportunity for sustainable biofuel production due to a number of positive properties that are attributed to it, such as high yield, low water and fertilizer requirements, high resistance to pests, and not least its ability to grow on marginal land without competing with food production (Jongschaap et al., 2007)(Achten et al., 2008). Between 2005 and 2009 especially, there was strong global enthusiasm for jatropha (Sanderson, 2009), which many investors government actors and NGOs perceived as a miracle or wonder crop (von Maltitz et al., 2014). Globally, however, jatropha did not live up to these inflated expectations. By 2014 global jatropha production was still negligible (van Eijck et al., 2014a), and, based on the experience of jatropha cultivation in Tanzania (Segerstedt and Bobert, 2013), it was concluded that 'both domestic production and (certified) exports are too expensive to be able to compete with conventional diesel/rapeseed oil from the EU'. Nonetheless 'the crop may have potential for large-scale production as a niche product' (ibid.).

Jatropha was also grown on a large scale in Mali (Favretto et al., 2015), Kenya (Hunsberger, 2014) and Mozambique (Slingerland and Schut, 2014; von Maltitz et al., 2014), but Ghana and Tanzania were the two African countries that attracted the greatest number of private companies prepared to make substantial investments in large-scale jatropha farming (Romijn and Caniëls, 2011; van Eijck et al., 2014b; Van Eijck et al., 2014). In Ghana research into jatropha has mainly focused on land issues (Boamah, 2014a, 2014b; Campion and Acheampong, 2014; Kidido and Kuusaana, 2014; Schoneveld and German, 2013; Wisborg, 2013) and questions of the environment and livelihoods (Acheampong and Campion, 2014, 2013; Boamah and Overå, 2016; Schoneveld et al., 2011), but we find no attempts to understand the phenomenon of the jatropha investments in Ghana from the perspective of a transition to sustainability or in respect of agricultural or industrial development.

Research into sustainable transitions emerged in European countries with a focus on the Netherlands, the UK and Denmark, being pursued mainly from three different perspectives: the multi-level perspective (MLP) (Geels, 2002), the strategic niche management (SNM) perspective (Kemp et al., 1998) and a technological innovation system (TIS) perspective (Bergek et al., 2008; Hekkert et al., 2007). Lately, research on sustainability transitions in developing countries has attracted much interest, with seminal contributions by (Angel and Rock, 2009; Berkhout et al., 2010, 2009; Romijn and Caniëls, 2011; van Eijck and Romijn, 2008). While the geographical range has mainly been on emerging economies in Asia (see e.g. (Hansen and Nygaard, 2014), research into sustainability transitions has also been undertaken in Africa, especially in Tanzania and Kenya (Byrne, 2009; Ockwell and Byrne, 2015; Tigabu et al., 2015). However, as Lundvall et al. have already pointed out (2009), there are profound differences between how transitions unfold in low-income developing countries and in western high-income, industrialized economies respectively. Compared to developed countries, developing countries often have weaker formal institutions, higher levels of political and bureaucratic inefficiency and corruption, greater political and economic instability, and less transparent and efficient legal frameworks. When it comes to using the theoretical frameworks of transition theory in the context of a developing country, the most important challenge may be the fact that technology, knowledge and finance in general are to a larger extent sourced through links

with international research organizations, foreign companies, investors and international donors (Hansen and Nygaard, 2013), as (Pietrobelli and Rabellotti, 2009) have also highlighted.

The role of international ties can be addressed by means of the global value chain (GVC) approach, which has played a prominent role in analyses of agricultural and industrial development in developing countries since the early 1990s (Gereffi, 1999). Much of the GVC literature focuses on how firms and farms in developing countries are integrated into global markets (Bolwig et al., 2010). Some of this literature concerns agricultural exports from Africa, mainly with a focus on food (Bolwig et al., 2013; Gibbon and Ponte, 2005), but also fibre (Glin et al., 2012; Rieple and Singh, 2010), while only a few GVC studies from developing regions concern agro-fuel (biofuel) exports (Hunsberger et al., 2014; Ponte and Hunsberger, 2014). GVC studies of global biofuels markets (Ponte, 2014) and biofuel imports (Harnesk et al., 2017) have recently been published, pointing to the strong influence of policies and NGO advocacy in the governance of biofuel value chains.

Based on the empirical knowledge gap outlined above, this paper sets out to analyse the drivers behind the large-scale foreign investments in a biofuel value chain in Ghana and to identify the main reasons for their rise and fall. To address this question, we shall draw on transition theory, especially the MLP framework, to acquire insights into the historical evolution of the niche and regime conditions and the interactions between them, as well as insights from the GVC framework to understand the international links involved. We shall draw on the theory of hype cycles as a structuring tool in the paper (Van Lente et al., 2013; Verbong et al., 2008).

The remainder of this paper is organized as follows. Section two presents an integrated analytical framework based on the MLP and GVC perspectives. Section three outlines the data collection and research methods that underpin the study. Section four presents the historical evolution of the *jatropha* niche, followed by section five, which discusses the main reasons for the rise and fall of foreign investments in biofuel production in Ghana. Some conclusions are presented in section six.

2 Conceptual framework

2.1 Multi-level perspective or MLP

The multi-level perspective (MLP) on systems innovations considers how niche proliferation is influenced by interacting processes at different socio-technical levels, namely the *landscape* (macro), *regime* (meso) and *niche* (micro) levels (Geels, 2002; Kemp et al., 1998). The *landscape* level covers the large-scale and exogenous structural context that influences dynamics at the regime and niche levels. The *regime* level refers to the relatively stable configurations of institutions, techniques and artefacts, and of the rules, practices and actor networks, that determine the 'normal' development and use of technologies. Because of stabilizing mechanisms, regimes are characterized by path-dependency, structural lock-in and actors' resistance to change, which hinder or constrain the emergence of alternative technological trajectories (Rohracher, 2008; Unruh, 2000). A *niche* is a local platform or 'incubation room' from which new socio-technical trajectories may emerge and eventually fulfil functions within existing regimes. Because of the stabilizing mechanisms just mentioned, niche proliferation is contingent upon destabilizing tensions that open up 'windows of opportunity' at the regime level (Hans de Haan and Rotmans, 2011; Verbong et al., 2008). Such tensions may arise from processes at the landscape level or from regime-level dynamics.

1 In the MLP, niches are distinct application domains that provide a time-restricted and protected
2 space within which new practices and technological innovations can incubate and become viable
3 through experimentation. The viability of niches is influenced by three internal niche-level processes
4 (Schot and Geels, 2008): (i) the shaping and *alignment of expectations*, (ii) the *formation of a social*
5 *actor network* and (iii) *learning processes*. Increasing alignment of expectations involves niche-level
6 actors increasingly sharing similar visions, beliefs and interests. A high level of aligned expectations is
7 generally conducive to niche development, although the envisaged opportunities must be made
8 specific, and they will rely on positive, tangible results (Geels and Raven, 2006). The second niche-
9 level process concerns the formation of a constituency behind a new socio-technical trajectory that
10 consists of a network of engaged actors. The formation of close social ties and regular interactions
11 among actors is seen as stimulating niche development, as does the involvement of a broader and
12 more varied actor network (Coenen et al., 2010; van der Laak et al., 2007). Lastly, learning processes
13 involve learning about the technological aspects of niche-level experiments, including technical
14 design, functionality and performance, as well as the learning processes pertaining to the social
15 embeddedness of these aspects (Hansen and Nygaard, 2014). The latter requires that actors and
16 society at large learn about many aspects of the technology, including economy, user preferences,
17 regulation and environmental impacts.

18 In empirical MLP research, the three levels of regime, landscape and niche are often operationalized
19 using territorial boundaries: regimes tend to be depicted as national processes, landscape dynamics
20 as international ones, and niche processes as sub-national or local. Hence transnational linkages and
21 the global dimensions of transitions have to a large extent been analysed as part of an all-embracing
22 'landscape' (Geels, 2011). Such territorial and arguably simplistic approaches have met with criticism
23 from within the MLP community (Raven et al., 2012). Social networks in niches, for example, are not
24 necessarily only local, as sustainability experiments and niche-level actors are often embedded in
25 global flows of knowledge, technology and finance (Coenen and Truffer, 2012; Rock et al., 2009).
26 Likewise, regimes may be transnational in their physical extent and influenced by global actor
27 networks and institutional linkages that may either support or destabilize them (Smith et al., 2010).
28 Thus, both regimes and niches may exhibit a similar form of multi-scalar layering in their spatial
29 reach (Wieczorek et al., 2015). However, the understanding of niche formation and transition
30 dynamics as shaped by interactions between actors and institutions situated across different spatial
31 scales has only recently been introduced in the MLP (Binz et al., 2012).

32 In this paper, we draw attention to the flows of knowledge and resources facilitated through
33 international biofuel investments and the resulting global value chains as one element in a
34 transnational analysis of niche development. We use insights from the GVC literature that provide an
35 actor-focused and 'relational' perspective on the organization and dynamics of industries.

36 2.2 Global value chain analysis or GVC

37 Global value chain (GVC) analysis has emerged since the early 1990s as a methodological tool for
38 understanding the dynamics of economic globalization and international trade (Gereffi and Lee,
39 2016; Gibbon et al., 2008; Gibbon and Ponte, 2005). It is based on the analysis of discrete 'value
40 chains' where input supply, production, trade, and consumption or disposal are explicitly and, at
41 least to some extent, coherently linked. The use of the 'chain' metaphor signals a focus on
42 relationships or links between buyers and suppliers (chain actors) and the movement of products
43 from producer to consumer. This entails an analysis centred on flows of material resources, finance,

knowledge and information between chain actors, where ‘upstream’ signals flow towards production, ‘downstream’ signals towards consumption. The GVC approach involves analysing the structure, actors and dynamics of value chains, including the types and locations of chain actors, their mutual ties, and the dynamics of their inclusion and exclusion. It also entails understanding the structure of rewards, the division of labour along a chain, and the distribution of added value (Bolwig et al., 2010).

