Evolution of the Jatropha Biofuel Niche in Ghana

Nygaard, Ivan; Bolwig, Simon

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

UNEP DTU PARTNERSHIP

WORKING PAPER SERIES 2017:1

EVOLUTION OF THE JATROPHA BIOFUEL NICHE IN GHANA

DISCLAIMER

For more on UNEP DTU Partnership;
www.UNEPDTU.org

AUTHORS

Ivan Nygaard

Senior Researcher at UNEP DTU Partnership, Department of Management Engineering, Technical University of Denmark, **ivny@dtu.dk**

Simon Bolwig

Head of Climate Change and Sustainable Development, and Senior Researcher at System Analysis, Department of Management Engineering, Technical University of Denmark, **sibo@dtu.dk**

FORMAT FOR CITATION

Nygaard, I., Bolwig, S., 2017. Evolution of the jatropha biofuel niche in Ghana. UNEP DTU Partnership Working Paper Series 2017:1, UNEP DTU Partnership, Technical University of Denmark.

TABLE OF CONTENTS

ABSTRACT

This article draws on the multi-level perspective (MLP) and global value chain (GVC) frameworks to analyse the drivers and trajectories of foreign private investment in biofuel production in Ghana. The analyses are based on a narrative of the evolution of a niche for jatropha production in Ghana spanning the period 1995–2004 and including detailed company case studies. Relating to the MLP framework the factors analysed influencing internal niche processes are alignment of expectations, network formation, and learning and knowledge sharing, while those relating to the GVC framework are value chain attributes, including chain structure, governance, ownership, and access to land and capital. The study identifies significant entry barriers to establishing new agriculture-based value chains for global biofuel markets, especially high volume requirements, high capital needs and international market risks, which contributed to the collapse of the jatropha sector in Ghana and thus to the failure to capitalise on the initially high expectations of biofuel production. We also found a low level of learning and knowledge-sharing between jatropha niche actors in Ghana, which, alongside weak public R&D support, reduced access to locally specific technical and managerial information. The report presents an example of non-evolutionary niche development, which goes beyond the European experience of industrial niche development on which the MLP framework was first established. The importance of investors and policy at different levels of the value chain illustrates the synergies that may be obtained from combining the MLP and GVC frameworks in research on energy transitions in developing countries.

ACKNOWLEDGEMENT

Fieldwork for this research was funded by a Danida Research Grant for a project entitled ‘Biofuel Production from Lignocellulosic Materials – 2GBIONRG’.

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, it was argued that ***'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, 2013) 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 jatropha investments in Ghana from the perspectives of a transition to sustainability or 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 for example (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., 2013). 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 high-income, western 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., 2015) 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 report 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 report (Van Lente et al., 2013; Verbong et al., 2008).

The remainder of this report 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.

In the MLP, niches are distinct application domains that provide a time-restricted and protected space within which new practices and technological innovations can incubate and become viable through experimentation. The viability of niches is influenced by three internal niche-level processes (Schot and Geels, 2008): (i) the shaping and ***alignment of expectations***, (ii) the ***formation of a social actor network*** and (iii) ***learning processes***. Increasing alignment of expectations involves niche-level actors increasingly sharing similar visions, beliefs and interests. A high level of aligned expectations is generally conducive to niche development, although the envisaged opportunities must be made specific, and they will rely on positive, tangible results (Geels and Raven, 2006). The second niche-level process concerns the formation of a constituency behind a new socio-technical trajectory that consists of a network of engaged actors. The formation of close social ties and regular interactions among actors is seen as stimulating niche development, as does the involvement of a broader and more varied actor network (Coenen et al., 2010; van der Laak et al., 2007). Lastly, learning processes involve learning about the technological aspects of niche-level experiments, including technical design, functionality and performance, as well as the learning processes pertaining to the

social embeddedness of these aspects (Hansen and Nygaard, 2014). The latter requires that actors and society at large learn about many aspects of the technology, including economy, user preferences, regulation and environmental impacts.

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

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

2.2 GLOBAL VALUE CHAIN ANALYSIS

Global value chain (GVC) analysis has emerged since the early 1990s as a methodological tool for understanding the dynamics of economic globalization and international trade (Gereffi and Lee, 2016; Gibbon et al., 2008; Gibbon and Ponte, 2005). It is based on the analysis of discrete ***'value chains'*** where input supply, production, trade, and consumption or disposal are explicitly and, at least to some extent, coherently linked. The use of the ***'chain'*** metaphor signals a focus on relationships or links between buyers and suppliers (chain actors) and the movement of products 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 report, 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 report 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.

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. Half of the twenty 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.

TABLE 1. LIST OF BIOFUEL COMPANIES DISCUSSED IN ARTICLE. SOURCE: AUTHORS' COMPILATION.

	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	US$ 2.4 Million by 2010	US$ 16 Million by 2011	US$ 2.6 Million by 2009	US$ 7.1 Million by 2009	US$ 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	500 ha	0	400 ha	5,000 ha	350 ha	1,400 ha	720 ha
Planned product	Seeds	Biodiesel	Biodiesel	Biodiesel	Crude oil	Crude oil	Crude oil
Achieved product	Seeds	None	None	Seeds	Seeds	Seeds	Seeds

4. EVOLUTION OF FOREIGN PRIVATE-SECTOR JATROPHA INVESTMENT

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 the 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 period of the ***'peak of inflated expectations'*** 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 when most companies closed down, only a few continuing to invest and operate. The last period from 2012-2016 was the ***'trough of disillusionment'***, when all companies except one hibernated or were liquidated. In the following, we describe the main events during each period at the landscape, regime and niche levels, which are important for the discussion in section five. Special emphasis is placed on the drivers in the global biofuel value chain.

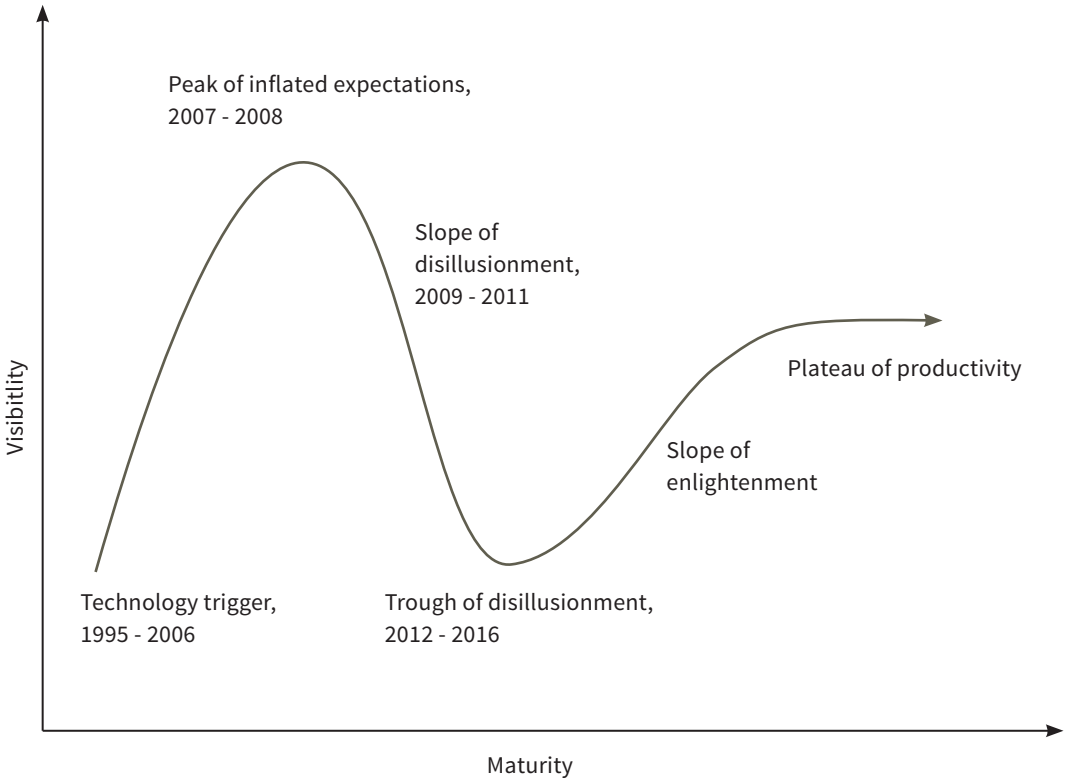

FIGURE 1. THE EVOLUTION OF THE JATROPHA LIFE CYCLE OR HYPE CYCLE IN GHANA, 1995–2016. THE X-AXIS MEASURES THE EVOLVING MATURITY AND APPLICATION OF THE JATROPHA TECHNOLOGY, AND THE Y-AXIS THE LEVEL OF VISIBILITY AND INTEREST IN THE TECHNOLOGY. SOURCE: ADAPTED FROM (GARTNER INC., 2017).

4.1 TECHNOLOGY TRIGGER, 1995-2006

4.1.1 LANDSCAPE LEVEL

The climate agenda and a worldwide movement to substitute fossil fuels with renewable energy gained momentum in this period, and biofuel was one of the options which moved from the demonstration stage to the founding of a biofuels niche internationally, supported by national government regulations in the US and in a number of countries in Europe. A major signpost on the international climate agenda was the World Summit on Sustainable Development held in Johannesburg from 26 August to 4 September 2002, which spurred political interest and political support for a more climate-friendly agenda.

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 fuel oil prices at US$ 15 to 20 per barrel, crude oil prices gradually increased to about US$ 60 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.

