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Paul Upham, *The Tyndall Centre, University of Manchester*

paul.upham@manchester.ac.uk

Vijay Kuttapan, *Charles Sturt University (Australia)*

vijayakumarpkd@gmail.com

Julia Tomei, *UCL Energy Institute*

j.tomei@ucl.ac.uk

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Authors

Paul Upham[a], Vijay Kuttapan[b], Julia Tomei[c]

a) Manchester Institute of Innovation Research, University of Manchester; Finnish Environment Institute, Helsinki; Centre for Integrated Energy Research, University of Leeds. Tyndall Manchester, Pariser Building, Sackville St., University of Manchester, Manchester M13 9PL, UK. Tel +44(0)161 306 3258. Fax +44(0)161 306 3255. paul.upham@manchester.ac.uk

b) Charles Sturt University, Elizabeth Mitchell Drive, Thurgoona NSW, Austrailia. vijayakumarpkd@gmail.com

c) UCL Energy Institute, Central House, 14 Upper Woburn Place, London, WC1H 0HY, UK. j.tomei@ucl.ac.uk

ABSTRACT
Policy interest in biofuels in India has grown dramatically during the last few years, with substantial government planting targets for *Jatropha curcas* in particular. This working paper discusses the sustainable livelihoods aspects of alternative Jatropha cultivation systems identified during fieldwork in three Indian states in 2009, based on site visits and senior manager interviews in three Indian states. The main cultivation systems found were: (a) cultivation by private fuel companies on leased ('captive') land; (b) cultivation by organised communities and by self-help groups on communal land; and (c) contract farming in which private companies in the fuel supply business contract farmers to cultivate Jatropha on the farmers' own land. We discuss these alternatives in relation to sustainable livelihoods concepts, contrast managers' views with other, much more critical research findings and highlight issues for further work.

Keywords

Jatropha curcas, biofuel, biodiesel, livelihoods, sustainable development

INTRODUCTION

Jatropha *curcas* (henceforth Jatropha) is a biodiesel feedstock about which there has been substantial international interest and investment, but also considerable concern (Estrin, 2009). The Indian Ministry of Rural Development estimates that there are between 500,000 to 600,000 hectares (ha) (5-6,000km^2) of Jatropha growing across India (ISIS, 2007) and the Indian Planning Commission (2003: p. *x*) envisage a major future for Jatropha for domestic transport fuel consumption, stating that: "with appropriate extension and availability of planting material it should be easy to cover 13.4 million hectares of land". China is reported as also claiming to have 2 million ha of Jatropha under cultivation and has announced plans for an additional 11 million ha across its southern states by 2010 (Fairless, 2007). Similarly, Burma has plans to plant several million hectares, as have the Philippines, and several African countries have initiated large-scale plantations (ibid). There is also commercial and government interest in Jatropha in many Latin American countries (CEPAL, 2007).

Opinions on Jatropha range from it having the potential to 'green' rural 'waste' land and to improve the livelihoods of rural people (Suhas et al., 2006), to its cultivation entailing unintended and adverse consequences (Findlater and Kandlikar, 2011; (Ariza-Montobbio and Lele, 2010.). In India in particular, Jatropha cultivation has been perceived as congruent with efforts to deal with the unpredictable monsoon patterns and increasing land pressures that are encouraging Indian policy makers to diversify agricultural practices, in addition reducing the risks of crop failure posed by monoculture (Agoramoorthy et al., 2009). Moreover, in terms of agronomy, it is generally considered that jatropha cultivation will be of most economic benefit to farmers if they are involved through the biofuel production chain, from seedling production to oil extraction. In addition, to reduce the risk of the crop failure, it has been suggested that Jatropha be grown in an agro forestry model as well as a fence crop (Tomomatsu and Swallow, 2007).Nonetheless the risks of, and posed by, cultivation of jatropha on agricultural land remains (Openshaw, 2000; Achten et al., 2008; Achten et al., 2010). Others have argued strongly in support of jatropha cultivation for biofuel, taking the view that it is institutions that determine whether or not a particular agricultural development programme is pro-poor, not any given crop or technology (Clancy, 2008). Indeed in principle jatropha production for biofuel could benefit the rural poor not only at the production stage but also via fuel provision for off-grid electricity and for transportation, both via diesel

engines. Similarly it has been argued that rural women may be those who would most benefit from Jatropha-based biofuel (Openshaw, 2000; Francis et al., 2005; Russi, 2008; Ewing and Msangi, 2009; Howarth et al., 2009).