Upgrading and governance are central GVC concepts. GVC research highlights how firms upgrade – that is, acquire capabilities and access new market segments – through participation in particular value chains, including by learning from buyers in these chains (Bolwig et al., 2010; Gereffi, 1999; Gereffi and Lee, 2016). Governance in the GVC literature is seen as the process by which so-called ‘lead firms’ (in the context of a larger institutional framework) organize activities with the purpose of achieving a certain functional division of labour along a value chain, resulting in specific allocations of resources and distributions of gains. It involves setting the terms of chain membership, such as compliance with standards (Gibbon and Ponte, 2005), the related incorporation or exclusion of other actors, and the re-allocation of value-adding activities (Gereffi, 1994; Gibbon et al., 2008; Kaplinsky, 2000). Recent literature points out that external actors – governments, standard-setters, multilateral institutions, NGOs – can significantly influence GVC governance (Ponte and Sturgeon, 2013; Riisgaard et al., 2010), especially in emerging industries like those for renewables, thus creating multi-polar chains (Ponte, 2014). In this paper, we focus on the governance concept, which we operationalize by analysing selected characteristics and linkages of firms involved in establishing the jatropha niche in Ghana.

3 Data and methods

The paper builds on case studies of seven biofuel companies in Ghana, summarised in Table 1, along with analyses of the value chains, markets, and policy frameworks surrounding these companies. Data were collected through a combination of field visits, semi-structured interviews with key stakeholders and actors, a review of the grey and scientific literature, newspaper articles and webpages. The authors conducted a one-week exploratory field visit to Scanfarm Ghana (formerly ScanFuel AS) in 2012, followed by two weeks of field visits in December 2014, including site visits to the other four major jatropha farms, Kimminic, Jatropha Africa, Biofuel Africa and Smart Oil. Semi-structured interviews were carried out with local managers of the five companies and with farm managers from Scanfarm, Kimminic and Jatropha Africa, while the founder of Scanfarm was interviewed by telephone in August 2017 (Hesselberg, 2017). The case studies of Galten and Goldstar relied on documentary analysis only as interviewees were unavailable. Another twelve interviews were conducted with researchers, NGOs and government officials. Ten of the twenty-one interviews were recorded and transcribed, while for the rest minutes were prepared the same day based on detailed field notes. Historical information for describing the value-chain actors and the narrative of how the niche and regime evolved was collected through the interviews and then supplemented and triangulated with information from literature, web-based newspaper articles, company webpages and databases containing company information. Here we made extensive use of the Wayback Machine (www.web.archive.org), an internet tool giving access to a vast library of captured old webpages. A comprehensive description of the biofuel companies is available in Table A1 while (Nygaard and Bolwig, 2017) provides a richer account of the evolution of the biofuel niche and regime in Ghana.

Table 1: The biofuel case companies. Source: authors' compilation. More details in Table A1.

	Jatropha Africa	Goldstar	Galten Ghana	Kimminic	Scanfarm Ghana	Biofuel Africa	Smart Oil
Country of origin	United Kingdom	USA	Israel	Canada	Norway	Norway	Italy
Mother company start-up date	Lion Bridge Venture, Sept. 2006	Goldstar Farms Ltd, early 2007	Galten, June 2006	Kimminic Corporation, March 2007	ScanFuel AS, Sept. 2007	Norwegian Biofuel AS, Oct. 2007	Agroils, 2006
Ghanaian subsidiary start-up date	Jatropha Africa Nov. 2006	Goldstar Biofuels, Early 2007	Galten Ghana Early 2007	Kimminic Estates March 2007	Scanfuel September 2007	Biofuel Africa, Oct. 2007	Smart Oil May 2008
Size of investment	Unknown (but small)	Unknown	USD 2.4 Million by 2010	USD 16 Million by 2011	USD 2.6 Million by 2009	USD 7.1 Million by 2009	USD 5.3 Million by 2015
Area claimed by company	120,000 ha	2,000,000 ha	100,000 ha	65,000 ha	304,000 ha	150,000 ha	105,000 ha
Area finally leased	50,000 ha	0	Unknown	65,000 ha	13,000 ha	10,696 ha	4,500 ha
Area cultivated with jatropha	500 ha	0	400 ha	5,000 ha	350 ha	1,400 ha	720 ha
Planned product	Seeds	Biodiesel	Biodiesel	Biodiesel	SVO	SVO	SVO
Achieved product	Seeds	None	None	Seeds	Seeds	Seeds	Seeds

4 Evolution of foreign private-sector jatropha production

Our presentation of the evolution of a niche for jatropha biofuels is divided into four periods (Figure 1), which coincide with the first phases of an emerging technology's life cycle or 'hype cycle' as described by (Gartner Inc., 2017) and discussed in (Ruef and Markard, 2010; Van Lente et al., 2013). Within this cycle of maturity and adoption of the jatropha technology, the initial 'technology trigger' period from 1999-2006 built up expectations, but there were few activities on the ground. The 'peak of inflated expectations' period from 2007-2008 was characterized by very high expectations, a rush for land and capital, and the establishment of farms and downstream facilities. The period from 2009-2011 was situated on the 'slope of disillusionment', with lower and mixed expectations, and where most companies closed down, while a few continued to invest and operate. The last period from 2012-2016 was the 'trough of disillusionment', when all except one company hibernated or was under liquidation. In the following, we describe the main events during each period at the landscape level, the regime level and the niche level, which are important for the discussion in section five. Special emphasis is placed on the drivers in the global biofuel value chain.

Figure 1. The evolution of the jatropha life cycle or hype cycle in Ghana, 1995 - 2016. The x-axis measures the evolving maturity and application of the jatropha technology and the y-axis the level of visibility and interest in the technology. Source: adapted from (Gartner Inc., 2017).

4.1.1 Technology trigger, 1995-2006

The major change at the landscape level in this period was the increase in world market oil prices. After almost fifteen years of relatively stable crude oil prices at 15 to 20 USD per barrel, crude oil prices gradually increased to about 60 USD per barrel in 2006 (Figure 2). Another landscape driver was the Clean Development Mechanism (CDM), which entered into force in 2005.

The combination of the environmental agenda, the CDM and the soaring oil prices stimulated international interest in biofuels. From 2000 to 2006, biodiesel production rose about ten times from 0.8 to 6.5 billion litres per year, driven mainly by a dramatic policy change in 2005-2006, when several countries in the EU set targets and mandates for biofuels and introduced biofuel tax exemptions (REN21, 2006). Figure 3 shows global biofuel production in the four periods.

Figure 2. Crude oil prices in the four periods. Monthly average Europe Brent Spot Price FOB in United States Dollars. Data source: www.eia.gov, accessed 10.01.2017.

Figure 3. Global production of biofuels in the four periods, in billion litres. Data source: (REN21, 2017) and previous issues.

At the beginning of this period, the energy regime in Ghana was under strong government influence, but like many other African countries, Ghana went through a reform process leading to a power-sector reform adopted in 2000 (Edjekumhene et al., 2001). The building of new oil-dependent power plants and the delays to the West African gas pipeline, along with the increase in oil prices, caused very high costs for imported energy, and energy imports therefore became a key issue for Ghana's trade balance (Energy Commission, 2005). Energy security and national energy production (import substitution) were thus high on the political agenda. In this context of regime instability, the plan for

a new biofuel niche actor to establish a biofuel factory pushed the government to make a preliminary analysis of the production and use of biofuels. A draft biofuel strategy document was issued in 2005 and revised in 2006 (Brew-Hammond, 2009; Energy Commission, 2006, 2005). Despite the limited practical experience with biofuels, the first draft biofuels policy was ambitious and recommended, among other instruments, mandatory blends of gasoline and biodiesel at five percent (5%) by 2010 and ten percent (10%) by 2015. These targets were maintained in the Strategic National Energy Plan (SNEP) published the same year (Brew-Hammond, 2009).

At the niche level, donor-supported projects led by GTZ, UNIDO and UNDP played a major role in the promotion of jatropha for biofuel production in West Africa in the early years (Henning, 2009, 1998; Nygaard, 2010). In Ghana, a 4 ha pilot plot for Jatropha cultivation and a press for pressing jatropha oil was established in 2001 (Mensah, 2009), while another project planted 2000-2400 ha of jatropha in an out-grower scheme. Finding a market for the seeds that were produced was a major problem facing the project, as were low yields and pest problems. Most farmers eventually cut down their jatropha trees, and the situation since 2007 remains unclear (Amissah-Arthur et al., 2007).

The first private-sector activities date back to 1999, when Onua Amoah, a Ghanaian industrialist, set out to investigate the feasibility of jatropha for biofuel production. Through his company Anuanom Industrial Bio Products (AIBP), he started a pilot research plantation for jatropha, some small-scale production of jatropha oil for testing and a test pressing facility. He also claimed to have developed an improved jatropha species, which could yield 9 tons of seeds/ha, compared to the 3-5 tonnes of seeds/ha obtainable from the wild jatropha species (Amoah, 2006a). Until his early death in 2007, he worked to attract finance for a 120,000 tons/year jatropha processing plant (Amissah-Arthur et al., 2007). Another 'local niche champion' (van Eijck and Romijn, 2008), Christian Kofi Marfo, an agricultural scientist, set up a company called Biofuel 1, which established a test farm of about 280 ha, as well as a press facility (Marfo, 2014). The test farm unfortunately burned down in a bush fire in 2007 (Amissah-Arthur et al., 2007; Marfo, 2014). A third champion, Kwabena Frimpong-Boateng, was a university professor and a high-ranking member of the National Patriotic Party (NPP). He worked closely with Amoah, and in August 2007 they and other private actors acquired land for jatropha cultivation.