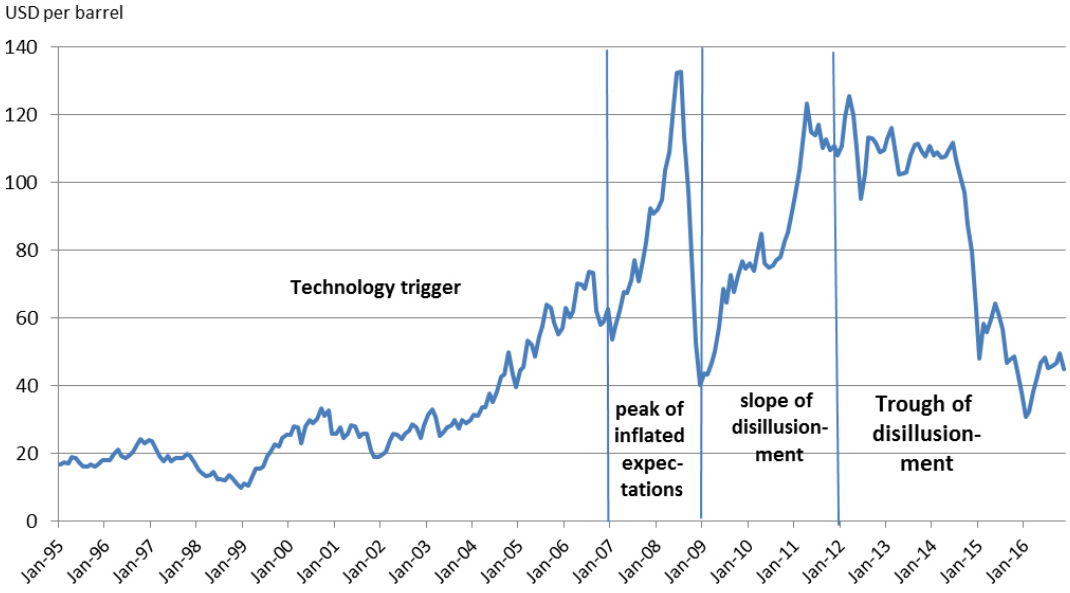

FIGURE 2. CRUDE OIL PRICES IN THE FOUR PERIODS. EUROPE BRENT SPOT PRICE FOB IN UNITED STATES DOLLARS. DATA SOURCE: WWW.EIA.GOV, ACCESSED 10 JANUARY 2017.

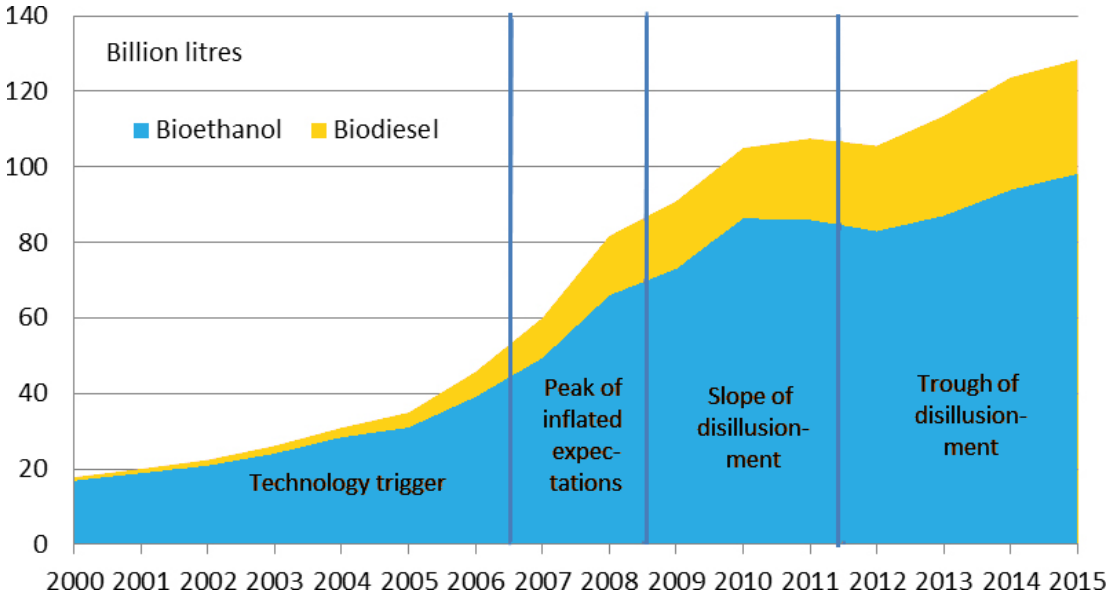

FIGURE 3. GLOBAL PRODUCTION OF BIOFUELS IN THE FOUR PERIODS, IN BILLION LITRES. DATA SOURCE: (REN21, 2016) AND PREVIOUS ISSUES.

4.1.2 REGIME LEVEL

At the beginning of this period, the energy regime in Ghana was under strong government influence. Major energy infrastructure such as the Volta River Authority, a national utility that had been operating the large Akosombo hydropower plant from 1962, was owned and driven by the government (Edjekumhene et al., 2001). The Tema Oil Refinery was owned by the government, which set the prices for electricity and fuel, relatively speaking regardless of the costs (Bacon and Kojima, 2006). In line with other countries in Sub-Saharan Africa (SSA), Ghana went through an important reform process in the 1990s, mainly driven by conditions set by the World Bank. The objective of the reform was to introduce cost-reflective prices of electricity and to introduce competition in the production sector by partial privatisation and the unbundling of the energy sector into separate production, transmission and distribution companies. In Ghana this process started in 1994 and resulted in a power sector reform adopted in 2000 (Edjekumhene et al., 2001).

Until 1997, Ghana's electricity generation was fully based on the 1200 MW Akosombo hydropower plant, but after a number of serious power supply crises due to upstream drought, new thermal power plants were added in 1997. These plants were expected to be partly fuelled by the West African Gas Pipeline, which was scheduled to supply cheap natural gas from Nigeria from as early as 2002 (Edjekumhene et al., 2001). However, for several reasons the pipeline did not start operating until December 2008.[1]

Until 2005, petroleum product prices were both regulated and subsidized by the government, and prices were increased at irregular intervals, sometimes by large amounts. In January 2003, the government introduced a pricing formula linking domestic prices to world prices and raised fuel prices by approximately 90 percent. However, during 2004 the government, which faced elections in December, continued to subsidize prices, and the subsidy to the Tema Oil Refinery continued to grow until it amounted to 2.2 percent of GDP. Finally, after the re-election of the president oil prices were deregulated, giving rise to an immediate consumer price increase of about 50% in February 2005 (Bacon and Kojima, 2006).

The new oil-dependent power plants, the delay of the gas pipeline and the increases in the number of private cars and in oil prices caused an extraordinary rise in the costs of imported energy during the early 2000s. Energy imports therefore became an important policy question related to Ghana's trade balance. The draft biofuel policy drawn up by the Energy Commission in 2005 emphasised that Ghana's oil import bill had grown from US$561 million in 2000 to US$816.6 million in 2004, equalling 19.7% of the country's total merchandise import, or 28% of total export earnings (Energy Commission, 2005). During this short period, the energy regime experienced significant changes in terms of deregulation and loss of government control, alongside an increased dependence on energy imports. Energy security and national energy production therefore became an important part of the political agenda.

In the area of biofuels, in 2003 a niche actor presented his plans to build the first biofuel factory in Ghana. This pushed the government to make a preliminary analysis of the production and use of biofuels and to set up four government-led multi-stakeholder committees to discuss and draft a biofuel strategy. The committees included representatives from the Environmental Protection Agency (EPA) and the Ministry of Food and Agriculture (MOFA) plus stakeholders from the petroleum industry, the private sector, academia and civil society. After almost two years of discussion the committee came up with a draft biofuel policy issued in 2005 (Brew-Hammond, 2009; Energy Commission, 2005).

The first proposal for a biofuel policy was ambitious and broad in scope. It recommended among several other initiatives that all government diesel vehicles should switch to 20% biodiesel blends (B20). It further proposed to remove all taxes on biofuels and to put a small levy on fossil fuels, the revenues of which should be used to subsidize biofuels. Finally it suggested that a special group within the Energy Commission should be mandated to manage the development and implementation of a biofuel programme (Energy Commission, 2005). In 2006 a revised draft of the biofuel policy was submitted to the government, including mandatory blends of gasohol and biodiesel at five percent (5%) by 2010 and ten percent (10%) by 2015. The Strategic National Energy Plan (SNEP) published in 2006 had the same blending targets (Brew-Hammond, 2009; Energy Commission, 2006).

4.1.3 NICHE LEVEL

Donor organisations such as GTZ, UNIDO and UNDP played a major role in the promotion of jatropha for biofuel production in West Africa during the early years. GTZ operated the first jatropha project in Mali in 1987, which focused on mapping existing jatropha hedges within the framework of a renewable energy programme (Henning, 1998). A second jatropha project ran from 1993 to 1997, aiming to use jatropha oil not only as a fuel, but also to activate a circular system combining ecological, economic and income-generating effects. Reinhard Henning was the project leader of the two GTZ projects and became a strong international champion promoting jatropha as a biofuel. Already in 1996 he had established the jatropha website www.jatropha.de, which served as an important source of information for practitioners until 2010, when new knowledge on jatropha cultivation and processing became available based on the experience of large-scale practices (Henning, 2009).

UNIDO and FIDA started a pilot project on the multifunctional platform (MFP) in 1994 in Mali and Burkina Faso. Based on this experience, UNDP launched a large project in 1999, which set out to establish 450 MFPs in Mali from 1999 to 2004, of which around 70 (15%) would be fuelled by jatropha oil (Burn and Coche, 2001).[2] UNDP then went on to establish two projects in Ghana in 2001. The first supported a women's group in Gbimsi village to establish a four-hectare pilot jatropha plot and a press for pressing jatropha oil to use in running their shea butter processing plant (Mensah, 2009). The second and larger project was the ADRA/UNDP/GEF jatropha project, which planted between 2000 and 2400 hectares of jatropha in an out-grower scheme (Amissah-Arthur et al., 2007). A major problem encountered by this project was to find a market for the produce (ibid.). There were also problems with pests and low yields. Hence most farmers eventually cut down their jatropha trees, and the project's status since 2007 remains unclear.