Here we treat 'sustainability' as substantially contextually defined. By this we mean that sustainability, particularly but not only 'social sustainability', is to a large extent a socially constructed term. This does not render it infeasibly flexible and hence useless for practical purposes, however. As a concept, sustainability may be simultaneously considered a deliberately rhetorical device, intended to draw together potentially contradictory agendas into potentially fruitful dialogue and directions, while at the same time embodying important concepts of environmental thresholds that should not be passed (Upham, 2000; 2001). While its flexibility carries the risk of inadvertently legitimising unsustainable trends, its ability to bring together actors with differing interests carries within it the potential for positive change. Unfortunately at the time of writing, it is far from clear that Jatropha is being cultivated in such a way as to contribute to such change. Evidence continues to build that promises of rural economic benefits are generally not being realised, or at least not being widely shared (Estrin, 2009). As Clancy suggests (2008), this appears partly to be a result of the inadequacies of the institutional (socio-economic) context in which Jatropha is being cultivated. However the livelihood risks associated with Jatropha also relate to the non-edible nature of the crop and the way in which yield improvements are achievable with relatively good quality land and water inputs. These factors alone have the potential to place upward price pressure on food crop production due to appropriation of the factors of production, regardless of land rights Couple this with the value of the crop for diesel vehicle transport and the more powerful purchasing power of those who own such vehicles or who act for them via markets, relative to those directly involved in producing the crop, and the potential for local disbenefits is clear.

This working paper describes the organisation of Jatropha cultivation systems identified in three Indian states in 2009. We also describe the views of project managers, discussing both in terms of sustainable livelihoods concepts. Our primary aim in this early piece of work is to provide a basis for more detailed study of the potential contribution of Jatropha and related Indian programmes, rather than to draw definitive conclusions. The views of managers involved in experimental and commercial Jatropha promotion programs differ from the concerns raised by others who have investigated Jatropha production in India – notably (Ariza-Montobbio and Lele 2010; Ariza-Montobbio, Lele et al. 2010). It is important that a wide range of viewpoints are obtained, particularly from the rural poor involved, and that government and state investments do not have perverse consequences. Our purpose here is to add to the limited literature on the topic, specifically by outlining the variety of Jatropha cultivation models, summarising a selection of associated policies in India at a state level and highlighting livelihoods issues that merit further research.

JATROPHA AND RELATED INDIAN POLICY

A native of tropical America, Jatropha is a bush or small tree belonging to the family of Euphorbiaceae and can be established from seed, seedlings and cuttings (Sarin et al, 2007). It has a high seed yield that continues to be produced for 30–40 years, and seed production may range from an initial 0.4 to over 12 air dry t/ha/y after five years of growth (Jones and Miller, 1992; Openshaw, 2000). The oil content in Jatropha seeds has been variously quoted at around 30–40% (Sarin et al, 2007). Oil pressed from 3.125kg of Jatropha seeds (or 'beans')

will make 1kg of biodiesel (Indian Planning Commission, 2003: 139). Experience of yields varies: for example, while Jones (2004) states that the above is approximately the annual yield of a Jatropha tree, the Centre of Excellence in Biofuels (2009) in Tamil Nadu finds that in the third year the yield is approximately 1.5kg of seeds per plant, stabilising at 2.1kg per plant during the fifth year onwards. The same centre estimates an oil yield of 2.5 to 3.5 tonnes per hectare under commercial conditions (ibid).