On the policy side, the National Jatropha Plantation Initiative was launched in late 2006 with government support to the tune of 1.6 million USD (Amissah-Arthur et al., 2007). The plan had a target to develop a million ha of jatropha plantations on available idle and degraded lands over the following five to six years. The project included the production of a large amount of seedlings delivered by AIBP (Amoah, 2006b). The strong push by niche actors for changes to the energy regime was aided by a UNCTAD/ECOWAS conference in 2006 on CDM and the financing of biofuels and jatropha plantation projects, where Amoah gave two engaging speeches (Amoah, 2006a, 2006b; UNCTAD, 2006).

4.1.2 Peak of inflated expectations, 2007-2008

The global demand for biodiesel increased rapidly during this period, rising from 6.5 billion litres per year in 2007 to 15.6 billion litres in 2008 (REN21, 2012). Two drivers at the landscape level were mainly responsible for this growth. The first was a strong and continued policy support to biofuels in an increasing number of countries focusing on targets, blending mandates and tax exemptions (REN21, 2009, 2008). The second was the large increase in crude oil prices from about 80 USD in June 2006 to 147 USD in September 2008, just before the onset of the global financial crisis, which drew oil prices back down again and tightened up financial markets. A third driver was the CDM,

which in this period attracted a lot of attention as a potential financing mechanism for biofuel projects in developing countries.

There were also impeding factors for niche development at the landscape level. Global food prices in this period climbed to their highest levels since the 1970s and initiated a global debate on food versus fuel as respective priorities. The FAO, World Bank and OECD published reports claiming that biofuel production was an important driver of the increase in food prices and raising questions about biofuels' potential to reduce CO₂ emissions (FAO, 2008; Mitchell, 2008; OECD, 2008; Romijn and Caniëls, 2011).¹ Linked to this debate was the discussion on large-scale land-grabbing in Sub-Saharan Africa, initiated in June 2007 by a European NGO using examples of land-grabbing for biofuel production from Tanzania, Uganda, Ethiopia, Nigeria and Ghana (GRAIN, 2007). The same year, the first critical research was published questioning common, positive perceptions of jatropha regarding yields and resilience (Achten et al., 2008; Jongschaap et al., 2007).

At the regime level, changes in this period were small. The draft biofuel policy of 2006 was not approved by the Ghanaian government, and the draft National Energy Law under preparation was delayed (Brew-Hammond, 2009). Work on biofuel standards continued, but they were not adopted (Antwi et al., 2010). The discovery of offshore oil and gas in 2007, along with the death of Amoah the same year, reduced the government's interest in biofuels, and it gradually withdrew from biofuel activities while still providing support to private investors (Boamah, 2014a; KITE, 2014).

Contrary to the low level of activity at the regime level, the years 2007 and 2008 witnessed high levels of optimism and activity among niche actors. There was a veritable rush for land, and rumours about the acquisition of large amounts of land for biofuels were widespread. (Schoneveld et al., 2010) estimated that by August 2009 there were fifteen active biofuel companies, of which thirteen were cultivating jatropha. Collectively they claimed to have access to 1,075,000 ha of land, of which 730,000 ha were in the forest-savannah transition zone in the Brong Ahafo and northern Ashanti regions (Schoneveld et al., 2010). By late 2009, more than twenty foreign companies had acquired land to grow crops for biofuel production, mostly for export (Dafrallah et al., 2010). It is uncertain how many of these companies were established before 2009, but the companies analysed in this article all started between 2006 and 2008 (Table 1).

4.1.3 Slope of disillusionment, 2009-2011

At the landscape level, the beginning of this period was characterized by the global financial crisis, which made international finance capital more adverse to risky investments. Crude oil prices plunged from 147 USD/barrel in July 2008 to about 40 USD in late 2008, and then slowly recovered to around 110 USD/barrel by January 2011, where they remained during 2011 (Figure 2). The importance of the CDM as an incentive for biofuel projects was gradually reduced along with the price drop of Certified Emission Reductions (CERs) to below 5 USD by the end of 2011.

The financial crisis and the drop in oil prices reduced the annual growth rate of biodiesel demand from above 50% to only 10% (REN21, 2012, 2010). This had short-term implications for the biodiesel industry, and by early 2009 German biodiesel production was only 60% of capacity, and several factories had closed down (Romijn and Caniëls, 2011). Nevertheless, construction of new plants continued in the period. In 2009, for example, Neste Oil Corporation began constructing the largest biofuel plant in the EU with a capacity of 0.9 billion litres per year, and traditional policy elements such as blending mandates and tax exemptions spread to more countries. In 2009 the EU renewable Energy Directive, which requires 10% of transportation fuels to come from renewables by 2020, set

the first mandatory sustainability standards for biofuels, and the US introduced the Renewable Fuel Standard (RFS) (REN21, 2012, 2010).

At the regime level, the preparation for national oil production reduced concern over energy security in Ghana. While the new National Democratic Congress (NDC) government that entered office in January 2009 was in favour of biofuels, it was also concerned with the potential competition with food security (Boamah, 2014a; Ministry of Energy, 2010a, 2010b). In 2010 a draft bioenergy policy developed by the Energy Commission restated the blending targets and the tax exemption of biofuels that had been contained in the 2005 proposal. It also proposed new incentives favouring a local market for biofuels and suggested levies and taxes on biofuels for export (Energy Commission, 2010). However, the draft policy was not approved, and the Renewable Energy Act (Act 832) adopted in 2011 did not include policies on biofuel blending targets or tax exemptions (GOG, 2011). The consistent failure of the government to enact the biofuel policy proposals developed by its own Energy Commission reflect the different positions on biofuel issues between two large regime actors, namely the Energy Commission (EC) and the Ministry of Energy (MOE). These positions were expressed in 2009 by two leading figures representing the two institutions: Abeeku Brew-Hammond, Head of the EC, who expressed a positive attitude towards biofuels for the national market (Brew-Hammond, 2009); and Wisdom Ahiataku-Togobo, Ministry of Energy, who had a more critical view of biofuels (Ahiataku-Togobo and Ofosu-Ahenkorah, 2009).

At the niche level, the first two years of this period saw a continuation of critical reports from NGOs and the Ghanaian press focusing on land grabbing and the destruction of the environment and local livelihoods, initiated by a Ghanaian NGO in August 2008 (Nyari, 2008). This debate influenced both niche and regime actors and contributed to the difficulties experienced in attracting finance for biofuel companies such as Biofuel Africa (Boamah, 2014a). The period started with the liquidation of the mother companies of Biofuel Africa (March 2009) and Jatropha Africa (June 2009), but both Ghanaian subsidiaries continued operation by the former managers as owners. Biofuel Africa started up maize farming, while Jatropha Africa continued operation in a limited way. Scanfarm converted to maize production in 2010 when it learned that jatropha yields would be much lower than expected, rendering the operation unprofitable. At the same time, the company changed name from the original Scanfuel to Scanfarm, and it reduced its land lease to a size more suitable for domestic food crop farming (Hesselberg, 2017). The scant information on Galten suggests that it had sown 99 ha out of a planned 1000 ha by early 2009 (Shpurur, 2009). Goldstar had established an office building and a webpage, but according to a court sentence in Oregon in 2016, its only purpose was to defraud investors in the US (U.S. Attorney's Office-District of Oregon, 2016). Kimminic and Smart Oil were the most successful companies at this time, though they followed two different strategies. Smart Oil, which had been started up with a small experimental test trial of 10 ha in 2008, established a 6 ha scientific test trial in June 2010 to prepare for commercial farming in 2012 (Darko, 2014). Kimminic continued building up large-scale farming and increased the planted area from 2400 ha in 2009 to 5000 ha by late 2011. It also started construction of a turnkey biofuel refinery, which, besides its own seeds, could process seeds from outgrower schemes and other companies (Kite, 2012; Marfo, 2014). Aside jatropha, Kimminic also planted an estimated 500 ha with maize and other food crops for the domestic market (Marfo, 2014; Kizito et al. 2013).

4.1.4 Trough of disillusionment, 2012-2016

At the landscape level, oil prices remained stable at around 100 USD per barrel until August 2014, when they dropped to 40-50 USD per barrel, continuing into 2016. In 2012 the cost of the CERs

declined from 5 to 0.31 USD per ton, at which point it lost its importance completely. The CDM was not extended beyond 2012, but was replaced by voluntary trading schemes, which have had only a very limited impact on biofuel schemes.

Global biodiesel production increased from 21 billion litres in 2011 to 30 billion litres in 2015 (REN21, 2016, 2015, 2014, 2013). Biofuel policies in Europe and the United States continued to be challenged by groups concerned about the negative environmental and social impacts of biofuels, and policy support increasingly shifted towards the promotion of advanced biofuels (REN21, 2016).

At the regime level, the draft biofuel policy from 2010 was merged with a policy on cooking fuels into a bioenergy strategy document (Energy Commission, 2014), but to date this strategy has not been translated into policy.