PRIVATE-SECTOR ENGAGEMENT

The first private-sector activities to consider jatropha as a source of biofuel production can be traced back to 1999, when Mr Onua Amoah, a Ghanaian industrialist, set out to investigate its feasibility. Through his company IABP, he started a pilot research plantation for jatropha and small-scale production of jatropha oil for

testing (Amoah, 2006a). Amoah claimed that he had developed an improved jatropha species which could yield nine tonnes of seeds (thirteen tonnes of fruit) per hectare, compared to the wild jatropha species, which produced only three to five tonnes of seeds per hectare (Amoah, 2006a).

Amoah planned to start a large-scale biofuel-processing plant in 2003,[3] but this plan failed when investors pulled out of the newly established Ghana Bio Energy Limited for undisclosed reasons.[4] In 2007, Amoah had established a 500 tonne/year test plant for producing biodiesel from jatropha oil, which, however, was not operational, mainly due to a lack of feedstock at the time (Amissah-Arthur et al., 2007). In 2007 he claimed that AIBP had secured funding from a credit facility of the ECOWAS Bank for Investment and Development (EBID) to construct a 120,000 tonne/per annum jatropha processing plant (ibid.). Amoah was a strong campaigner and good at convincing investors and government officials of the benefits of jatropha. He is also said to have been instrumental in establishing the Government's National Jatropha Plantation Initiative (NJPI), launched in late 2006 (Amoah, 2006b) (see below).

Another champion, Dr Christian Kofi Marfo, an agricultural scientist, established a company called Biofuel 1, which made its own test farm of about 280 hectares (Marfo, 2014). Like AIBP, Biofuel 1 had established a pressing facility, which by 2006 had a capacity of 2000 tonnes of seeds per month (Amissah-Arthur et al., 2007). Most of the test plantation, however, burned in a bush fire, causing a large loss for the company. Biofuel 1 also claimed to have access to 12,000 hectares of land in the Brong-Ahafo region, although it could not finance this (Amissah-Arthur et al., 2007; Marfo, 2014).

A third local champion was Mr Kwabena Frimpong-Boateng, well-known in Ghana as a university professor, a cardiothoracic surgeon, and the founder of the National Cardiothoracic Centre and the Ghana Red Cross society. In 2006 he also sought nomination to run for President for the National Patriotric Party (NPP) in 2008, but failed. Frimpong-Boateng had a jatropha plantation in Winneba. He also worked closely together with Onua Amoah and in August 2007, together with Onua Amoah and others, he acquired lands for jatropha cultivation at Sawla, Wa, Pusiga, Techiman and Nkoranza.[5] It is interesting to note here that the wining NPP candidate and later President of Ghana, Nana Akufo-Addo, was also close to actors in the biofuel venture. For example, his Director of Campaign and Operations for the presidential elections in 2008, Raymond Okudzeto, who was an important politician in the National Patriotic Party (NPP), had already become the national director of Galten Biofuel in December 2007.

GOVERNMENT

The National Jatropha Plantation Initiative was launched in late 2006 and was supported by the government with US$ 1.6 million (Amissah-Arthur et al., 2007; Biopact, 2007). This government initiative planned to develop one million hectares of jatropha plantations on available idle and degraded lands in phases over the next five to six years. Implementation of the plan was led by an inter-ministerial government committee, chaired by the Minister of Food and Agriculture, and including Amoah as a member. Plantations were to be developed in all the districts of the country. By early 2007, thirty districts had been selected for the first phase establishing the first 40,000 hectares. The project included production of a large number of seedlings delivered by AIBP (Amoah, 2006b).[6]

Towards the end of this period, international actors such as potential investors and fuel importers were present in the national arena searching for business opportunities. One such actor was the British jatropha oil company D1, which initiated negotiations with Kofi Marfo and his company Biofuel 1. D1 exported seeds from Ghana through a firm to which Kofi Marfo introduced it, but D1 never established a company or plantation in Ghana (Marfo, 2014).

The strong push by niche actors for changes to the energy regime was aided by a UNCTAD/ECOWAS conference in 2016 on CDM and the financing of biofuels and jatropha plantation projects, at which Amoah gave two speeches (Amoah, 2006a, 2006b; UNCTAD, 2006).

4.2 PEAK OF INFLATED EXPECTATIONS, 2007-2008

4.2.1 LANDSCAPE LEVEL

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). At the landscape level, three drivers were mainly responsible for this growth. The first was strong and continued policy support to biofuels in an increasing number of countries, with a focus on targets, blending mandates and tax exemptions (REN21, 2009, 2008). The second was the large increase in crude oil prices from US$ 80 in June 2006 to US$ 140 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 factors impeding niche development at this level. Global food prices climbed to their highest levels since the 1970s and initiated a global debate on 'food versus fuel'. The FAO, the World Bank and the OECD published reports claiming that biofuel production was an important driver of the increase in food prices and raising questions about the potential of biofuels to reduce CO2 emissions (FAO, 2008; Mitchell, 2008; OECD, 2008; Romijn and Caniëls, 2011). 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 the common, positive perceptions of jatropha regarding yields and resilience (Achten et al., 2008; Jongschaap et al., 2007).

4.2.2 REGIME LEVEL

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). The work on biofuel standards continued, but no standards were adopted (Antwi et al., 2010). The discovery of offshore oil and gas in 2007, along with Amoah's death 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).

4.2.3 NICHE LEVEL

2007 and 2008 witnessed high levels of optimism and activity among niche actors. There was a 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 hectares of land, of which 730,000 hectares 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 had been established before 2009, but the companies analysed in this report all started between 2006 and 2008 (Table 1). In the following we will briefly describe these businesses with reference to their ownership, management and business strategies.

JATROPHA AFRICA is directed by Ohene Akoto and was established in Ghana in November 2006 as a subsidiary of the United Kingdom-based company Lion Bridge Ventures, which in turn was started in September 2006 by Clive Murray Cooker.[7] Lion Bridge Ventures was a small start-up company with five investors, two of whom were Ghanaian residents. The Ghanaian director and co-founder of Jatropha Africa holds a MBA from the University of Cape Coast. According to the company's first webpage from 2007, the company was started with the objective of ***'growing seedlings, contract planting, harvesting and selling oil seed as feedstock to bio diesel companies and farmers'***.[8] The company acquired 50,000 hectares of land in Kawampe, Gulumpe and Kadelso, all communities in Kintampo North District in the Brong Ahafo Region (Kite, 2012).[9] According to the operational manager, Mr Ampadu, Jatropha Africa works with local chiefs on a shared profit basis and only pays for land which is developed. Farmers can grow crops on the land until the company needs it, and after planting jatropha they can intercrop it with groundnuts or other crops (Ampadu, 2014). The company planted up to 500 hectares in the first few years.[10] In the beginning they worked with Onua Amoah and got the best seeds with high yields and oil content (Ampadu, 2014).

GOLDSTAR BIOFUELS, managed by Jack Holden, started operating in Ghana in early 2007 (Amissah-Arthur et al., 2007) as a subsidiary of a Gold Star Farms Ltd, managed by his wife, the Ghanaian Diana Holden.[11] Gold Star Farms was a joint venture between two US citizens, Jack Holden and Lloyd Benton Sharp.[12] Goldstar biofuels claimed that they had access to two million hectares (five million acres) of land in Ghana (Dogbevi, 2008). According to Goldstar's webpage from 2008, Goldstar intended to be a *'vertically integrated company that starts by growing the renewable feedstock, extracting the oils from the seeds of the jatropha fruit, then refining the oil into biodiesel and last but not least pumping the fuel into fuel tanks around the world'*.[11]

GALTEN GHANA was established in June 2007 as a subsidiary of Galten, the Israeli clean-tech start-up, founded by Doron Levi and Shlomi Jonas in 2006. According to the webpage, Shlomi Jonas had served as CEO in medical supply companies and biotechnology companies in Israel, while Doron Levis, chairman and COO, has a degree in business management and has been involved in sales and marketing, as well as new business start-ups. The chairman of Galten Ghana was a Ghanaian businessman and at the time a leading politician, being responsible for the campaign of the NPP presidential candidate, Nana Akufo-Addo in 2008.[13] In a press release dated 9 September 2007, it is stated that *'Galten will raise $10 million from a group of investors led by UK private equity fund Capital Partners'.* Galten states on the webpage that its business model *'is to get hold of large land areas, mainly on the African Continent for jatropha plantations as the source of bio-diesel'.*[14] According to a press release from June 2006, the government of Ghana and the Central Region had *'assured viability of 200,000 hectares for Galten's Biofuel projects'.*[15]

KIMMINIC CORPORATION was founded by George Amponsem, a Canadian Ghanaian, in March 2007 for the purpose of biofuel development and started operating in Ghana through its fully owned subsidiary, Kimminic Estates Limited (Kite, 2012).[16] It began land preparation in February 2008, the first plantation being established in April 2008 (Boamah and Overå, 2016). Mr Amponsem was a management consultant. From 2005, he ran his own consultancy start-up, Gamps Consulting Service, with his wife Heidi Amponsem. George Amponsem and his wife had experience of management consulting from working for PWC Consulting for seven and four years respectively, and they also held PhDs in business administration and in organizational development and marketing respectively.[17] Mr Amponsem did not have any specific experience of the farming or oil sectors (Marfo, 2014), except for having been raised on a cocoa farm in Ghana and doing management consultancy for oil companies. The size and origin of the initial investment in Kimminic remains unclear, but according to Boamah and Overå (2016) it came from Canadian investors and Ghanaian residents in Canada, including Mr Amponsem.[18]

Kimminic's strategy was to become a vertically integrated biofuel company, including all elements of the value chain from cultivation to export of refined biofuel. The strategy was large-scale production in a combination with manual and mechanised farming methods. Kimminic wanted to scale up to a size that would make it profitable to refine the biofuel to biodiesel in its own factory (Marfo, 2014). Land negotiations and experimentation with jatropha cultivation started in 2007. The company entered into a forty-year joint venture leasing contract with local chiefs in councils in the Brong-Ahafo Region. The leasing agreement involved, among other conditions, granting an annual profit share of 25% to the communities. The total land area was 65,000 ha, divided into four plots. The first jatropha plantation was established in April 2008 (Boamah, 2015).