In terms of Indian national policies for supporting and promoting Jatropha, the National Network on Integrated Development of Jatropha and Karanja (*Pongamia glabra*) ran from 2004-7, established by the National Oilseeds and Vegetable Oil Development Board (NOVOD). This was, a network of 42 agricultural universities and research institutions that are now involved in a search for species suitable for the various agro-climatic regions of India, techniques for mass planting and a systematic cropping systems etc (Petroleum Conservation Research Association, 2004). On the demand side, the Ministry of Petroleum and Natural Gas introduced a biodiesel purchasing policy, which came into effect in January 2006.The policy requires oil marketing companies to buy biodiesel at a purchasing price of Rs.25/litre (equivalent to €0.40/litre at current exchange rates) from one of 20 purchasing centres in 12 states. The suppliers of the biodiesel must register with a state level coordinator in order to meet the specifications of the Bureau of Indian Standards. The oil companies then mix the biodiesel with the conventional diesel at a blending rate of 5% at the purchase centres. To date, little biofuel has been available through this route and the private sector firms whom we questioned considered that the purchasing price Rs26.5/litre was far below that necessary to encourage investment in these sectors. Biofuel is also exempt from excise duty (S. No. 53A of the Notification No. 4/2006) and NOVOD have also initiated a back-ended credit-linked subsidy programme. The programme provides subsidies for: a) nursery raising and commercial plantations; b) establishment of procurement centres; c) installation of pre-processing and processing equipment. There is also loan assistance from the Rural Infrastructure and Development Fund sponsored by National Bank for Agriculture and Rural Development (NABARD). Additionally, there are other centrally sponsored schemes that are used to promote biofuel production, including the National Rural Employment Guarantee Scheme (NREGS); the Watershed Development Programme; Swarnajayanti Gram Swarozgar Yojana (SGSY) (a development programme targeted at the rural poor); the Village Energy Security Programme (VESP); and the National Afforestation Programme (NAP).