At the niche level, companies were hibernating and activities were closing down in this period. The shareholding value of Galten declined from about 10 MUSD by January 2012 to zero on 1 January 2013,² signalling the closure of the company (Darko, 2014). In late 2011 an equity group failed to provide a new capital inflow of USD 3 million to Kimminic (Marfo, 2014), causing the company to suspend operations in May 2012 (Boamah, 2015). At the time of fieldwork Kimminic was still searching for funding, and by November 2015 it had closed down.³ In December 2014 the operations of Jatropha Africa were characterized by low-intensity farming scattered over different plots in four villages, and the planted area had not increased. The company appeared to be hibernating, waiting for new investors (Ampadu, 2014). Biofuel Africa had completely abandoned jatropha by the time of our fieldwork and was instead engaged in large-scale food-crop farming (maize and rice). Smart Oil started on its large-scale plantation in July 2012, planting 450 ha in 2012 and reaching 720 ha in late 2014. The company found it unprofitable to produce jatropha oil for biofuel at the prevailing oil price of 50 USD. It thus embarked on a strategy to sell jatropha oil in non-energy markets, where prices are higher and volume requirements lower, such as for biochemical uses and the treatment of leather (Darko, 2014). In 2015 Smart Oil bought jatropha seeds from other growers in Ghana for this market.

5 Drivers and trajectories of foreign private investment in jatropha in Ghana

This section draws on the MLP and GVC frameworks to discuss the drivers and trajectories of foreign private investment in biofuel production in Ghana as outlined in section four. We first discuss the factors identified by MLP scholars as influencing internal niche processes – alignment of expectations, network formation, and learning and knowledge sharing – and then go on to discuss important value chain attributes, including governance, firm ownership, and access to land and capital.

5.1 Alignment of expectations

Compared to the development of other socio-technical niches, in Ghana the jatropha niche was to a large extent driven by expectations rather than by tangible results from research or practice. From 2000 onwards, the dominant discourse in Ghana, as well as globally, depicted jatropha as a new wonder crop able to produce vegetable oil on marginal land with low inputs of water, fertilizer and pesticides. The high expectations attached to jatropha continued during the following years and in Ghana reached their ‘peak of inflated expectations’ period in 2007-2008, when all the major jatropha companies were established. Despite the appearance of the first critical reports on economic and sustainability issues in 2007, foreign investors continued to be interested in the crop,

and the positive expectations of jatropha as a profitable business continued among some niche and regime actors until around 2012.

The first vision of niche actors was to supply the local market at preferential prices in a partnership with the government, but during the 'peak of inflated expectations' period this was quickly changed to a vision of large-scale production for export markets. This change of vision can be explained as a combination of changes at both the regime and niche levels and the interactions between them. At the niche level, expectations of the creation of a local market for biofuels were mainly driven by the three Ghanaian local niche champions previously mentioned. During the 'technology trigger' period, these men were very active as 'system builders' (Ockwell and Byrne, 2015) and ensured a strong alignment of expectations among niche actors, as well as between niche and regime actors, rooted in a fear of increasing oil prices, and aiming at import substitution. These efforts resulted in several project proposals, political statements and draft policy papers developed in partnership between niche and regime actors.

During the 'peak of inflated expectations', however, the 'local market' vision changed to one of large-scale, vertically integrated export production. Several factors contributed to the demise of the local market vision: 1) the discovery of offshore oil in 2007 and the sharp decline in oil prices in 2008, which combined to weaken the import substitution argument; 2) a new NDC-led government in 2009, which was influenced by the fierce NGO opposition to biofuels and made no effort to support the development of a local biofuel market through blending mandates (which had been discussed since 2005) or other policies; and 3) the reduced influence and engagement of the niche champions, including the death of the strongest proponent of import substitution, Amoah.

The large-scale export vision, on the other hand, was created in large part by the many new foreign-owned companies that established export-oriented production in Ghana in these years in response to favourable biofuels policies in the EU and North America, as outlined later. These companies' links with the political system in Ghana were rather weak, and they did not seem to invest significant resources in promoting a national biofuels market by linking up with regime actors.

In summary, the global discourse of jatropha as a wonder crop led to high expectations in Ghana regarding jatropha as a profitable business opportunity, which after 2008 were fuelled by niche actors' interests and were maintained until 2012. The change in visions of the jatropha business model from import substitution to export orientation exemplifies the ability of niche actors to adapt to new conditions, which, however, occurred mainly through the entry of new (foreign) actors. The 'slope of disillusionment' period from 2009 to 2012 saw a misalignment of expectations between the niche level (high expectations and foreign investments) and the regime level (low expectations and weak national policies), ending in the deep 'trough of disillusion'.

5.2 Formation of networks

In the first 'technology trigger' period until 2006, the local niche champions mentioned above successfully influenced the regime; they belonged to the government stakeholder committees set up to elaborate the draft biofuel policy issued in 2005, and there were strong relationships between a small group of pioneers from the private sector, government agencies and universities in the first years until 2007-2008 (Energy Commission, 2014; Marfo, 2014)(Energy Commission, 2014)(Energy Commission, 2014)(Energy Commission, 2014)(Energy Commission, 2014)(Energy Commission, 2014). Even in the period of the 'slope of disillusionment', individual niche actors were also involved in government committees on biofuel

standards and biofuel policy (Janssen and Rutz, 2008).⁴ Yet the new niche actors of foreign-owned companies (from Israel, UK, Norway and Canada, often with Ghanaian directors) did not form strong or formal networks that could have enhanced knowledge-sharing and policy advocacy. Advocacy and other forms of institutional work to change the existing regime were instead done on an individual basis and did not achieve the level of influence which a formalized organisation of jatropha growers might have had. Hence, weak network formation may have contributed to the demise of the niche.

5.3 Learning and knowledge-sharing

When foreign-owned companies entered the jatropha sector in 2007, donor projects had already acquired experience of jatropha growing in the region. These included the UNDP projects in Mali (from 1996) and the ADRA/UNDP/GEF project in Ghana (from 2001), which planted 2000-2400 ha of jatropha in an out-growers scheme that was closed in 2006 due to low yields and a lack of market outlets (Amissah-Arthur et al., 2007). However, such experiences were not analysed and documented by independent experts. The tendency not to document or communicate negative project results is not unusual (Hunsberger, 2010; Nygaard, 2010) and is linked to the interest in attracting new funding. Similarly, niche champion Amoah claimed to have developed an improved, high-yielding jatropha seed variety, but failed to document its attributes (Amissah-Arthur et al., 2007; KITE, 2014), and so no wider learning effects were achieved. Consequently, the new entrants had to rely on their own knowledge. The period of 'inflated expectations' was characterized by high levels of uncertainty among these companies regarding key aspects such as the business model (e.g. large vs. small scale), technologies (seed varieties, nutrient and pest management, harvesting methods, etc.), natural resources and yields. For example, the original business plan of Scanfarm relied on yield estimates that were significantly higher than what could be realised on its own test farm (Hesselberg, 2017). Notwithstanding large knowledge gaps about local conditions, they also found it difficult to access general knowledge about large-scale jatropha farming, despite visiting projects, attending conferences worldwide and studying the literature (Darko, 2014; Helvig, 2014). Thus, while securing land to help obtain capital and starting clearing and planting to show progress, the new companies established their own trials. Biofuel Africa established a 800 ha test farm in Sugakope in cooperation with the Wosornu Foundation, where they experimented with different seeds and with mechanized harvesting (Helvig, 2014; Kolnes, 2009a), Smart Oil ran a 10 ha experimental plantation, and Scanfarm established a plot of 350 ha. Kimminic appears to have relied on the extensive knowledge of niche champion Marfo, who became the company's local director in 2009 and had run his own plantation before it burned down in 2007 (Marfo, 2014).

In the period from 2003 to 2009, niche and regime actors organized and participated in many international conferences relating to jatropha. These events were important for learning from experiences abroad, and they provided an opportunity for niche actors to establish a narrative of their own success, which in turn would help raise expectations and access capital. Table A2 summarizes the publicly available presentations made by Ghanaian niche actors at these conferences, which generally paint a very positive picture of jatropha experiences and expectations in Ghana. This was especially the case at the beginning of the period – see e.g. (Amoah, 2006a, 2006b) – while later the presentations seem more focused on presenting the companies' own stories of having received a bad press (Kolnes, 2009a, 2009b).

The above analysis suggests that the low level of learning and knowledge-sharing between niche actors in Ghana was a major reason why the expectations reached such high level in the period of

1 'inflated expectations' and why the disillusionment that followed was so severe. Weak sector-wide
2 learning seems likewise to have constrained the development of jatropha export operations by
3 reducing access to locally specific technical and managerial information, thus increasing the risks, as
4 well as the extra costs incurred when each company had to conduct its own experiments.
5

6 5.4 Value chain governance

7 During the 'peak of inflated expectations', there was an important and growing international market
8 for refined jatropha biofuel as a result of blending mandates, especially in the EU and US. In Ghana,
9 while blending mandates and biofuel standards were described in draft policy documents, it was
10 entirely uncertain if and when such policies would be enacted and what the domestic price of
11 biofuel would be. It is therefore not surprising that nearly all companies adopted a business plan
12 based on exports – selling jatropha as oil seeds, crude vegetable oil or refined biodiesel to overseas
13 buyers.
14

15 The companies followed different strategies in this regard. Jatropha Africa planned to sell oil seeds
16 to biofuel processing companies. The Norwegian companies Scanfarm and Biofuel Africa planned to
17 take a further step downstream and produce straight vegetable oil (SVO) for further refining by oil
18 companies in the EU or USA (Helvig, 2014; Hesselberg, 2017). Kimminic planned a full vertical
19 integration of the value chain, from growing the seeds to producing the biodiesel at its own on-site
20 refinery and selling it in overseas markets. Owning a biodiesel refinery also allowed the company to
21 refine vegetable oil produced by other companies in Ghana and to supply biofuel to the domestic
22 market once blending mandates had been introduced. Both Galten and Goldstar claimed to be
23 planning vertical integration, but they never started a production. The strategy of Smart Oil changed
24 over time, from selling SVO for further refinement in the EU to full vertical integration whereby the
25 oil seeds were exported (sold) to the mother company Futuris in Italy, where they were pressed into
26 SVO and combusted in a co-generation electricity plant operated by Futuris.
27