SCANFUEL LTD was established in September 2007 as a fully owned subsidiary of the Norwegian Scanfuel As, founded by Thor Hesselberg and his wife Merete Hesselberg.[19] Thor Hesselberg was at the time CEO and founder of NorthPoint AS, a start-up within the telecoms sector,[20] which he founded as a student in 1995 and which he and his wife had been running since 2000. Hesselberg held a MBA, and his wife also had a business administration background.[21] Agnar Gravdahl, a well-connected businessman from Stavanger, was chairman of the board.[22] He held 10% of the shares in the company, while the Hesselberg couple held 60% and IKM invest another 20%. The company, which was established through contacts of a Ghanaian national living in Norway, leased 13,000 hectares of land from a local chief, Nana Sarpong, who was a lawyer and former minister of interior and health. In 2008 the legal documentation was completed at the

Land Commission (Scanfarm, 2011). The original plan was to grow jatropha for the production of vegetable oil for subsequent processing into biodiesel. A jatropha seed garden was first established on land belonging to the University of Ghana using a Malaysian seed variety (Scanfarm, 2011). By December 2008, US$ 2.6 million (NOK 22 million) had been invested in Ghana out of a planned investment of US$ 5.2 million (NOK 40 million).[23]

BIOFUEL AFRICA was established in October 2007 as a joint venture and a fully owned subsidiary of Norwegian Biofuel AS (Boamah, 2010). Jan Reinås, a well-connected businessman in Norway, was chairman of the board. The main investor in Biofuel AS was the investment company Nordfuel, later known as Perennial Biofuel, which had been founded in 2007 (Helvig, 2014).[24, 25] The Norwegian manager of Biofuel Africa, Arne Helvig, came with experience of the pharmaceutical industry in Norway (Helvig, 2014). Steiner Kolnes was trained as an engineer in automation and had been working in Ghana since 2003 on a telecoms project. However, he had been raised on a farm in Norway, and in 2004/2005 he became interested in jatropha and was involved in testing growth conditions together with AngloGold Ashanti in Ghana.[26]

Biofuel Africa started with the objective of becoming a vertically integrated biofuel company, capturing all elements of the value chain, from cultivation to the export of crude jatropha oil for refining in Europe by buyers (Helvig, 2014). The strategy was to perform large-scale and highly mechanised farming and primary processing in order to benefit from economies of scale throughout the value chain, ultimately to reach a scale that would interest oil companies and refineries in Norway and the EU.

The company established an 850-hectare test farm in Sugakope25 and another farm in Alipe, a village in Central Gonja District in northern Ghana, in November 2007. Due to opposition from local NGOs, individual environmental activists and the Ghanaian press, Biofuel Africa abandoned the farm in Alipe and moved to a new project site in Yendi District, also in northern Ghana, where a new jatropha plantation was established (Boamah, 2010). In February 2008, Biofuel Africa received approval from the Ghanaian Environmental Protection Agency (EPA) for a jatropha biodiesel project on land areas of 23,762 hectares in Central Gonja and Yendi Districts (Boamah, 2010). Jatropha Africa had options to lease a further 150,000 hectares from local chiefs at a specific price, but with no obligations to exploit these options (Helvig, 2014; Kolnes, 2009a). In 2008, Jatropha Africa cleared 1100 hectares of land and planted about 400 hectares with jatropha (Boamah, 2010).

SMART OIL LTD, managed by Anthony Darko, was incorporated in May 2008 as a Ghanaian subsidiary of SmartOil 2. SmartOil 2 had been founded in 2006 by Mr Darko and a small Italian consultancy company, Agroils, with equal amounts of financial inputs from the two parties (Darko, 2014).[27] Agroils was a start-up founded in 2006 in Florence, Italy, by a group of engineers specialising in jatropha.[28] The staff of Agroils had been visiting projects worldwide, participated in conferences and done literature research,[29] but according to Mr Darko, the knowledge available on jatropha was still very limited (Darko, 2014). Mr Darko did not have any experience of farming or agro-business, but he had a background in economics and information technology, as well as international experience as a former manager in the USA.[30] The first business plan for Smart Oil was to experiment with jatropha cultivation in Ghana, and consequently Smart Oil started up with a ten-hectare experimental trial plantation in June 2008. At this stage the financial input was limited.

4.3 SLOPE OF DISILLUSIONMENT, 2009-2011

4.3.1 LANDSCAPE LEVEL

The beginning of this period was characterized by the global financial crisis, which made international financial capital more averse to risky investments. Crude oil prices plunged from US$ 140 per barrel in September 2008 to US$ 40 in late 2008, and then slowly recovered to US$ 110 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 US$ 5 dollars 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: by early 2009, for example, German biodiesel production was only 60% of capacity, and several factories had closed down (Romijn and Caniëls, 2011). Nevertheless, the construction of new plants continued during 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 USA introduced the Renewable Fuel Standard (RFS) (REN21, 2012, 2010).

4.3.2 REGIME LEVEL

Energy security concerns had to a large extent driven the initial governmental biofuel agenda, and the preparation for national oil production reduced this concern.[31] Consequently, the new government, established in January 2009, welcomed the biofuels idea, though it was more concerned with the potential effects on food security (Boamah, 2014a). This can be deduced from the National Energy Policy document and the Energy Sector Strategy and Development Plan issued in February 2010: both documents urge that biofuel development be balanced against food security, while at the same time supporting the development of a biofuel industry and private-sector investment. Interestingly, these policy documents did not repeat the blending targets and financial incentives announced in SNEP 2006 (Ministry of Energy, 2010a, 2010b).

In August of the same year, the Energy Commission submitted a new draft bioenergy policy, which repeated the blending targets and the tax exemption of biofuels. It further proposed several new supporting incentives, in particular: i) a guaranteed market price for biofuel; ii) zero import duty and VAT on equipment for the processing of biofuels; iii) income tax relief for ten years of operation for biofuel companies; and iv) tax holidays for feedstock-producing companies using labour-intensive methods (Energy Commission, 2010). The draft bioenergy policy also introduced an incentive to use biofuels in Ghana by suggesting levies and taxes be imposed on biofuel exports. The draft policy also specified institutional roles in order to reduce the existing problems caused by the unclear mandates of the different institutions mentioned in the policy document, notably the Energy Commission, the Environmental Protection Agency, the Ministry of Forestry and Agriculture, the Ghana Standards Board, the National Petroleum Authority (NPA), the Land Commission and the Houses of Chiefs. The status of the draft bioenergy policy remains unclear to this date, but while the Renewable Energy Act (Act 832), adopted in 2011, contained provisions for further regulation of the biofuel sector, including licencing the production and transport of biofuels, it did not provide any concrete policies with respect to blending targets or tax exemptions (GOG, 2011).

These remarkable differences in announced biofuel policies from the government and the Energy Commission respectively illustrate the different positions taken on biofuel issues between the Energy Commission on the one hand and the Ministry of Energy on the other hand. The opposing positions are also clearly expressed by two leading figures in the two institutions: Abeeku Brew-Hammond, Head of the Energy Commission, who expressed a positive attitude towards biofuels in October 2009 (Brew-Hammond, 2009), and Wisdom Ahiataku-Togobo, Renewable Energy Expert at

the Ministry of Energy (from December 2010, Director of Renewable Energy), who in May 2009 expressed a critical view of biofuels. In particular, he remarked that the costs of biofuels were not competitive with fossil fuels in the national market, even at a crude oil price of US$ 140 per barrel. He also warned that this export-oriented industry would challenge food production, as biofuels are produced on fertile lands (Ahiataku-Togobo and Ofosu-Ahenkorah, 2009).

Since 2006, the political focus has gradually shifted from concerns about fuel imports towards how to resolve the recurrent crises in power supply. Both the energy policy document of 2010 and the Renewable Energy Act focus on increasing energy production capacity through independent power producers, while the Energy Act describes in detail the conditions for feed-in tariffs for renewable energy, especially solar PV (Kemausuor et al., 2015).

4.3.3 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, due to other landscape factors such as the international financial crisis, the fall in oil prices and the reduced importance of the CDM. In the following we will provide a more detailed account of how the six companies fared during this period of disillusionment for niche development.

JATROPHA AFRICA

Lion Bridge Ventures went into voluntary liquidation in June 2009, and Jatropha Africa was taken over by Clive Cooker and Ohene Akoto (Ampadu, 2014). After the liquidation, Ohene Akoto was still searching for investment funds to develop the large amounts of land acquired by Jatropha Africa. Thus, a blog from August 2009, published on the Africa Sustainable Energy & Environment Platform, said that ***'Jatropha Africa Ltd. is soliciting approximately US$ 65 million for the development of available land, support equipment, a crushing plant, local biodiesel plant, generators, on water logistics and other operational costs until cash flows are self-sustaining in approximately three years. From year four and through subsequent years revenue is projected to be US$ 97 million with exceptional profitability'***.[32]

During the period 2009-11, Jatropha Africa neither expanded its planted area nor established any pressing facilities, indicating that it had failed to attract any significant investments. The existing farm continued operation, however, in close cooperation with local communities. Interviews did not reveal any exact information about the quantities harvested during this period, but in late 2001 the company announced that it had sold the first ten tonnes of jatropha seeds to Japan, indicating a much lower harvest than the four tonnes per hectare expressed earlier by the company (Kite, 2012).[33]

In cooperation with several European universities, Jatropha Africa received EU funding for a capacity-building project whose main objective was to create sustainable, non-food bio-oil supply chains. The project had a budget of one million euros, involved multiple countries, and ran from late 2009 to late 2012. Participation in the project is likely to have created an important learning and networking space for Jatropha Africa,[34] while the tangible outcome for the local community was a small jatropha oil press and a jatropha-fuelled generator set up to provide electricity for the community (Kite, 2012)..