SUSTAINABLE LIVELIHOODS CONCEPTS

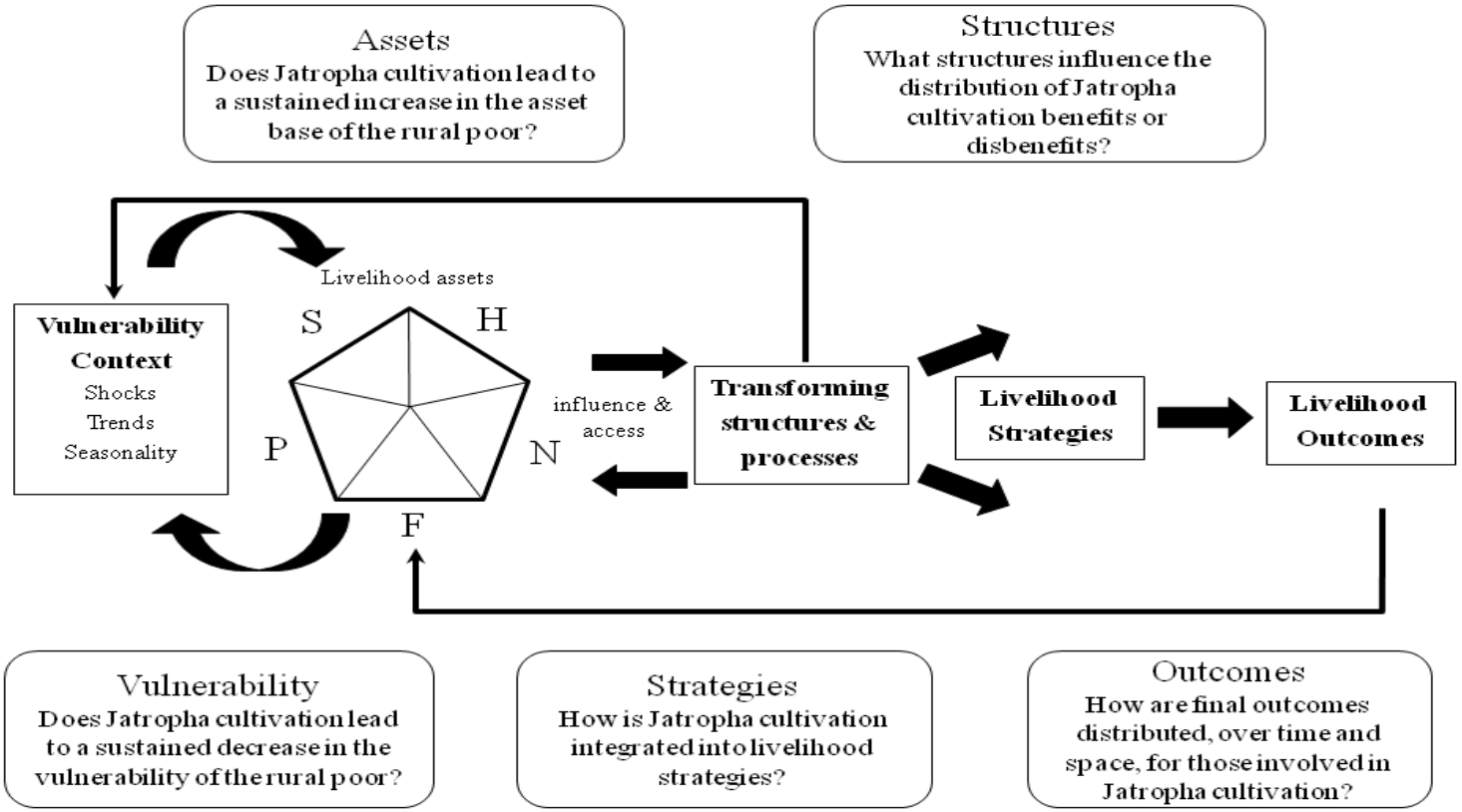
Our focus here is on the Jatropha cultivation in the context of sustainable livelihoods. During the 1990s the concept of 'sustainable livelihoods' (SL) became increasingly central to debates on rural development, poverty reduction and environmental management (Scoones, 1998). The concept emerged in response to new approaches to poverty reduction, the diversity and complexity of rural livelihoods, and the influence of structural and institutional issues (Ashley and Carney, 1999). The most popular definition of a sustainable livelihood is that of Chambers and Conway (1992):

> *'A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.'*

Sustainable livelihood is thus a normative concept, one that recognises not only the diversity of livelihoods but also the importance of social resilience and environmental sustainability. Approaches to SL offer an improved way of thinking about poverty reduction, helping both practitioners and theorists to understand the realities of the poor and the complexities of rural life. By taking a wider and better informed view of the opportunities offered by a development intervention, SL approaches aim to help the poor to make lasting improvements to their lives (Ashley and Carney, 1999). An SL approach therefore provides not only a set of principles and a framework for thinking through rural livelihoods, but also an operational objective.

In order to understand, analyse and promote sustainable rural livelihoods, several frameworks have been developed that set out to investigate the various factors influencing rural livelihoods and the relationships between these factors (cf. Scoones, 1998; DfID, 1999; Ellis, 2000). In all the frameworks, poor people are placed at the centre of the analysis, making explicit the ways in which resources are accessed by communities, and how these processes contribute in determining the household and community's sustainability (Redclift, 2000). The SL frameworks also highlight the structural and institutional settings which define people's livelihood options. One of the most widely adopted SL frameworks was developed by DfID in the late 1990s. This framework makes explicit the choices and trade-offs underlying different livelihood strategies, and the internal and external factors (and relationships between them) that drive different livelihood outcomes. By framing rural livelihoods in this way, livelihoods are understood to be dynamic and to vary under different contexts. Here we add to the basic framework a set of Jatropha-related issues (Figure 1), which we discuss subsequently.