28 By controlling larger segments of the value chain through downstream vertical integration, the
29 companies could in principle reduce market risks by supplying a product (refined biodiesel) for which
30 a global commodity market existed, as opposed to supplying intermediate products for more
31 fragmented markets. However, such a strategy is also very demanding in terms of capital
32 requirements (especially for advanced processing) and regarding the expertise needed to perform
33 each chain function effectively and efficiently – cultivation, pressing to SVO, refining to biodiesel,
34 transportation, and marketing – and to coordinate the functions internally within the company. The
35 fact that jatropha was a new technology obviously increased the costs and risks involved in such a
36 strategy.
37

38 Kimminic was successful in establishing a functioning large-scale plantation of 5000 ha and might
39 have survived with a business model of oil seed exports, but it could not to attract enough funds to
40 complete the pressing and refinery facility. Biofuel Africa aimed to sell SVO and found that their
41 potential buyers demanded very large quantities, which required large investments in and a rapid
42 expansion of primary production capacity. The company successfully established the first part of a
43 large-scale plantation (400 ha) and developed close buyer contacts with Statoil (Norway) and Neste
44 Oil (Finland) to ensure a market for the SVO and to raise capital. However, Biofuel Africa went
45 bankrupt in early 2009 when Statoil lost interest following the financial crisis and had to stop its
46 farming operation (Helvig, 2014). Alongside developing its farming operation, Scanfarm also built
47 relations with potential buyers in the EU and USA and received positive feedback on the quality of
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

the test samples they sent to them (Hesenberg, 2017). Jatropha Africa aimed to sell only raw oil seeds and also went bankrupt in 2009. Smart Oil grew slowly with limited funds and changed its strategy along the way from transport fuels to renewable electricity generation. It proved the most resilient of the companies studied.

While the company cases reviewed here are too limited to assess which value chain strategy is the 'best' when it comes to promoting the development of a jatropha niche, they do point to the existence of significant entry barriers to establishing new agriculture-based value chains for global biofuel markets, especially in terms of volume, investment capital and market risks.

5.5 Firm ownership and capital linkages

The seven companies investigated in this study were established as subsidiaries of start-up companies based in Europe, North America and Israel. Access to capital for the start-ups was very limited compared to the companies' own visions of their potential size and growth, and raising capital was a time-consuming activity during their short lives. Several investors were typically involved in supplying venture capital, and in the case of three companies, Ghanaian residents residing abroad were among the investors. We could not trace the exact origin of all the invested capital, but there were links to the oil industry. The two Norwegian companies were registered in Stavanger, a town known for its off-shore industry, and at least one of them sourced capital from a company servicing the Norwegian oil and gas sector (see Table A1). Similarly, one of the investors in the Italian-owned company (Smart Oil) was an Italian petro-company.

In terms of investor or owner competence, it is noteworthy that only in the case of Smart Oil did a foreign investor (Agroils) seem to have technical competence in agriculture or bioenergy, while only one Ghanaian co-owner (of Jatropha Africa) seem to have such competence. In the other cases, the dominant competence was in the area of business administration and business development, acquired through higher education and/or work experience in sectors other than agriculture or energy, such as telecoms, pharmaceuticals or business consultancy. This also applies to the two Norwegian firms, although in these cases one or more investors (but not managers) had experience from the oil industry. Overall, the fact that the companies were start-ups with limited equity and that the owners generally lacked competence in agriculture or the oil industry contributed significantly to the vulnerability of the companies.

5.6 Access to land and capital linkages

The dominant form of land acquisition for large-scale jatropha production was the leasing of land from traditional chiefs or councils, often for a period of fifty years. Among the five firms for which information is available, four (Biofuel Africa, Kimminic, Smart Oil and Scanfarm) obtained official registration of the lease, while in one case (Jatropha Africa) the arrangements concerning remained informal. In one case (Kimminic), the lease involved joint ownership and profit-sharing of part of the operation with local communities. An outgrower scheme was also planned in this case. The size of the jatropha operations in terms of the area planted with jatropha at any given time (typically around 2008-09) varied between 350 and 1400 ha, while in 2011 Kimminic cultivated about 5000 ha. These acreages were much smaller than the companies had planned; the land for jatropha leased by four companies for which we have reliable data was 4,500 ha (Smart Oil), 13,000 ha (Scanfarm), 23,764 ha (Biofuel Africa), and 65,000 ha (Kimminic) respectively. Altogether, these companies only planted around 3 percent (7,800 ha) of this land resource with jatropha (see Table 1).

Together with the high expectations regarding the profitability of jatropha production, access to land was a critical asset used by the start-ups to raise investment capital. This was clearly expressed in our interviews with companies, and in the case of Galten its homepage stated that the business model was 'to get hold of large land areas for the plantation of Jatropha'.⁵ Secondly, demonstrating control over large land resources was a key to convincing potential overseas buyers that the operation would eventually supply the oil in the large quantities these buyers demanded. Thirdly, planting large areas was necessary to achieve the benefits of the economies of scale involved in the production, processing, transporting and selling of jatropha. Hence, access to land was a key means to overcome entry barriers in terms of access to capital, production volumes and economies of scale. The start-ups were thus not only incentivized to secure access to large tracts of land at an early stage, but also – in some cases – to exaggerate the size of this resource, as well as the degree of control they exercised over it (see Table 1). As documented elsewhere (Boamah, 2014a), such land claims attracted widespread criticism from NGOs especially and most likely contributed to reducing investor confidence in jatropha.

Considering the poor agronomic and financial performance of jatropha together with the rapid shift to food crop farming (Scanfarm and Biofuel Africa) or co-production of food alongside jatropha (Kimminic), suggests that a hidden objective of these companies could have been to acquire land for other purposes than biofuel production, such as commercial food production, or, as observed in Tamil Nadu, India, the use of farm land for real estate development or as collateral for bank loans (Baka, 2013). As in the Tamil Nadu case (ibid), some companies in Ghana were involved in sometimes strongly contested land acquisitions (Acheampong and Campion, 2014; Boamah, 2014a); yet unlike in Tamil Nadu, we found no evidence that companies in Ghana acquired land with the intent to use it for (in retrospect) more profitable uses than developing a biofuels value chain.

6 Conclusion

This article has applied the MLP and GVC frameworks in order to analyse the drivers and trajectories of foreign private investment in biofuel production in Ghana. We have presented an example of a non-evolutionary niche development, which goes beyond European experiences of industrial niche development on which the MLP framework was first established. We argue that analysis of key value-chain attributes such as governance, ownership and access to capital is important for understanding biofuel niche development in developing countries, suggesting that an integration of the MLP and GVC perspectives would be fruitful.

The configuration and governance of the emerging jatropha value chain involved important entry barriers, which contributed to the collapse of the emerging jatropha sector in Ghana and thus to the failure to capitalize on the initial high expectations regarding jatropha biofuel production. These barriers included high volume requirements, high capital needs, and market risks related to unpredictable events - notably oil price fluctuations and the financial crisis. While such conditions may be common for the energy sector, they were clearly a show stopper for the development of a new agriculture-based value chain in Ghana. An important contextual factor here was the absence of a domestic demand for biodiesel related to weak policy support despite the efforts of local niche actors to promote the biofuels agenda in Ghana. In the MLP language, as politico-economic conditions beyond the influence of these actors changed during the late 2000s, expectations became misaligned - both within the niche and between the niche and the regime. Misalignment was also present in a low level of learning and knowledge-sharing between jatropha actors, which, alongside

weak public R&D support, reduced access to technical and managerial information for the export operators.

In line with the findings of previous research on biofuel value chains (Ponte, 2014), policy and NGOs had a stronger influence on the governance and dynamics of the jatropha value chain than what is typical for agricultural value chains. The study furthermore highlights the role of foreign investors in biofuels value chains. Relatedly, our analysis shows that global drivers, i.e. trends in international fuel and capital markets, as well as the strategies and capabilities of foreign investors, can strongly influence the development of a new biofuel value chain in a developing country. With these emphases, the study adds to previous research on jatropha, which highlights other politico-economic factors and dynamics such as land tenure, regional and local power relations, and the interests of donors and NGOs (e.g., Baka, 2013; Boamah, 2015; Hunsberger, 2010). Finally, the importance of investors and policy environment at different levels of the value chain illustrate the synergies in combining the MLP and GVC frameworks, which should be further explored in future research on energy transitions in developing countries.