GOLDSTAR

According to Dafrallah et al. (2010: 43, referring to Jack Holden), ***'Gold Star has already secured the commitment of farmers to grow the crop on approximately 5 million acres of land. Two million acres of the targeted plantations are currently under cultivation throughout the country, with the exception of the Western region'.*** According to the same source, at that time the company claimed to be constructing a processing plant at Nkawkaw in the Eastern Region to produce biodiesel for exports. However, as mentioned by Dogbevi (2012), Goldstar had ***'gone silent'*** by 2012.

GALTEN

By early 2009, Galten had planted 99 hectares out of an intended 1000 hectares on a single site (Shpurer, 2009).[35] This seems to be the basis for the rather optimistic announcement on the company's webpage on 10 March 2009 that *'the first jatropha plantation is already in operation, with the next 10,000 hectares in the pipeline out of a total 100,000 hectares available to Galten'*.[36] According to a Powerpoint presentation at the Israeli Biomass Conference in 2010, Galten was employing forty workers that year, had established a nursery with a capacity of one million seedlings and had planted a thousand hectares of jatropha.[37] We could not find any documentation to verify that Galten actually planted this amount of land, and it also remains unclear how much capital Galten raised from its start in 2007 until 2009. A newspaper article states that the stakeholder equity was around US$ 85,000 in March 2009 when Galten tried to raise money on the Israeli stock market (Shpurer, 2009). According to the conference presentation just mentioned, total investment was US$ 2.35 Million in 2010.39

KIMMINIC

In late 2009, Kimminic received a very important input of knowledge and experience when Kofi Marfo, the owner of Biofuel1, became General Manager of Kimminic Estates Ltd. This capacity increase became possible because the 300-hectare plantation owned by Kofi Marfo was burnt in a bush fire in 2007. Mr Marfo included his farm as an asset, but without being shareholder in the company. At this time, Kimminic was already cultivating 2400 hectares at Ejura Mr. Marfo introduced advanced management, remuneration and control systems at the four plots in Bredi, Abease, Yeji and Dinkra in the Brong Ahafo region (Marfo, 2014). The arrangement, which left 25% of the profits to the local communities, allowed jatropha to be intercropped with maize and had various Corporate Social Responsibility (CSR) elements in the business model, meant that Kimminic avoided the strong local and NGO resistance encountered by other large-scale projects (Boamah, 2015). By the end of 2011, Kimminic had planted about 5000 hectares with jatropha and cleared 7500 hectares (Kite, 2012; Marfo, 2014).

During 2009-11 Kimminic Corporations pursued a plan to become a fully vertically integrated company, and besides Kimminic Estates Ltd, two new fully owned subsidiaries, Kimminic Oil Ltd and Kimminic Logistics Ltd, were established. Kimminic Oil started construction of a biofuel (biodiesel) refinery close to the main plantation in Yeji. The refinery was a turnkey project involving four international companies. The plant was dimensioned to process 400 tonnes of seeds per day, equivalent to a harvest from 80,000 ha. This allowed the treatment of seeds from out-grower schemes and other companies in the area such as the nearby Smart Oil (Marfo, 2014).

Kimminic Logistics was established to produce and transport crude jatropha oil, biodiesel and organic fertilizer from jatropha for the national and international markets. Locating the biodiesel refinery at Yeji, close to Lake Volta, meant that the biodiesel could be transported easily and cheaply on barges on the lake to the Akosumbo inland port, from where it would be transported by truck to the port of Tema. Seedcake was to be exported as organic fertilizer in pellets or, as a second choice, to be burned in a thermal power plant for electricity production (Marfo, 2014).

Kimminic was a free-zone company, meaning that it had to export at least 70% of the produce and sell the rest in the domestic market. To guarantee a local market, and to ensure that the government would not place restrictions on Kimminic exporting more than the 70%, the company pushed the government for a blending mandate. It also negotiated with local oil companies to set up a blending facility. However, Kimminic did had supply agreements with EU oil companies, as well as with an aviation company, and so did not depend strongly on the development of a domestic market (Marfo, 2014).

SCANFUEL

Jatropha seedlings, produced in the nursery established in 2008, were planted on 350 hectares of land in April 2009, and the first crop was harvested in August 2009. The seeds were not processed but sold to a buyer in Burkina Faso (Scanfarm, 2011). In 2009 a study was carried out to investigate the feasibility of converting the land to food production, and by 2010 the farm shifted from jatropha to maize cultivation (Wisborg, 2012). With this shift Scanfuel changed its name to Scanfarm, and the founding Hesselberg couple left the company in December 2010.[38] The same year Scanfarm received a reward for being the National Best Maize farmer in 2010 (Wisborg, 2012).

In early 2009 Scanfuel was accused in the Ghanaian and international media of land-grabbing and the destruction of local farming livelihoods. This media storm seems to have its origin in an article in the Norwegian newspaper ***Aftonbladet*** in December 2008, quoting Hesselberg as having access to 400,000 ha.[39] It included articles in ***Ghana Business News*** in May 2009, which were corroborated by research done by a Norwegian researcher during April and May 2009, published by the Norwegian NGO SPIRE (Bull, 2009). Wisborg (2012) and Boamah (2014a) include a comprehensive account of these events. According to both sources, the Scanfarm management said in interviews that that the decision to change from fuel to food production was purely a commercial one and was not influenced by the accusations of land-grabbing or the food versus fuel debate.

BIOFUEL AFRICA

In November 2008 BioFuel Africa Ltd faced financial problems due to a lack of funding caused partly by the global financial crisis and partly by opposition to the project described below (Boamah, 2010). According to Arne Helvig, the company was in serious negotiations with Neste Oil and Statoil over the establishment of a joint venture. In early 2009 BioFuel Africa was close to achieving a financial input from Statoil against a 30% ownership, but the financial crisis induced Statoil to change its strategy and revert to its ***'core business'***, and it left the biofuel sector as a result. Biofuel Africa went bankrupt in March 2009, along with its mother company, Biofuel AS, prompted by (undocumented) allegations of corruption from Statoil, which meant an end to any remaining opportunities for external finance (Boamah, 2011; Helvig, 2014). At the time, Biofuel Africa had invested about US$ 10 million in the Ghanaian operations. The main investor, Perennial Bioenergy AS, has since gone out of business, and the founders of BioFuel Africa, Arne Helvig and Steinar Kolnes, lost equity of about US$ 0.5 million (NOK 4 million). At that time they had planted 550 hectares of jatropha.

Following the bankruptcy, Kolnes and Helvig tried to continue the operations in Ghana under the name of Solar Harvest Ltd, which was fully owned by the Norwegian company, Solar Harvest AS.[40] They first attempted to establish food production in connection with the existing jatropha farm (Boamah, 2010), but at the time of fieldwork in 2014, Solar Harvest had instead established a 400-hectare rice farm in an irrigated area in Botanga close to Tamale.[41] By then the jatropha plantations had become overgrown with weeds, and the machinery had been left partly dismantled on the ground.

SMART OIL

According to Friends of the Earth (Burley and Bebb, 2010), by 2010 Smart Oil had obtained 105,000 hectares of land. This figure may be exaggerated, but according to a captured webpage from Smart Oil in April 2010,[42] the firm had entered a Memorandum of Understanding with the Paramount Chief of Yeji for a land option of 46,000 hectares for the cultivation of 30,000 hectares of jatropha. In November 2011, Smart Oil signed a leasing contract for 6,750 hectares (including 4,500 hectares available for jatropha farming) with the Paramount Chief. Smart Oil started modestly and set up a six-hectare scientific test trial in June 2010, with financial support from an Italian Petro company, which in return got access to the scientific results (Darko, 2014). Later, in June 2011, another start-up, Futuris S.p.A., incorporated in 2009,[43] became the main shareholder of Agroils S.r.l. A key reason for this investment was to develop the jatropha project in Ghana jointly through Smart Oil Ltd.

4.4 TROUGH OF DISILLUSIONMENT, 2012-2016

4.4.1 LANDSCAPE LEVEL

Oil prices remained stable at around US$ 100 per barrel until August 2014, when they dropped to US$ 40-50 per barrel, continuing into 2016. In 2012 the cost of the CERs declined from US$ 5 to 0.31 per ton, at which point they lost their 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).

4.4.2 REGIME LEVEL

At the regime level in this period, the focus continued to be on resolving the deepening crises in power supply in Ghana. A feed-in tariff for renewables was approved in 2013 and revised in 2014, and the political focus shifted to small- and large-scale solar PV.[44] The first large-scale grid-connected PV system of 20 MW was installed in late 2015 (Adomdza et al., 2016; Kemausuor and Ackom, 2016). The draft biofuel policy of 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.

4.4.3 NICHE LEVEL

By early 2012 the two Norwegian owned companies, Scanfarm and Biofuel Africa, had converted to food-crop farming and seemed to be performing well, while most of the remaining jatropha companies were in serious financial trouble. By the end of 2014 only Smart Oil and Jatropha Africa were still in operation.