Figure 1. The sustainable livelihoods framework



The central feature of the framework is the *livelihood assets* pentagon, upon which individuals draw to build their livelihoods. The rationale for this approach is that by starting with what people have rather than what they do not, the framework starts with an analysis of strengths as opposed to needs (Carney, 1998). The assets analysis also considers how assets have changed over time, what changes are expected to occur, what drives change in the asset base, and how access to assets differs between social groups. The livelihood options open to people are defined by the *structures* (organisations, markets) *and processes* (policies, laws, institutions, incentives). These external structures and processes impact upon livelihoods in two critical ways: firstly, in determining who has access to the different forms of capital; and secondly, in defining which strategies are open and attractive to individuals. An understanding of the structures and processes also provides a link between the micro and the macro, which helps to identify barriers, constraints and possible enablers (Cahn, 2002). The *vulnerability context* also frames the external environment in which assets exist and includes trends, shocks and cultural practices. The vulnerability context is also about how people adapt to shocks. Carney (1998) identifies three types of *livelihood strategies*: natural resource based; non-natural resource based; and migration. Scoones (1998) characterises lists these as: agricultural intensification/ extensification; livelihood diversification; and migration. Which strategy is adopted will depend on the assets that people have access to, the vulnerability context and the structures and processes under which they operate. The framework also emphasises that livelihood strategies may change over time in response to external pressures, such as population change, politics, natural disasters and conflict. The final component of the framework relates to *livelihood outcomes*, which may include more income, increased well-being, reduced vulnerability, improved food security, and/ or more sustainable use of the natural resource base (Carney, 1998).

The sustainable livelihoods framework provides a holistic, participatory and dynamic approach for thinking about poverty in rural settings. The approach also aims to place people at the centre of the analysis, and emphasises social resilience and environmental sustainability. In addition, the focus on institutions provides a way of understanding how human activities are shaped by rules, norms and conventions. Scoones (1998: p.13) argues that while the framework provides 'no predictive power' it is useful for identifying the 'right sort' of questions to be asked. The framework thus provides a way of linking the macro-level context to micro-level outcomes in assessments of the impacts of different interventions, projects and programmes. An important indicator of the success of any intervention is its capacity to contribute to rural livelihoods, simultaneously enhancing social resilience whilst protecting the local environment (Cherni and Hill, 2009).

INDIAN JATROPHA CULTIVATION SYSTEMS

In order to investigate patterns of Jatropha cultivation in India, plantation site visits and interviews with managers were undertaken at Jatropha cultivation sites in three Indian provinces: Tamil Nadu, Chhattisgarh and Andhra Pradesh, which are located as on the map below (Figure 2). While we do not make claims regarding the generalisability of what we found to India or to the provinces as a whole, which would require a much more extensive survey, we nonetheless observed enough variety with which to discuss differing livelihoods implications and with which to highlight issues meriting more detailed investigation. Table 1 summarises the attributes of the biofuel cultivation systems identified. Our objective was to identify and describe the social organisation and policy context of Jatropha cultivation in relation to livelihoods thinking, not the detail of agricultural practice.