References

- Acheampong, E., Campion, B., 2014. The Effects of Biofuel Feedstock Production on Farmers' Livelihoods in Ghana: The case of *Jatropha curcas*. *Sustainability* 6, 4587–4607. doi:10.3390/su6074587
- Acheampong, E., Campion, B.B., 2013. Socio-economic impact of biofuel feedstock production on local livelihoods in Ghana. *Ghana J. Geogr.* 5, 1–16. doi:10.13140/2.1.3133.5048
- Achten, W.M.J., Verchot, L., Franken, Y.J., Mathijs, E., Singh, V.P., Aerts, R., Muys, B., 2008. *Jatropha* bio-diesel production and use. *Biomass and Bioenergy* 32, 1063–1084. doi: 10.1016/j.biombioe.2008.03.003
- Ahiataku-Togobo, W., Ofosu-Ahenkorah, A., 2009. Bioenergy Policy Implementation in Ghana. COMPETE International Conference 26-28 May 2009, Lusaka Zambia.
- Ajanovic, A. (2011). Biofuels versus food production: Does biofuels production increase food prices? *Energy*, 36(4), 2070–2076. doi:10.1016/j.energy.2010.05.019
- Amissah-Arthur, H., Edjekumhene, I., Ampong, C., 2007. Review of *Jatropha* initiatives in Ghana. Submitted to the UNDP Agenda for Growth Project by KITE, Ghana.
- Amoah, O., 2006a. *Jatropha*: A catalyst for economic growth. Presentation by Onua Amoah, CEO, Anuanom Industrial Bio Products Ltd, Ghana at UNCTAD/ECOWAS Bank regional workshop entitled “Financing biofuels and *jatropha* plantation projects with special emphasis on Clean Development Mechanisms (CDM)”, Accra - Ghana.
- Amoah, O., 2006b. *Jatropha* Project in Ghana: How to restore vegetation and ecosystem along major man made lakes and ways to raise finance. Presentation by Onua Amoah, CEO, Anuanom Industrial Bio Products Ltd, Ghana at UNCTAD/ECOWAS Bank regional workshop entitled “Financing biofuels and *Jatropha* plantation projects with special emphasis on Clean Development Mechanisms (CDM)”, Accra - Ghana.
- Ampadu, Y., 2014. Interview with Yeboah Ampadu. Local manager and administrator, *Jatropha* Africa, Legon 10. December 2014.
- Angel, D., Rock, M.T., 2009. Environmental rationalities and the development state in East Asia: Prospects for a sustainability transition. *Technol. Forecast. Soc. Change* 76, 229–240. doi:10.1016/j.techfore.2008.01.004
- Antwi, E., Bensah, E.C., Quansah, D.A., Arthur, R., Ahiekpor, J., 2010. Ghana's biofuels policy : challenges and the way forward. *Int. J. Energy Environ.* 1, 805–814.
- Baka, J., 2013. The political construction of wasteland: Governmentality, land acquisition and social

- inequality in South India. *Dev. Change* 44(2), 409–428.
- 1 Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. Analyzing the functional
2 dynamics of technological innovation systems: A scheme of analysis. *Res. Policy* 37, 407–429.
3 doi: 10.1016/j.respol.2007.12.003
- 4 Berkhout, F., Angel, D., Wieczorek, A.J., 2009. Sustainability transitions in developing Asia: Are
5 alternative development pathways likely? *Technol. Forecast. Soc. Change* 76, 215–217.
6 doi:10.1016/j.techfore.2008.04.003
- 7 Berkhout, F., Verbong, G., Wieczorek, A.J., Raven, R., Lebel, L., Bai, X., 2010. Sustainability
8 experiments in Asia: innovations shaping alternative development pathways? *Environ. Sci.*
9 *Policy* 13, 261–271. doi:10.1016/j.envsci.2010.03.010
- 10 Binz, C., Truffer, B., Li, L., Shi, Y., Lu, Y., 2012. Conceptualizing leapfrogging with spatially coupled
11 innovation systems: The case of onsite wastewater treatment in China. *Technol. Forecast. Soc.*
12 *Change* 79, 155–171. doi:10.1016/j.techfore.2011.08.016
- 13 Boamah, F., 2015. Biofuels and land politics: Connecting the disconnects in the debate about
14 livelihood impacts of jatropha biofuels land deals in Ghana. Dissertation for the degree
15 philosophiae doctor (PhD) at the University of Bergen.
- 16 Boamah, F., 2014a. Imageries of the contested concepts “land grabbing” and “land transactions”:
17 Implications for biofuels investments in Ghana. *Geoforum* 54, 324–334.
18 doi:10.1016/j.geoforum.2013.10.009
- 19 Boamah, F., 2014b. How and why chiefs formalise land use in recent times: the politics of land
20 dispossession through biofuels investments in Ghana. *Rev. Afr. Polit. Econ.* 41, 406–423.
21 doi:10.1080/03056244.2014.901947
- 22 Boamah, F., Overå, R., 2016. Rethinking Livelihood Impacts of Biofuel Land Deals in Ghana. *Dev.*
23 *Change* 47, 98–129. doi:10.1111/dech.12213
- 24 Bolwig, S., Ponte, S., du Toit Riisgaard, Lone, A., Halberg, N., 2010. Integrating poverty and
25 environmental concerns in to value chain analysis. A conceptual framework. *Dev. Policy Rev.* 28,
26 173–194. doi:10.1111/j.1467-7679.2010.00480.x
- 27 Bolwig, S., Riisgaard, L., Gibbon, P., Ponte, S., 2013. Challenges of agro-food standards conformity:
28 Lessons from East Africa and policy implications. *Eur. J. Dev. Res.* 25 (3), 408–427.
29 doi:10.1057/ejdr.2013.8
- 30 Brew-Hammond, A., 2009. Bioenergy for accelerated agro-industrial development in Ghana. Keynote
31 address delivered on behalf of Dr Joe Oteng-Adjei (Minister for Energy), by Prof Abeeku Brew-
32 Hammond (Board Chairman, Energy Commission), at the Bioenergy Markets West Africa
33 Conference, La Palm Royal Beach Hotel, Accra on Tuesday 27 October 2009.
- 34 Byrne, R.P., 2009. Learning drivers: Rural electrification regime building in Kenya and Tanzania. PhD
35 Thesis. University of Sussex.
- 36 Campion, B.B., Acheampong, E., 2014. The chieftaincy institution in Ghana: Causers and arbitrators
37 of conflicts in industrial jatropha investments. *Sustainability* 6, 6332–6350.
38 doi:10.3390/su6096332
- 39 Coenen, L., Raven, R., Verbong, G., 2010. Local niche experimentation in energy transitions: A
40 theoretical and empirical exploration of proximity advantages and disadvantages. *Technol. Soc.*
41 32, 295–302. doi:10.1016/j.techsoc.2010.10.006
- 42 Coenen, L., Truffer, B., 2012. Places and spaces of sustainability transitions: Geographical
43 Contributions to an emerging research and policy field. *Eur. Plan. Stud.* 20, 367–374.
44 doi:10.1080/09654313.2012.651802
- 45 Dafrallah, T., Edjekumhene, I., Edze, P., Ngom, A., Ommer, V., 2010. Bioenergy for rural development
46 in West Africa: The case of Ghana, Mali and Senegal. ENDA, Energy, Environment,
47 Development.
48 [http://www.gnesd.org/upload/gnesd/pdfs/bioenergy%20country%20reports/enda%20ben%20](http://www.gnesd.org/upload/gnesd/pdfs/bioenergy%20country%20reports/enda%20ben%20final%20report-review%20ghana,mali,%20senegal.pdf)
49 [final%20report-review%20ghana,mali,%20senegal.pdf](http://www.gnesd.org/upload/gnesd/pdfs/bioenergy%20country%20reports/enda%20ben%20final%20report-review%20ghana,mali,%20senegal.pdf), accessed 20.07.2017
- 50 Darko, A.A., 2014. Interview with Anthony A Darko, Smart oil, Kumasi 8. December 2014.

- Edjekumhene, I., Bawa, A.M., Brew-Hammond, A., 2001. Power sector reform in Ghana: the untold story. Kumasi Institute of Technology (KITE), Kumasi.
- Energy Commission, 2014. Interview with Dorothy Adjei, Ghana Energy Commission, 12 December 2014.
- Energy Commission, 2010. Draft Ghana bioenergy policy. Ghana Energy Commission.
- Energy Commission, 2006. Strategic National Energy Plan (2006 - 2020). Ghana Energy commission.
- Energy Commission, 2005. National bio-fuels policy recommendations (final draft). Ghana Energy Commission.
- FAO, 2008. The state of food and agriculture - Biofuels: Prospects, risks and opportunities. Food and Agriculture Organisation of the United Nations (FAO), www.fao.org, accessed 20.07.2017
- Favretto, N., Stringer, L.C., Dougill, A.J., 2015. Towards improved policy and institutional coherence in the promotion of sustainable biofuels in Mali. *Environ. Policy Gov.* 25, 36–54. doi:10.1002/eet.1663
- Gartner Inc., 2017. Gartner hype cycle. www.gartner.com, accessed 25.01.2017.
- Geels, F., Raven, R., 2006. Non-linearity and expectations in niche-development trajectories: Ups and downs in Dutch biogas development (1973-2003). *Technol. Anal. Strateg. Manag.* 18, 375–392. doi:10.1080/09537320600777143
- Geels, F.W., 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environ. Innov. Soc. Transitions* 1, 24–40. doi: 10.1016/j.eist.2011.02.002
- Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy* 31, 1257–1274. doi:10.1016/S0048-7333(02)00062-8
- Gereffi, G., 1999. International trade and industrial upgrading in the apparel commodity chain. *J. Int. Econ.* 48, 37–70. doi:10.1016/S0022-1996(98)00075-0
- Gereffi, G., 1994. The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks. *Commod. Chain. Glob. Capital.* 95–122. doi:10.1177/0730888405277964
- Gereffi, G., Lee, J., 2016. Economic and social upgrading in global value chains and industrial clusters: Why governance matters. *J. Bus. Ethics* 133, 25–38. doi:10.1007/s10551-014-2373-7
- Gibbon, P., Bair, J., Ponte, S., 2008. Governing global value chains: an introduction. *Econ. Soc.* 37, 315–338. doi:10.1080/03085140802172656
- Gibbon, P., Ponte, S., 2005. Trading down: Africa, value chains and the global economy. Temple University Press, Philadelphia, PA.
- Glin, L.C., Mol, A.P.J., Oosterveer, P., Vodouhê, S.D., 2012. Governing the transnational organic cotton network from Benin. *Glob. Networks* 12, 333–354. doi:10.1111/j.1471-0374.2011.00340.x
- GOG, 2011. Renewable Energy Act 2011. The government of Ghana. [http://energycom.gov.gh/files/RENEWABLE%20ENERGY%20ACT%202011%20\(ACT%20832\).pdf](http://energycom.gov.gh/files/RENEWABLE%20ENERGY%20ACT%202011%20(ACT%20832).pdf), accessed 20.07.17
- GRAIN, 2007. The new scramble for Africa. GRAIN <https://www.grain.org/article/entries/606-the-new-scramble-for-africa>, accessed 20.07.2017 .
- Hans de Haan, J., Rotmans, J., 2011. Patterns in transitions: Understanding complex chains of change. *Technol. Forecast. Soc. Change* 78, 90–102. doi:10.1016/j.techfore.2010.10.008
- Hansen, U.E., Nygaard, I., 2014. Sustainable energy transitions in emerging economies: The formation of a palm oil biomass waste-to-energy niche in Malaysia 1990–2011. *Energy Policy* 66, 666–676. doi:10.1016/j.enpol.2013.11.028
- Hansen, U.E., Nygaard, I., 2013. Transnational linkages and sustainable transitions in emerging countries: Exploring the role of donor interventions in niche development. *Environmental Innovation and Societal Transitions* 8, 1-19. doi:10.1016/j.eist.2013.07.001
- Harnesk, D., Brogaard, S., Peck, P., 2017. Regulating a global value chain with the European Union's sustainability criteria - experiences from the Swedish liquid transport biofuel sector. *J. Clean. Prod.* 153, 580-591. doi:10.1016/j.jclepro.2015.09.039

