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The *Jatropha* biofuels sector in Tanzania 2005–2009: Evolution towards sustainability?

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ABSTRACT

Biofuel production has recently attracted much attention. Some anticipate substantial social and environmental benefits, while at the same time expecting sound profitability for investors. Others are doubtful, envisaging large trade-offs between the pursuit of social, environmental and economic objectives, particularly in poor countries in the tropics. The paper explores these issues in Tanzania, which has been an African forerunner in the cultivation of a bio-oil shrub called *Jatropha* curcas L. We trace how isolated *Jatropha* biofuel experiments developed since early 2005 towards a sectoral production and innovation system, and we investigate to what extent that system has been capable of developing and maintaining sustainable practices and producing sustainable outcomes. The application of evolutionary innovation theory allows us to view the developments in the sector as a result of evolutionary variation and selection on the one hand, and revolutionary contestation between different coalitions of stakeholders on the other. Both these processes constitute significant engines of change. While variation and selection are driven predominantly by localised technical and agronomic learning, the conflict-driven dynamics are highly globalised and occur primarily as a result of reflexive learning about problematic sustainability impacts. The sector is found to have moved some way towards a full sectoral innovation and production system, but it is impossible to predict whether a viable sector with a strong "triple bottom line" orientation will ultimate emerge, since many issues surrounding the social, environmental and financial sustainability still remain unresolved, especially relating to local and global governance.

1. Introduction

Biofuel production from the tropical plant *Jatropha* curcas L. has recently attracted much attention. It has been widely claimed to be the only early biofuel that is not a food crop and can grow on marginal lands, thereby avoiding competition with food production and even helping in soil regeneration and erosion prevention (e.g., Jongschaap et al., 2007; Achten et al., 2007, 2008; ProForest, 2008; IFAD, 2010). Tanzania – along with India – have been major forerunners in attracting initiatives in this line of business (GEXSI, 2008). A survey of emerging *Jatropha* biofuels activities conducted in March-June 2005 uncovered a number of recently-started experiments (van Eijck, 2007; van Eijck and Romijn, 2008; Caniëls and Romijn, 2008). A second survey carried out in September–December 2008 (Roks and van Vlimmeren, 2009) revealed a veritable explosion of activities, organised in a variety of business models.

The aims of this paper are to: (1) explore to what extent, and how the *Jatropha* biofuel experiments in Tanzania have developed towards a fully fledged sectoral production and innovation system; and (2) investigate whether that system has developed and maintained sustainable practices and produced sustainable outcomes.

Following the UN World Commission on Environment and Development (1987) and the United Nations 2005 World Summit, sustainable development is referred to as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. In general terms, this implies the creation and maintenance of a good balance between economic, environmental and social/equity considerations. In this paper we will refer to these as "People, Planet, Profit", or PPP. Obviously, each of the three generic PPP dimensions consists of various sub-dimensions, but unlike the main dimensions, the characteristics of the sub-dimensions are largely specific to time, place and sector. The *Jatropha* biofuels sector in Tanzania has been widely pushed because of its alleged potential to mitigate global warming and restore degraded tropical ecosystems (two environmental sub-dimensions), avoid competition with food production and create reliable opportunities for boosting local livelihoods (two social sub-dimensions), alongside promising a

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sound economic boost at the macro and local micro level (two economic sub-dimensions).

Our methodology is grounded in evolutionary innovation theory, and combines two different types of analysis. The first type concerns the question of how technologies and associated organisational forms and business practices have arisen and evolved over time through evolutionary variation and selection. The second type is a study of how different stakeholders have attempted to safeguard their interests in processes of debate, coalition formation, power play and conflict. This highly globalised process of contestation is found to be a key driver of sectoral development alongside more locally based evolutionary variation and selection. Stakeholders differ predominantly in terms of the importance they attach to the various (sub-)dimensions of sustainability, which is reflected in their actions. We show that in a newly emerging sector such as this one, where so many contentious issues are at play, the sustainability performance and outcomes of the sector as a whole arise from the co-evolution of technology and organisation through gradual learning on the one hand, and opposing societal forces on the other. Thus, the paper also seeks to make an innovative theoretical contribution by expanding the role of societal contestation and conflict in evolutionary innovation systems research.

In Sections 2 and 3 we outline the theoretical framework. Section 4 describes the data gathering. In Section 5 we apply the framework to the *Jatropha* case in Tanzania. Our own two surveys constitute the main sources, supplemented with secondary sources such as press reports, NGO studies, company reports, reports from other researchers, etc. Section 5 comes into four parts, which trace sequentially how the sector evolved from early 2005 to late 2009. Section 6 teases out the key stumbling blocks and unresolved sustainability issues in the sector that arise from the analysis in Section 5, and reflects on the merits and possible limitations of our methodology.