JATROPHA AFRICA

Interviews conducted by Kite in early 2012 revealed that the company expected to expand the existing 300 hectares to 1000 hectares by the end of 2012, and to reach 10,000 hectares in the next ten years (Kite, 2012). By December 2014, however, their activities consisted of low-intensity farming, scattered over different plots in four different villages, and the farming area had not increased. The jatropha-fuelled generator set had been left idle. It had never been connected to the nearby school, which was already connected to grid power (Jatropha Africa, 2014). Investors were still expected to come on board in a couple of months. The declared strategy was to increase jatropha production, establish a pressing facility and grow vegetables along with jatropha using irrigation from the nearby Black Volta River (Ampadu, 2014).

GOLD STAR FARMS

The manager of Jatropha Africa and the Director of Smart Oil agree that Goldstar never cultivated any jatropha (Ampadu, 2014; Darko, 2014). There were good reasons why Goldstar had already gone silent after 2010. In 2016, the owners Jack Holden and Lloyd B. Sharp were sentenced to seven and five years of imprisonment respectively in Oregon, United States, for mail and wire fraud, money-laundering and conspiracy to commit both offences.[45] According to newspaper coverage of the trial,[45] the two men spent most of 2007 and 2008 collecting US$ 1.2 million from a group of small investors from a religious community in the city of Portland, where Holden and Sharp posed as very devout Christians – Holden as a former missionary and pastor. According to newspapers reports, the sentenced men were especially cunning in that they turned just enough of their money into letterheads, offices and factory buildings to give the appearance they were hard at work.[45] They apparently produced test diesel, but never in commercial quantities. Holden falsely told investors that he had arranged with local tribes to grow five million acres of jatropha trees in Ghana and that his company, Goldstar Farms, would use their investments to buy a prefabricated refinery from China that would be shipped to Ghana to produce biodiesel.[45]

GALTEN

Since 2009, very few traces have been left of Galten, but as late as 1 August 2012, Galten explained to an Israeli business paper that ***'Yorkville Advisers LLC will invest up to US$ 5 million in Galten Biodiesel Ltd through a Standby Equity Purchase Agreement (SEPA) by Yorkville unit YA Global Investments LP'***.[46] Again it is unclear if this investment was a wish or a reality, but according to Bloomberg, Galten's share value declined from about US$ 10 million in January 2012 to zero on 1 January 2013.[47] Research done by Campion and Acheampong (2014) from August to November 2011 includes interviews with farmers and company workers at Ididome, but they do not reveal details of the area of land involved or the functionality of the plantation. According to an interview in 2014 with another biofuel actor who visited the premises, ***'They only planted a few hectares'*** (Darko, 2014).

KIMMINIC

After an equity group failed to provide a new capital inflow of US$ 3 million in late 2011 (Marfo, 2014), the company had suspended operations by May 2012 (Boamah, 2015). According to Marfo, about US$ 16 million had been invested at this time. A bush fire, apparently started by a group of angry workers influenced by Action Aid advocacy, hit part of the plantation in January 2013 (Boamah, 2014a). By December 2014 guards were still posted at the plantation, but weeds were taking over the jatropha plants, some of the machinery had been stolen or dismantled, and the half-finished biofuel processing plant bore the clear signs of a failed investment (Kiminic, 2014). At that time Kimminic was still searching for funding, and both Mr Marfo, Head of Kimminic Estates, and Mr Frederic Mana Antuma Gyamfi, Head of Kimminic Logistics, said that the company would revive itself in less than a year's time (Kiminic, 2014; Marfo, 2014). However, according to the LinkedIn profile of Mr Anponsem, Kimminic was closed by November 2015, and Mr Anponsem and his wife are currently continuing in Gamps Consulting Services.[48]

SMART OIL

An industrial-scale plantation was started by Smart Oil in July 2012 in parallel with obtaining an environmental permit from the EPA and full registration of the land lease in the National Register. Smart Oil planted about 450 hectares in 2012 and finally reached a figure of 720 hectares by December 2014.[49] Its business strategy was one of vertical integration, from the production to the export of crude oil for refining and use in Europe. According to an interview with Anthony Darko, Smart Oil's strategy had changed over time, from selling crude oil for biodiesel refining in the EU to using the crude oil in a diesel-powered cogeneration plant in Italy and selling the electricity at premium prices (green certificate system, coefficient of 1.8 for biomass from agriculture). In 2014, neither Smart Oil nor any other biofuel companies in Ghana had established a pressing facility of their own. As a result, jatropha was exported as whole seeds to Europe, and Smart Oil was buying stocks of jatropha from, for example, Kimminic and the Ghaya project to sell through the same channels. Yet according to Darko, an oil price of US$ 50 made it unprofitable to produce jatropha oil for biofuel. Smart Oil's strategy therefore shifted to selling jatropha oil in non-energy markets where prices are higher and volume requirements lower, for example, for biochemical uses and the treatment of leather (Darko, 2014).

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). 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).[50] 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 hectares 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 experience was 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. 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 hectares test farm in Sugakope in cooperation with the Wosornu Foundation, where they experimented with different seeds and with mechanized harvesting (Helvig, 2014; Kolnes, 2009a), while Smart Oil ran a 10 hectare experimental plantation. 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 experience 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. The table in Annex 1 summarizes the publicly available presentations made by Ghanaian niche actors at these conferences, which generally paint a very positive picture of jatropha experience 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 ***'inflated expectations'*** and why the disillusionment that followed was so severe. Weak sector-wide learning seems likewise to have constrained the development of jatropha export operations by reducing access to locally specific technical and managerial information, thus increasing the risks, as well as the extra costs incurred when each company had to conduct its own experiments.

5.4 VALUE CHAIN GOVERNANCE

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

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

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

Kimminic was successful in establishing a functioning large-scale plantation of 5000 hectares and might have survived with a business model of oil seed exports, but it could not to attract enough funds to complete the pressing and refinery facility. Biofuel Africa aimed to sell crude oil and found that their potential buyers demanded very large quantities, which required large investments in and a rapid expansion of primary production capacity. The company successfully established the first part of a large-scale plantation (400 ha) and developed close buyer contacts with Statoil (Norway) and Neste Oil (Finland) to ensure a market for the crude oil and to raise capital. However, Biofuel Africa went bankrupt in early 2009 when Statoil lost interest following the financial crisis and had to stop its farming operation (Helvig, 2014). 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 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, while 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. 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 hectares. 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 hectares (Smart Oil), 13,000 hectares (Scanfarm), 23,764 hectares (Biofuel Africa), and 65,000 hectares (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'***.[51] 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.

6. CONCLUSION

This report 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 experience 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 a marriage between 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. 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

ENDNOTES AND

ANNEX

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.

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.

Adomdza, G.K., McGAgonluri, F., Kemausour, F., Nygaard, I., Hansen, U.E., Lauritzen, H., 2016. Exploring product development possibilities and alternative uses of PV solar cells in Ghana.

Ahiataku-Togobo, W., Ofosu-Ahenkorah, A., 2009. Bioenergy Policy Implementation in Ghana. COMPETE International Conference 26-28 May 2009, Lusaka Zambia.

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 entiteled "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 entiteled "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 â€TM s biofuels policy : challenges and the way forward. Int. J. Energy Environ. 1, 805–814.

Bacon, R., Kojima, M., 2006. Coping with higher oil prices. ESMAP, World Bank, Washington.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Res. Policy 37, 407–429.

Berkhout, F., Angel, D., Wieczorek, A.J., 2009. Sustainability transitions in developing Asia: Are alternative development pathways likely? Technol. Forecast. Soc. Change 76, 215–217. doi:10.1016/j.techfore.2008.04.003

Berkhout, F., Verbong, G., Wieczorek, A.J., Raven, R., Lebel, L., Bai, X., 2010. Sustainability experiments in Asia: innovations shaping alternative development pathways? Environ. Sci. Policy 13, 261–271. doi:10.1016/j.envsci.2010.03.010

Binz, C., Truffer, B., Li, L., Shi, Y., Lu, Y., 2012. Conceptualizing leapfrogging with spatially coupled innovation systems: The case of onsite wastewater treatment in China. Technol. Forecast. Soc. Change 79, 155–171. doi:10.1016/j.techfore.2011.08.016

Biopact, 2007. Ghana takes small steps to get biofuels off the ground, Biopact. Block at Biopact, 29 March, 2007. **http://global.mongabay.com/news/bioenergy/2007/03/ghana-takes-small-steps-to-get-biofuels.html** (accessed 09.07.16).

Boamah, F., 2010. Competition between biofuel and food?: The case of a jatropha biodiesel project and its effects on food security in the affected communities in Northern Ghana. Master thesis in resources and human adaptation, Department of Geography, University of Bergen, Bergen.

Boamah, F., 2011. The Relationship between Land Grabbing for Biofuels and Food Security, a Bane or Boon? The Food Security Implications of Jatropha Biodiesel Project in Northern Ghana. Paper presented at the international conference on Global Land Grabbing, 6-8 April 2011, organised by the Land Deals Politics Initiative.

Boamah, F., 2014a. Imageries of the contested concepts “land grabbing” and “land transactions”: Implications for biofuels investments in Ghana. Geoforum 54, 324–334. doi:10.1016/j.geoforum.2013.10.009

Boamah, F., 2014b. How and why chiefs formalise land use in recent times: the politics of land dispossession through biofuels investments in Ghana. Rev. Afr. Polit. Econ. 41, 406–423. doi:10.1080/03056244.2014.901947

Boamah, F., 2015. Biofuels and land politics: Connecting the disconnects in the debate about livelihood impacts of jatropha biofuels land deals in Ghana. Dissertation for the degree philosophiae doctor (PhD) at the University of Bergen.