- Hekkert, M.P., Suurs, R. a. a., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M., 2007. Functions of innovation systems: A new approach for analysing technological change. *Technol. Forecast. Soc. Change* 74, 413–432. doi:10.1016/j.techfore.2006.03.002
- Helvig, A., 2014. Interview with Arne Helvig Biofuel Africa, Tamale, 6. December 2014.
- Henning, R.K., 2009. The Jatropha System - an integrated approach to rural development. Bagani, Weissenberg, Germany. <https://betuco.be/agroforestry/Jatropha%20-%20integrated%20approach%20of%20rural%20development%205x.pdf>, accessed 09.07.16.
- Henning, R.K., 1998. Use of *Jatropha curcas* L. (JCL): A household perspective and its contribution to rural employment creation - Experiences of the Jatropha Project in Mali, West Africa 1987-1997. Presentation at the regional workshop on the potential of *Jatropha curcas* in Rural Development & Environmental Protection, Harare, Zimbabwe, May 1998.
- Hesselberg, T. 2017. Interview with Thor Hesselberg, founder of ScanFuel/Scanfarm, Telephone to Norway, 2. August 2017.
- Hunsberger, C., 2014. *Jatropha* as a biofuel crop and the economy of appearances: Experiences from Kenya. *Rev. Afr. Polit. Econ.* 41 (140), 216-231. doi:10.1080/03056244.2013.831753
- Hunsberger, C., 2010. The politics of *Jatropha*-based biofuels in Kenya : Convergence and divergence among NGOs , donors , government officials and farmers divergence among NGOs , donors , government officials and farmers. *J. Peasant Stud.* 37, 939–962. doi:10.1080/03066150.2010.512465
- Hunsberger, C., Bolwig, S., Corbera, E., Creutzig, F., 2014. Livelihood impacts of biofuel crop production: Implications for governance. *Geoforum* 54, 248–260. doi:10.1016/j.geoforum.2013.09.022
- Janssen, R., Rutz, D., 2008. Bioenergy policies for sustainable development in Africa. Proceedings from COMPETE International Conference 25-27 November 2008, Bamako.
- Jongschaap, R.E.E., Corre, W.J., Bindraban, P.S., Brandenburg, W.A., 2007. Claims and facts on *Jatropha curcas*: Global *Jatropha curcas* evaluation, breeding and propagation programme. Plant Research International B.V., Wageningen.
- Kaplinsky, R., 2000. Globalisation and unequalisation: What can be learned from value chain analysis? *J. Dev. Stud.* 37, 117–146. doi:10.1080/713600071
- Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technol. Anal. Strateg. Manag.* 10, 175–195. doi:10.1080/09537329808524310
- Kidido, J.K., Kuusaana, E.D., 2014. Large-scale investment in biofuel feedstock production and emerging land issues in Ghana, in: *Journal of Social Science Studies*. p. 163. doi:10.5296/jsss.v1i2.5114
- KITE, 2012. Assessment of biofuel producers in Ghana. Report prepared by KITE and commissioned by the UNEP Risø Centre (URC).
- KITE, 2014. Meeting with Ishmael Edjekumhene, KITE, 12. December 2014.
- Kizito, F., Williams, T.O., McCartney, M., Erkossa, T. 2013. Green and blue water dimensions of foreign direct investment in biofuel and food production in West Africa. In Allan, T, Keulertz, M., Sojamo, S., Warner, J. (Eds.) *Handbook of land and water grabs in Africa*. London and New York: Routledge.
- Kolnes, S., 2009a. Pressures on West African land. Presentation by Steinar Kolnes, CEO co-founder Biofuel Africa Ltd. at the conference “Reconciling development and investment policies”, Bamako, Mali 9. Dec. 2009.
- Kolnes, S., 2009b. Biofuel Africa says ActionAid is wrong about biofuels in Ghana. *Ghana Bus. News*. <https://www.ghanabusinessnews.com/2009/07/16/biofuel-africa-says-actionaid-is-wrong-about-biofuels-in-ghana/>, accessed 20.07.2017
- Lundvall, B., Joseph, K., Chaminade. C., Vang, J., 2009. *Handbook of innovation systems and developing countries: Building domestic capabilities in a global setting*. Edward Elgar Publishing, Cheltenham.

- Marfo, K., 2014. Interview with Dr Kofi Marfo, Kimminic, Legon, 10 December 2014.
- Mensah, S.A., 2009. Ghana: Extraction and use of jatropha oil by Gbimsi village women's group to power shea butter processing equipment, in: Karlsson, G., Banda, K. (Eds.), *Biofuels for sustainable rural development and empowerment of women - Case studies from Africa and Asia*. Energia, The Netherlands, pp. 13–17.
- Ministry of Energy, 2010a. National Energy Policy, Ministry of Energy, Ghana
- Ministry of Energy, 2010b. Energy Strategy and Development Plan. Ministry of Energy, Ghana.
- Mitchell, D., 2008. A note on rising food prices. World Bank Policy Res. Work. Pap. 4682.
- Nyari, B., 2008. Biofuel land grabbing in Northern Ghana. RAINS Ghana https://tnrf.org/files/E-INFO-RAINS_Biofuel_land_grabbing_in_Northern_Ghana_Bakari_Nyari_2008.pdf, accessed 20.07.2017
- Nygaard, I., 2010. Institutional options for rural energy access: Exploring the concept of the multifunctional platform in West Africa. *Energy Policy* 38, 1192–1201. doi:10.1016/j.enpol.2009.11.009
- Nygaard, I., Bolwig, S., 2017. Evolution of the jatropha biofuel niche in Ghana. UNEP DTU Partnership Working Paper Series 2017, no. 1, UNEP DTU Partnership, Technical University of Denmark.
- Ockwell, D., Byrne, R., 2015. Improving technology transfer through national systems of innovation: climate relevant innovation-system builders (CRIBs). *Clim. Policy* 1–19. doi:10.1080/14693062.2015.1052958
- OECD, 2008. Economic assessment of biofuel support policies. Directorate for Trade and Agriculture Economic. doi:10.1787/9789264050112-en
- Pietrobelli, C., Rabellotti, R., 2009. The global dimension of innovation systems: Linking innovation systems and global value chains, in: Lundvall, B.-Å., Chaminade, C., Vang, J. (Eds.), *Handbook of innovation systems and developing countries*. Edward Elgar Publishing, Cheltenham, UK, pp. 214–238.
- Ponte, S., 2014. The evolutionary dynamics of biofuel value chains: From unipolar and government-driven to multipolar governance. *Environ. Plan. A* 46, 353–372. doi:10.1068/a46112
- Ponte, S., Hunsberger, C., 2014. "Sustainable" biofuels in the global South. *Geoforum* 54, 243–247. doi:10.1016/j.geoforum.2014.02.005
- Ponte, S., Sturgeon, T., 2013. Explaining governance in global value chains: A modular theory-building effort. *Rev. Int. Polit. Econ.* 21, 1–29. doi:10.1080/09692290.2013.809596
- Raven, R., Schot, J., Berkhout, F., 2012. Space and scale in socio-technical transitions. *Environ. Innov. Soc. Transitions* 4, 63–78. doi:10.1016/j.eist.2012.08.001
- REN21, 2017. Renewables 2017 Global Status Report. REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 04.08.2017.
- REN21, 2016. Renewables 2016 Global Status Report. REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- REN21, 2015. Renewables 2015, Global Status Report. Renewable Energy Policy Network for the 21st Century, REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- REN21, 2014. Renewables 2014 Global Status Report. Renewable Energy Policy Network for the 21st Century, REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- REN21, 2013. Renewables 2013: Global Status Report. REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- REN21, 2012. Renewables 2012 Global Status Report. REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- REN21, 2010. Renewables 2010 Global Status Report. REN21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- REN21, 2009. Renewables global status report - 2009 update. Renewable Energy Policy Network for the 21st Century, REN 21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>,

accessed 20.07.2017.