Figure 2 Location of study states

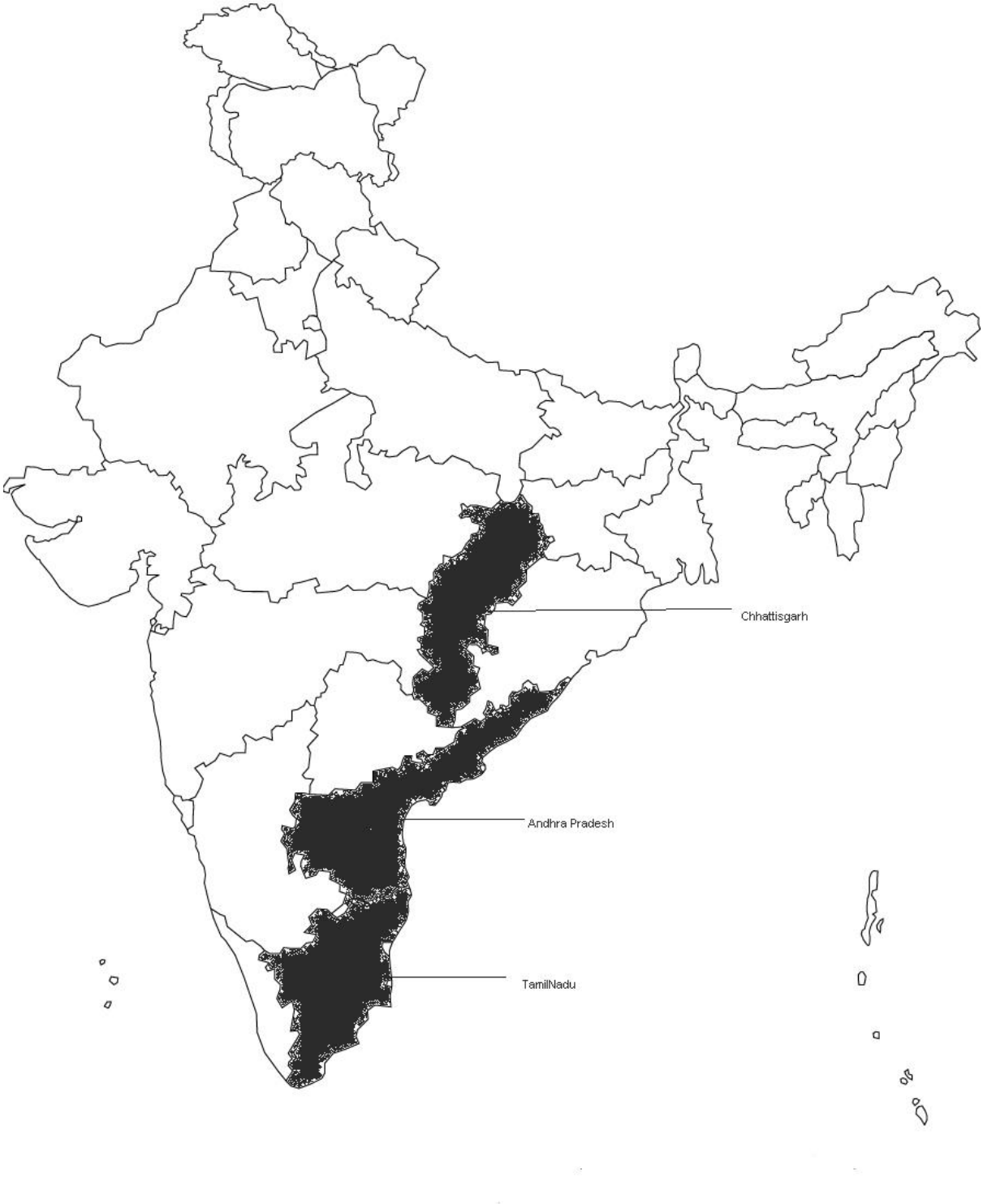


Table 1. Biofuel promotion models in Chhattisgarh, Andhra Pradesh and Tamil Nadu

State	Supporting institutions	Land	Planting support	Sale of oil-bearing seed	Processing	Targeted end user
Cultivation led by state and NGO actors						
Chhattisgarh	State department, forest department, CBDA and CREDA	Forest land, revenue land, communal land	Panchayat and agricultural department	JFMC and others sell seeds to either state run procuring centre or to private firms	Processed by the state biofuel plant or by commercial plant when available	Biodiesel production for national market and for rural electrification
Andhra Pradesh (community forest model)	Forest department	Forest land	Forest department	Seed sold to state agency. There are plans to sell oil to state run transport and private companies	The state purchase centre sells the seeds in the market; there are plan to sell oil to private companies also	State and national markets
Cultivation led by both public and private actors						
Andhra Pradesh (public-private partnership)	Free distribution of seedlings and other inputs to small farmers, either by government or private firm	Private farm lands	Farmers are responsible for cultivation. Farmers have buy back agreement with companies	Farmers will harvest the seeds and sell it to either the state purchasing centre or sell to private companies	State purchase centre will sell the seeds in the market	Biodiesel for the national and local markets
Chhattisgarh (contract farming model)	Up to 500 seedlings are given to farmers free of cost. Fertilizers and other input cost are subsidized	Private farmland	Farmers are responsible for cultivation. The company will give technical	Farmers harvest the seeds and sell either to a state run procuring centre or to a private company under	State procuring centre sell the seeds in the market. The UK based firm planned to set up	Biodiesel for national, local and for rural electrifications. The UK based firm