Boamah, F., Overå, R., 2016. Rethinking Livelihood Impacts of Biofuel Land Deals in Ghana. Dev. Change 47, 98 129. doi:10.1111/dech.12213

Bolwig, S., Ponte, S., du Toit Riisgaard,Lone, A., Halberg, N., 2010. Integrating poverty and environmental concerns in to value chain analysis. A conceptual framework. Dev. Policy Rev. 28 28, 173–194. doi:10.1111/j.1467-7679.2010.00480.x

Bolwig, S., Riisgaard, L., Gibbon, P., Ponte, S., 2013. Challenges of Agro-food Standards Conformity: Lessons from East Africa and Policy Implications. Eur. J. Dev. Res. 25, 408–427.

Brew-Hammond, A., 2009. Bioenergy for Accelerated Agro-Industrial Development in Ghana. Keynote Address delivered on behalf of Dr Joe Oteng-Adjei (Minister for Energy), by Prof Abeeku Brew-Hammond (Board Chairman, Energy Commission), at the Bioenergy Markets West Africa Conference, La Palm Royal Beach Hotel, Accra on Tuesday 27 October 2009.

Bull, B.C., 2009. Norwegian land grabbers in Ghana – The case of ScanFuel.

Burley, H., Bebb, A., 2010. Africa : up for grabs. The scale and impact of land grabbing for agrofuels. Friends of the Earth.

Burn, N., Coche, L., 2001. Multifunctional Platform for Village Power, in: Karlson, G. V (Ed.), Generating Opportunities. Case Studies on Energy and Women. UNDP, New York, pp. 60–69.

Byrne, R.P., 2009. Learning drivers: Rural electrification regime building in Kenya and Tanzania. PhD Thesis. University of Sussex.

Campion, B.B., Acheampong, E., 2014. The Chieftaincy Institution in Ghana: Causers and Arbitrators of Conflicts in Industrial Jatropha Investments. Sustainability 6, 6332–6350. doi:10.3390/su6096332

Coenen, L., Raven, R., Verbong, G., 2010. Local niche experimentation in energy transitions: A theoretical and empirical exploration of proximity advantages and disadvantages. Technol. Soc. 32, 295–302. doi:10.1016/j.techsoc.2010.10.006

Coenen, L., Truffer, B., 2012. Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. Eur. Plan. Stud. 20, 367–374. doi:10.1080/09654313.2012.651802

Dafrallah, T., Edjekumhene, I., Edze, P., Ngom, A., Ommer, V., 2010. Bioenergy for Rural Development in West Africa: The case of Ghana, Mali and Senegal. ENDA, Energy, Environment, Development, **http://www.gnesd.org/upload/gnesd/pdfs/bioenergy%20country%20reports/enda%20ben%20final%20report-review%20ghana,mali,%20senegal.pdf.**

Darko, A.A., 2014. Interview with Anthony A Darko, Smart oil, Kumasi 8. December 2014.

Dogbevi, E.K., 2008. Gold Star to cultivate five million acres of land for biofuels in Ghana. Ghana Bus. News.

Dogbevi, E.K., 2012. As Jatropha promoters in Ghana go mute, biofuels cited in another possible global food price hikes. Ghana Bus. News.

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, 2005. National bio-fuels policy recommendations (final draft). Ghana Energy Commission.

Energy Commission, 2006. Strategic National Energy Plan (2006 - 2020). Energy commission. doi:10.1017/CBO9781107415324.004

Energy Commission, 2010. Draft Ghana Bioenergy policy. Energy Commission.

Energy Commission, 2014. Interview with Dorothy Adjei, Energy Commission in Ghana, 12 December 2014.

FAO, 2008. The state of food and and agriculture - Biofuels: Prospects, risks and opportunities. Food and Agriculture Organisation of the United Nations (FAO), www.fao.org.

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.

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., 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

Geels, F.W., 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environ. Innov. Soc. Transitions 1, 24–40.

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., 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., 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, Philadephia, 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 goverment of Ghana.

GRAIN, 2007. The new scramble for Africa. GRAIN **https://www.grain.org/article/entries/606-the-new-scramble-for-africa.**

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.

Harnesk, D., Brogaard, S., Peck, P., 2015. Regulating a global value chain with the European Union's sustainability criteria - experiences from the Swedish liquid transport biofuel sector. J. Clean. Prod. 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., 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.

Henning, R.K., 2009. The Jatropha System - an integrated approach to rural development. Bagani, Weissenberg, Germany. (Available at ttp://betuco.be/agroforestry/Jatropha - integrated approach of rural development 5x.pdf) Accessed 09.07.16.

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., 2013. Jatropha as a biofuel crop and the economy of appearances: Experiences from Kenya. Rev. Afr. Polit. Econ.

Hunsberger, C., Bolwig, S., Corbera, E., Creutzig, F., 2014. Livelihood impacts of biofuel crop production: Implications for governance. Geoforum 54, 248–260.

Janssen, R., Rutz, D., 2008. Bioenergy Policies for Sustainable Development in Africa. Proceedings from COMPETE International Conference 25-27 November2008, Bamako.

Jatropha Africa, 2014. Field visit to Jatropa Africa Farm near Buipe, 2. December 2014.

Jongschaap, R.E.E., Corre, W.J., Bindraban, P.S., Brandenburg, W.A., 2007. Claims and Facts on Jatropha curcas L.: Global Jatropha curcas evaluation, breeding and propagation programme. Plant Research International B.V., Wagening.

Kaplinsky, R., 2000. Globalisation and Unequalisation: What Can Be Learned from Value Chain Analysis? J. Dev. Stud. 37, 117–146. doi:10.1080/713600071

Kemausuor, F., Ackom, E., 2016. Toward universal electrification in Ghana. Wiley Interdiscip. Rev. Energy Environ. doi:10.1002/wene.225

Kemausuor, F., Nygaard, I., Mackenzie, G., 2015. Prospects for bioenergy use in Ghana using Long-range Energy Alternatives Planning model. Energy 93, 672–682. doi:10.1016/j.energy.2015.08.104

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

Kiminic, 2014. Fieldvisit at Kimminic farms in Yeji and Ejura, 8. December 2014.

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.

Kolnes, S., 2009a. Pressures on West African land. Presentation by Steinar Kolnes, CEO co-funder 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.

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 32.

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.

Nygaard, I., 2010. Institutional options for rural energy access: Exploring the concept of the multifunctional platform in West Africa. Energy Policy 38, 1192–1201.

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

PANGEA, 2009. Enabling sustainable biopower, biogas and biofuels development in West Africa. Proceedings from the Bioenergy Markets West Africa Conference, La Palm Royal Beach Hotel, Accra on Tuesday 27 October 2009.

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, 2006. Global Status Report 2006 Update. Renewable Energy Policy Network for the 21st Century (REN21).

REN21, 2008. Renewables 2007 Global status report. REN21 Secretariat and Worldwatch Institute, www.ren21.net.

REN21, 2009. Renewables global status report - 2009 update. Renewable Energy Policy Network for the 21st Century, **http://www.ren21.net/.**

REN21, 2010. Renewables 2010 Global Status Report. REN21 Secretariat.

REN21, 2012. Renewables 2012 Global Status Report. REN21 Secretariat.

REN21, 2013. Renewables 2013: Global Status Report. REN21 Secretariat, Paris.

REN21, 2014. Renewables 2014 Global Status Report. Renewable Energy Policy Network for the 21st Century (REN21). doi:10.1108/eb055690

REN21, 2015. Renewables 2015, Global Status Report. Renewable Energy Policy Network for the 21st Century (REN21).

REN21, 2016. Renewables 2016 Global Status Report. REN21 Secretariat, Paris.

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.

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.

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.

Scanfarm, 2011. Field visit to Scanfarm 1. September 2011.

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 L. Gov. Conf.

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.

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.

Shpurer, S., 2009. The startup , the dream and the weed. Haaretz Digit. Ed.

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. doi:10.1016/j.respol.2010.01.023

Tigabu, A., Berkhout, F., van Beukering, P., 2013. The diffusion of a renewable energy technology and innovation system functioning: Comparing bio-digestion in Kenya and Rwanda. Technol. Forecast. Soc. Change.

UNCTAD, 2006. Financing biofuels and jatropha planations 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., Verbong, 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.

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.

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

Verbong, 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., 2012. Justice and Sustainability : Resistance and Innovation in a transnational land deal in Ghana. Presentation at the annual World Bank Conference on land and poverty, Washington DC, April-23-26, 2012.

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. http://wagpco.com/index.php?option=com_content&view=article&id=109&Itemid=113&lang=en (accessed 21 December 2016)

2. By 2009, fewer than ten were actually functioning on jatropha oil (Nygaard, 2010).

3. In the web-based paper 'Modern Ghana' it is described as ***'the near completion of the first phase of a 12-million dollar factory, to produce bio-diesel at Pomadze in the Central Region. When operational, the bio-diesel factory would have a capacity of 360,000 tonnes annually'*** http://www.modernghana.com/news/38862/1/ghana-to-start-bio-diesel-production.html (accessed 21 December 2016)

4. http://www.gasandoil.com/news/africa/3e1f8b1edeb32b4411285002c1b5e27e (accessed 21 December 2016)

5. http://politics.myjoyonline.com/pages/news/200704/3641.php (accessed 21 December 2016)

6. This National Jatropha Plantation Initiative (NJPI) has also been described as a fact in Amissah-Arthur et al. (2007) and as late as in 2010, by Dafrallah et al. (2010) but still without any notice of what happened to the initiative.