- REN21, 2008. Renewables 2007 Global status report. REN21 Secretariat and Worldwatch Institute, <http://www.ren21.net/resources/publications/>, accessed 20.07.2017..
- REN21, 2006. Global Status Report 2006 Update. Renewable Energy Policy Network for the 21st Century, REN 21 Secretariat, Paris. <http://www.ren21.net/resources/publications/>, accessed 20.07.2017.
- Rieple, A., Singh, R., 2010. A value chain analysis of the organic cotton industry: The case of UK retailers and Indian suppliers. *Ecol. Econ.* 69, 2292–2302. doi:10.1016/j.ecolecon.2010.06.025
- Riisgaard, L., Bolwig, S., Ponte, S., du Toit, A., Halberg, N., Matose, F., 2010. Integrating poverty and environmental concerns into value-chain analysis: A strategic framework and practical guide. *Dev. Policy Rev.* 28, 195–216. doi:10.1111/j.1467-7679.2010.00481.x
- Rock, M., Murphy, J.T., Rasiah, R., van Seters, P., Managi, S., 2009. A hard slog, not a leap frog: Globalization and sustainability transitions in developing Asia. *Technol. Forecast. Soc. Change* 76, 241–254. doi:10.1016/j.techfore.2007.11.014
- Rohracher, H., 2008. Energy systems in transition: contributions from social sciences. *Int. J. Environ. Technol. Manag.* 9, 144. doi:10.1504/IJETM.2008.019026
- Romijn, H.A., Caniëls, M.C.J., 2011. The jatropha biofuels sector in Tanzania 2005–2009: Evolution towards sustainability? *Res. Policy* 40, 618–636. doi: 10.1016/j.respol.2011.01.005
- Ruef, A., Markard, J., 2010. What happens after a hype? How changing expectations affected innovation activities in the case of stationary fuel cells. *Technol. Anal. Strateg. Manag.* 22, 317–338. doi:10.1080/09537321003647354
- Sanderson, K., 2009. Wonder weed plans fail to flourish. *Nature* 461, 328–329. doi:10.1038/461328a
- Schoneveld, G.C., German, L., 2013. Translating Legal Rights into Tenure Security: Lessons from the new commercial pressures on land in Ghana. *J. Dev. Stud.* 50, 187–203. doi:10.1080/00220388.2013.858129
- Schoneveld, G.C., German, L. a, Nutakor, E., 2010. Towards sustainable biofuel development: Assessing the local impacts of large-scale foreign land acquisitions in Ghana. World Bank Land Governance Conference, 26-27 April 2010.
- Schoneveld, G.C., German, L., Nutakor, E., 2011. Land-based investments for rural development? A grounded analysis of the local impacts of biofuel feedstock plantations in Ghana. *Ecol.Soc.* 16, 10. doi:10.5751/ES-04424-160410
- Schot, J., Geels, F.W., 2008. Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy. *Technol. Anal. Strateg. Manag.* 20, 537–554. doi:10.1080/09537320802292651
- Segerstedt, A., Bobert, J., 2013. Revising the potential of large-scale Jatropha oil production in Tanzania: An economic land evaluation assessment. *Energy Policy* 57, 491–505. doi:10.1016/j.enpol.2013.02.023
- Shpurer, S., 2009. The start-up , the dream and the weed. Haaretz Digit. Ed. <http://www.haaretz.com/print-edition/business/the-startup-the-dream-and-the-weed-1.271399>, accessed 20.07.2017
- Slingerland, M., Schut, M., 2014. Jatropha developments in Mozambique: Analysis of structural conditions influencing niche-regime interactions. *Sustain.* 6, 7541–7563. doi:10.3390/su6117541
- Smith, A., Voß, J.P., Grin, J., 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Res. Policy.* 39(4), 435–448. doi:10.1016/j.respol.2010.01.023
- Tigabu, A., Berkhout, F., van Beukering, P., 2015. The diffusion of a renewable energy technology and innovation system functioning: Comparing bio-digestion in Kenya and Rwanda. *Technol. Forecast. Soc. Change.* 90, 331–345. doi:10.1016/j.techfore.2013.09.019
- U.S. Attorney's Office-District of Oregon, 2016. Eugene con man sentenced in \$1.4 million biodiesel fraud scheme. <https://www.justice.gov/usao-or/pr/eugene-con-man-sentenced-14-million->

[fraud-scheme](#), accessed 20.07.2017

- UNCTAD, 2006. Financing biofuels and jatropha plantations projects with special emphasis on Clean Development Mechanism (CDM). Conference held by UNCTAD and ECOWAs in Accra, Ghana, 13-14 November 2006.
- Unruh, G., 2000. Understanding carbon lock-in. *Energy Policy* 28, 817–830. doi:10.1016/S0301-4215(00)00070-7
- van der Laak, W.W.M., Raven, R.P.J.M., Verbon, G.P.J., 2007. Strategic niche management for biofuels: Analysing past experiments for developing new biofuel policies. *Energy Policy* 35, 3213–3225. doi:10.1016/j.enpol.2006.11.009
- van Eijck, J., Batidzirai, B., Faaij, A., 2014a. Current and future economic performance of first and second generation biofuels in developing countries. *Appl. Energy* 135, 115–141. doi:10.1016/j.apenergy.2014.08.015
- van Eijck, J., Romijn, H., 2008. Prospects for Jatropha biofuels in Tanzania: An analysis with Strategic Niche Management. *Energy Policy* 36, 311–325. doi:10.1016/j.enpol.2007.09.016
- van Eijck, J., Romijn, H., Balkema, A., Faaij, A., 2014. Global experience with jatropha cultivation for bioenergy: An assessment of socio-economic and environmental aspects. *Renew. Sustain. Energy Rev.* 32, 869–889. doi:10.1016/j.rser.2014.01.028
- van Eijck, J., Romijn, H., Smeets, E., Bailis, R., Rooijakkers, M., Hooijkaas, N., Verweij, P., Faaij, A., 2014b. Comparative analysis of key socio-economic and environmental impacts of smallholder and plantation based jatropha biofuel production systems in Tanzania. *Biomass and Bioenergy* 61, 25–45. doi:10.1016/j.biombioe.2013.10.005
- van Lente, H., Spitters, C., Peine, A., 2013. Comparing technological hype cycles: Towards a theory. *Technol. Forecast. Soc. Change* 80, 1615–1628. doi:10.1016/j.techfore.2012.12.004
- Verbon, G., Geels, F.W., Raven, R.P.J.M., 2008. Multi-niche analysis of dynamics and policies in Dutch renewable energy innovation journeys (1970–2006): hype-cycles, closed networks and technology-focused learning. *Technol. Anal. Strateg. Manag.* 20, 555–573. doi:10.1080/09537320802292719
- von Maltitz, G., Gasparatos, A., Fabricius, C., 2014. The rise, fall and potential resilience benefits of Jatropha in Southern Africa. *Sustainability* 6, 3615–3643. doi:10.3390/su6063615
- Wieczorek, A.J., Raven, R., Berkhout, F., 2015. Transnational linkages in sustainability experiments: A typology and the case of solar photovoltaic energy in India. *Environ. Innov. Soc. Transitions* 17, 149–165. doi:10.1016/j.eist.2015.01.001
- Wisborg, P., 2013. Human rights against land grabbing? A reflection on norms, policies, and power. *J. Agric. Environ. Ethics* 26, 1199–1222. doi:10.1007/s10806-013-9449-8

Endnotes

¹ Later, researchers such as Ajanovic (2011) showed that by far the largest part of the price increase was caused by other factors such as adverse weather conditions, increasing oil prices and speculation. Nevertheless, these reports - even if biased or inaccurate - were instrumental in the increasing negative reputation of biofuels in the period 2008–2011.

² <https://www.bloomberg.com/quote/GALTEN:IT>, accessed 21.12.2016

³ <https://ca.linkedin.com/in/george-amponsem-12706437>, accessed 21.12.2016.

⁴

<https://web.archive.org/web/20110903021244/http://www.jatrophaafrica.com/ourwork/view/httpwww.jatrophaafrica.comourworkviewGhana-Biofuel-Committee>, accessed 21.12.2016.

⁵ <https://web.archive.org/web/20071219140141/http://www.galtengroup.com/news.html>, accessed 21.12.2016.

Figure(s)

Europe Brent Spot Price FOB Crude oil
<http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RB RTE&f=M>
23:01:36 UTC+0100
Data Source: Thomson Reuters

Year	Dollars per Year		Dollars per barrel
2016	44.73	Nov-16	44.73
	49.52	Oct-16	49.52
	46.57	Sep-16	46.57
	45.84	Aug-16	45.84
	44.95	Jul-16	44.95
	48.25	Jun-16	48.25
	46.74	May-16	46.74
	41.58	Apr-16	41.58
	38.21	Mar-16	38.21
	32.18	Feb-16	32.18
	30.7	Jan-16	30.7
	38.01	Dec-15	38.01
	44.27	Nov-15	44.27
	48.43	Oct-15	48.43
	47.62	Sep-15	47.62
	46.52	Aug-15	46.52
2015	56.56	Jul-15	56.56
	61.48	Jun-15	61.48
	64.08	May-15	64.08
	59.52	Apr-15	59.52
	55.89	Mar-15	55.89
	58.1	Feb-15	58.1
	47.76	Jan-15	47.76
	62.34	Dec-14	62.34
	79.44	Nov-14	79.44
	87.43	Oct-14	87.43
	97.09	Sep-14	97.09
	101.61	Aug-14	101.61
	106.77	Jul-14	106.77
	111.8	Jun-14	111.8
	109.54	May-14	109.54
	107.76	Apr-14	107.76
2014	107.48	Mar-14	107.48
	108.9	Feb-14	108.9
	108.12	Jan-14	108.12
	110.76	Dec-13	110.76
	107.79	Nov-13	107.79
	109.08	Oct-13	109.08
	111.6	Sep-13	111.6
	111.28	Aug-13	111.28
	107.93	Jul-13	107.93
	102.92	Jun-13	102.92

Supplementary Material

[Click here to download Supplementary Material: Supplementary material REV2.docx](#)