			advice under the contract farming agreement	contract farming. The farmer's decision on this is influenced by the market price	plant once the seeds are available at commercial scale	planned to trade the oil on the international market
Tamil Nadu (contract farming)	The state provides 50% subsidy for the seedlings. There are 11 private companies, which are actively involved in the cultivation of Jatropha under contract farming	Private farmland	Farmers are responsible for the success of the crop	Farmers will sell seed to companies with whom they have agreement	Oil extraction is done at 11 oil extraction units in the state	Mainly for national and international market
Cultivation primarily led by private actors						
Chhattisgarh (joint venture)	Between farmers and companies	Revenue and village wasteland	Companies and farmers are responsible for the cultivation	Companies organise and collect the seeds	Companies will do all the processing	Oil for the markets.
Tamil Nadu	There are 11 companies operating under contract farming and one company operating under captive farming	Private land, village and wastelands	Farmers and companies are responsible	Farmers sell the seed to companies under the buyback guarantee scheme.	Oil extraction done by 11 companies in the state itself	Oil for the national and international markets

Acronyms:
CBDA – Chhattisgarh Biofuel Development Authority
CREDA- Chhattisgarh state Renewable Energy Development Agency
JFMC- Joint Forest Management Committee
NREGS- National Rural Employment Guarantee Scheme
NABARD- National Bank for Agriculture and Rural Development
APARD- Andhra Pradesh Academy of Rural Development

Jatropha cultivation in Tamil Nadu

Tamil Nadu lies at the southernmost part of the Indian peninsula. In common with other Indian states, about 60% of the population depends on agriculture and agriculture-related activities. The success of agriculture is conditional on the timely arrival of two seasonal monsoons, the erratic arrival of which has in recent years encouraged farmers to opt for innovative agricultural practices, such as growing Jatropha (Paramathma et al, 2009). The government of Tamil Nadu actively promotes growing Jatropha on both private land and what is described as 'wasteland' (referred to as both 'wasteland' and 'marginal land' in Andhra Pradesh; the term is highly controversial, as discussed below). Although the state government has also identified other non-edible, oil-yielding plant species, as potential biodiesel feedstocks, including *Pongamia pinnata, Calophyllum inophyllum, Hevca brasiliensis, Azadirachta indica* and *Madhuca* species, Jatropha is given more policy attention because of assumed lower input requirements and an ability to grow in marginal soils.