7. https://beta.companieshouse.gov.uk/company/05941107/filing-history?page=1 (accessed 21 December 2016)

8. https://web.archive.org/web/20070202041303/http://www.jatrophaafrica.com/index.html (accessed 21 December 2016)

9. Friends of the Earth claims 120,000 hectares. Reiterated in Acheampong and Campion (2014).

10. 300 hectares (Kite, 2012), 100 + 400 hectares out growers (Dafrallah et al., 2010)

11. https://web.archive.org/web/20081005190612/http://goldstarfarms.com/index.html (accessed 21 December 2016)
A capture of the webpage from Oct 2010 shows that Diana Holden is 'sole owner of all Gold Star farms and Gold Star biodiesel operations worldwide'. https://web.archive.org/web/20100918044447/http://www.goldstarfarms.com/executive_team.html (accessed 21 December 2016). Current webpage claims that Diana Holden is also said to be 'owner of Black Star Oil and Investments Ltd. which currently has an MOU with the Ghana Government to build and operate a 300,000 barrel per day crude oil refinery and petro chemical plant on 2,000 acres in the Western Region in Ghana' http://goldstarfarms.com/bio_ladyD.html (accessed 21 December 2016)

12. http://www.oregonlive.com/portland/index.ssf/2015/10/portland_jury_finds_jack_holde.html (accessed 21 December 2016)

13. Nana Akufo-Addo lost in the elections in 2008 and 2012, but was elected president in 2016

14. https://web.archive.org/web/20071219140141/http://www.galtengroup.com/news.html (accessed 21 December 2016)

15. https://web.archive.org/web/20071205044721/http://www.galtengroup.com/company.html (accessed 21 December 2016)

16. https://www.linkedin.com/in/gideon-norvor-905ba491 (accessed 21 December 2016)

17. https://www.linkedin.com/in/heidi-amponsem-4425692 , https://ca.linkedin.com/in/george-amponsem-12706437 (accessed 21 December 2016)

18. The board of directors captured at a webpage from 2011 provide some vague indications of the investor group https://web.archive.org/web/20110424120711/http://kimminic.com/about/board-directors (accessed 21 December 2016)

19. http://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=39530539 (accessed 21 December 2016)

20. https://web.archive.org/web/20041206165834/http://www.northpoint.no/index.asp (accessed 21 December 2016)

21. https://web.archive.org/web/20031208205205/http://www.northpoint.no/senior_partners.htm (accessed 21 December 2016)

22. http://www.bloomberg.com/research/stocks/people/person.asp?personId=23810838&privcapId=882346 (accessed 21 December 2016)

23. http://www.aftenbladet.no/aenergi/Fikk-halve-Rogaland-til-a-lage-bioolje-315553b.html (accessed 21 December 2016)

24. http://za.kompass.com/c/auto-expo-scandinavian-as/no064928/ and http://www.bloomberg.com/research/sTocks/private/snapshot.asp?privcapId=42958578´ (accessed 21 December 2016)

25. http://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=42958578 (accessed 21 December 2016)

26. http://www.cmtevents.com/speakerprofiles.aspx?EV=091021&spid=369237& (accessed 21 December 2016)

27. http://www.smartoil.it/company.html (accessed 21 December 2016)

28. http://www.agroils.com/images/downloads/agroils_presentation_nov_08.pdf (accessed 21 December 2016)

29. http://www.smartoil.it/team.html (accessed 21 December 2016)

30. http://www.smartoil.it/team.html (accessed 21 December 2016)

31. Oil production started in December 2010 http://www.reuters.com/article/ghana-jubilee-idUSL6N0DA59S20130423?irpc=932 (accessed 21 December 2016)

32. http://sustainableenergyinafrica.ning.com/profiles/blogs/digging-green-gold-in-ghana (accessed 21 December 2016)

33. https://web.archive.org/web/20150516230306/http://www.jatrophaafrica.com/News (accessed 21 December 2016)

34. http://www.acpnonfood.com/Workshop3.html (accessed 21 December 2016)

35. https://web.archive.org/web/20130811180130/http://www.haaretz.com/print-edition/business/the-startup-the-dream-and-the-weed-1.271399 (accessed 21 December 2016)

36. https://web.archive.org/web/20090310235149/http://www.galtengroup.com/company.html (accessed 21 December 2016)

37. http://www.eilatenergy.org/Portals/17/Doron%20Levi,%20Biofuel%20Agriculture%20in%20Africa,%20Business%20and%20Local%20Development.pdf (accessed 21 December 2016)

38. https://www.linkedin.com/in/thorhesselberg (accessed 21 December 2016)

39. http://www.aftenbladet.no/aenergi/Fikk-halve-Rogaland-til-a-lage-bioolje-315553b.html (accessed 21 December 2016)

40. https://www.linkedin.com/company/solar-harvest-as-biofuel-africa-as-biofuel-africa-ltd (accessed 21 December 2016)

41. http://www.biofuel.no/news_viewer.php?news=20130404 (accessed 21 December 2016)

42. www.agroils.com assessed 03.12.12. Not currently available and not captured by Wayback Machine at https://web.archive.org/web .

43. http://futuris.it/public/eng/index.html (accessed 21 December 2016)

44. As of February 2016, a total of 80 provisional licences have been issued by the Energy Commission for electricity from renewable energy2. Fifty-five (55) out of this 80 are for solar PV alone, with a total capacity of over 3,000 MW (Adomdza et al., 2016)

45. http://www.biofuelsdigest.com/bdigest/2016/05/09/oregon-fraudster-sentenced-to-more-than-7-years-in-prison-for-biodiesel-scams/

http://www.oregonlive.com/portland/index.ssf/2015/10/portland_jury_finds_jack_holde.html

http://www.oregonlive.com/portland/index.ssf/2015/10/accused_swindler_jack_holden_s.html

http://www.oregonlive.com/portland/index.ssf/2015/04/pure_evil_swindler_sent_to_pri.html

http://www.oregonlive.com/portland/index.ssf/2015/09/suspected_biodiesel_fraud_sche.html all accessed 21 December 2016

46. http://www.globes.co.il/en/article-1000770703 (accessed 21 December 2016)

47. https://www.bloomberg.com/quote/GALTEN:IT (accessed 21 December 2016)

48. https://ca.linkedin.com/in/george-amponsem-12706437 (accessed 21 December 2016)

49. http://www.smartoil.it/company.html (accessed 21 December 2016)

50. https://web.archive.org/web/20110903021244/http://www.jatrophaafrica.com/ourwork/view/httpwww.jatrophaafrica.comourworkviewGhana-Biofuel-Committee (accessed 21 December 2016)

51. https://web.archive.org/web/20071219140141/http://www.galtengroup.com/news.html, (accessed 21 December 2016)

ANNEX 1. GHANAIAN INDUSTRY ACTORS AS SPEAKERS AT INTERNATIONAL JATROPHA CONFERENCES (authors' compilation based on Web resources accessed 11. December 2016)

Conference	Date and place	Participant speakers	Source
Ghana Holds First Biodiesel Investors' Forum, held by the Energy Commission of Ghana in collaboration with Ghana Bio Energy Limited	29. April 2004	Onua Amoah, Ghana Bio Energy Limited	http://evworld.com/news.cfm?newsid=5582
Financing biofuels and jatropha plantation projects with special emphasis on Clean Development Mechanisms (CDM), UNCTAD	13 –14 November 2006, Accra, Ghana	Onua Amoah, CEO, Anuanom Industrial Bio Products Ltd., Ghana	(Amoah, 2006a)(Amoah, 2006b) (UNCTAD, 2006).
Jatropha World Conference	5. October 2008, Hamburg, Germany	Giovanni Venturini Del Greco, General manager, Agroils S.r.l	http://www.cmtevents.com/speakerprofiles.aspx?ev=081031&spid=397319&
COMPETE International Workshop 'Bioenergy Policies for Sustainable Development in Africa'	25-27 November 2008, Bamako, Mali	Ohene Akoto, Jatropha Africa	(Janssen and Rutz, 2008)
COMPETE International Conference 'Bioenergy Implementation in Africa'	26-28 May 2009, Lusaka, Zambia	Wisdom Ahiataku-Togobo, Ministry of Energy	(Ahiataku-Togobo and Ofosu-Ahenkorah, 2009)
World Jatropha Summit 'Towards Higher Yields, Large-Scale Production and Exports for the International Market'	28-29 May, 2009, Accra, Ghana	Speakers unknown, Interview with Ohene Akoto, Jack Holden	https://emeliaennin.wordpress.com/2009/05/31/biofuel-threat-to-food-security/
Second Jatropha World Africa conference	14-15 October 2009, Brussels, Belgium	Steiner Kolnes, Biofuel Africa	http://www.cmtevents.com/speakerprofiles.aspx?EV=091021&spid=369237&
Bioenergy Markets West Africa conference	27 October 2009, Accra, Ghana	Abeku Brew-Hammond, Energy Commission Kofi Marfo, Biofuel1 Ohene Akoto, Jatropha Africa	(Brew-Hammond, 2009)(PANGEA, 2009)
Regional dialogue with key stakeholders on commercial pressures on West African land, led by SWAC/OECD as part of the Annual Meeting of the Food Crisis Prevention Network co-organised by CILSS, 8-10 December 2009	9. December 2009, Bamako, Mali	Steiner Kolnes, Biofuel Africa	(Kolnes, 2009a)
Production of non-food, bio-oil supply chains for renewable energy in Ghana: needs, Challenges and Opportunities, Training Workshop. http://www.acpnonfood.com/Workshop3.html	7-9 October 2010	Clive Coker, Jatropha Africa Ohene Akoto, Jatropha Africa Wisdom Ahiataku-Togobo, Ministry of Energy	http://www.acpnonfood.com/WS3.4-20101007-(Clive%20Coker).pdf http://www.acpnonfood.com/WS3.6-20101007-(Ohene%20Okato).pdf Renewable energy policy (emphasis on biofuel sources); Legislative framework; Government support.

UNEP DTU PARTNERSHIP

WORKING PAPER SERIES 2017:1

EVOLUTION OF THE JATROPHA BIOFUEL NICHE IN GHANA