2. Conceptual starting point: systems of innovation

A logical point of departure for addressing our objectives is the innovation systems literature (e.g., Edquist, 1997; Lundvall, 1992), in which innovation is seen as a collective process driven by learning, involving a wide variety of interacting agents. The systems perspective also points us towards the importance of sectoral structures and institutions, and how they impact on learning and innovation. It allows for a holistic interpretation of economic development as driven by co-evolving technologies and societal factors (Malerba, 2004).

There are several distinct sub-sets of innovation systems literature, not all of which are suitable for analysing the dynamics of newly emerging systems and analysing PPP-sustainability issues and how these interact with systems development. Only the more recently developed systems approaches include an explicit focus on societal and environmental sustainability. These approaches address the question how, and under what conditions, more 'environmentally friendly' innovations can emerge, develop and be broadly accepted in society to the point where they can begin to offer superior performance characteristics over extant unsustainable practices, thus enabling a so-called socio-technical 'transition' to occur (for a good review, see Coenen and Díaz López, 2010). One of these approaches is Strategic Niche Management (SNM), which has its roots in evolutionary transition studies (e.g., Hoogma et al., 2002; Kemp et al., 2001, 1998; Weber et al., 1999; Elzen et al., 2004; Raven, 2005). SNM posits that successful radical innovations with environmentally sustainable characteristics emanate from socio-technical experiments in which various stakeholders collaborate and exchange knowledge and experience, thus embarking on an interactive learning process that will facilitate the incubation of new technologies. This occurs in a protected space called a 'niche' (Hoogma et al., 2002, 30).

In a later refinement of the SNM framework, which we also follow in this study, SNM writers have made a distinction between two types of interlinked niche-levels in which technological development and diffusion processes take place: the so-called 'global' niche level and the local niche level. The global level is where the emerging technological trajectory can be seen. It consists of accumulated, global, abstract and generic knowledge. Local niches (which are for instance national or regional) feed new knowledge into the global niche, and can also tap into the accumulated knowledge that is available at the global niche level. In this paper, the global niche level primarily refers to the international level. The local niche level consists of the set of projects and experiments carried out by actors in Tanzania, using their own networks and knowledge, and a specific configuration of the technology that is locally relevant.

Niche experiments take place in the context of a 'socio-technical regime', which essentially defines the established way of doing things in a particular sector. It comprises "... the whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, established user needs, regulatory requirements, institutions and infrastructures" (Hoogma et al., 2002, 19). There can even be more than one relevant regime for a radically new innovation. Radical innovations often require the building of entire new value chains, which may cut across different sectors of economic activity (e.g. Raven, 2007). In our biofuels case, no less than four regimes come into play, namely (fossil) energy, agriculture, oil processing, and land use and ownership customs and practices.

In turn, the regime(s) is (are) embedded in a contextual 'landscape'—a set of structural societal factors such as demographics, political system, cultural patterns and lifestyles, and macro-economic conditions (Raven, 2005, 31–32). The landscape is beyond the direct influence of niche and regime actors. Changes at the landscape level most often take place very slowly, but sudden changes have also been known to happen (as in the case of the oil crises in the 1970s, political coups, or unexpected natural disasters).

Another line of innovation systems research with a strong sustainability focus is the Technological Innovation System (TIS) approach (e.g., Hekkert et al., 2007), which – compared to SNM – is more narrowly focused on the development of technological systems, and hones in on the critical functions that have to be fulfilled in these systems in order to generate truly sustainable innovations. Both SNM and TIS focus on newly emerging innovation systems that generate innovations with environmentally promising characteristics. They try to analyse the socio-economic and environmental learning trajectories involving incubation and commercialisation, and the outcomes of these processes.

Major differences between stakeholder priorities and agendas are recognised in these approaches. These problems are explained in terms of tensions between progressive innovation-promoting (niche) actors and conservative actors in the established regime or technological-system context, who try to oppose promising novelties to safeguard their vested interests (see, e.g., Smith, 2007). For example, the TIS framework speaks in terms of the need to engage in struggle for legitimation of sustainable radical innovations in renewable energy and transport, because incumbent technologies, actors and institutions in these sectors have had many decades to secure their powerful and organised positions. Not only may they be hesitant to embrace radical innovations in their area, but they may actively try to block their progress. Much of the early efforts of an emerging technological innovation system thus have to be spent on legitimation—activities