In 2007, the state announced a Jatropha promotion programme to be implemented by the Centre of Excellence in Biofuels, in coordination with the Directorate of Agriculture. Over the period 2007 – 2012, the Tamil Nadu government aims to bring 100,000 ha under Jatropha cultivation. Under this programme, the government sells the seedlings to farmers at a subsidy of 50%. Currently, plant improvement research is undertaken at Tamil Nadu Agricultural University (TNAU) and the state government has also arranged for TNAU to provide standardised technical assistance to farmers. Additional support is provided by state government institutions with the subsidised buy-back of seed and free seedlings; agricultural co-operative banks also give credit to farmers in order to reduce the financial investment risk for farmers. Credit is provided at a heavily subsidised interest rate and the crop is grown on a commercial scale with active involvement of private stakeholders (Paramathma et al, 2006). At present there are approximately 17,806ha of land under Jatropha cultivation in the state, as well as three oil purchasing companies and 22 biodiesel processors. The main purchasers of biodiesel in India are public sector oil marketing companies, in 2009 buying biodiesel for Rs. 25 per litre (€0.40 /litre). The state government is encouraging farmers to intercrop Jatropha with vegetable and flower crops such as cabbage, tomato, chillies, aubergine and marigolds. Although contract faming is the most common arrangement, there is also some captive farming, in which a company leases the land from farmers for 30 years and grows the crop itself. In the case study in Tamil Nadu, we were told by project and policy managers that the lands leased by such farmers were previously 'wastelands' and land occupied by *Prosopis juliflora*, a scrubland bush used for firewood. Figures 3a, 3b and 4 illustrate Jatropha planting in Tamil Nadu.

Figures 3a, 3b and 4 Experimental *Jatropha c.* plots in Tamil Nadu

Jatropha cultivation in Chhattisgarh

Chhattisgarh, known as the Rice Bowl of India, is located in central India and is the tenth largest state. The Chhattisgarh government has undertaken a substantial plantation programme following the National Mission on Biodiesel and has set a target to plant 1 million hectares of Jatropha on 'wasteland' and degraded forest land. Indeed, the authorities have identified 5.9 million hectares of degraded land, which constitutes more than 19% of the

area of the state (CBDA, 2007). In 2005, the Chhattisgarh Biodiesel Development Authority (CBDA) was formed as a coordinating agency for the Chhattisgarh Renewable Energy Development Authority (CREDA). The CBDA enjoys strong state government support and has coordinated both roadside and block plantations (a technique of forest plantation, whereby blocks of trees are raised; mostly practised in social forestry, where community lands are involved). The state government also gave farmers some 500 free seedlings, thereafter charging Rs.0.50 (€0.01) for each seedling. Under the CBDA, a farmer is entitled to a maximum of 5,000 Jatropha saplings for planting, the explicit aim being to help poor and marginal farmers. In addition, government organisations can lease 'wasteland' from the state government for Jatropha cultivation. This land has been initially allocated to government organisations for a period of 20 years and this may be extended for a further 10 years (CBDA, 2007).

To further encourage the farmers to cultivate Jatropha, the state government provides a support price for the seed/ oil, the minimum for Jatropha seed being Rs.650 (€10.46) per quintal (equivalent to 100kg; 2009 prices). The Chhattisgarh State Minor Forest Produce Co-operative Federation, the primary role of which was previously to collect and sell forest products such as honey and beedi leaves, has been made a state procurement agency and purchases Jatropha seeds from the 913 Primary Forest Co-operatives spread across the states. The role of the co-operatives is to collect forest produce from tribal people and hence to link these (in effect, both people and produce) to retail outlets in the cities. As of 2007, the state claims to have raised 22 crores (10 million) Jatropha saplings, with 88,000ha of barren and wastelands planted during the agricultural year 2005–2006 (CBDA, 2007). Planting was by the Joint Forest Committees and Self Help Groups (SHG), actively supported by the CBDA. SHGs are voluntary associations of small groups (10-15 members) of poor people of similar social and economic conditions. The main objective of an SHG is empowerment of women by providing them access to resources in order to gain economic independence. SHGs may be supported by informal and formal institutions such as microfinance institutions.

The site visited in the present study was the plantation of a UK-based firm, which, at that time, was actively promoting the cultivation of Jatropha through both contract farming and leasing of land, with a buy-back agreement with farmers. The company provided free seedlings and technical assistance, working through a number of existing structures, institutions and rural development programmes. This included agreements with locally elected community councils, tribal councils and private firms. The company also worked with the local Joint Forest Management committee (a partnership involving both the state forest department and local communities) as well as with women's self-help groups, which lease land from local community councils for Jatropha cultivation. With the Joint Forest Management committees, the company arranged for Jatropha seedlings to be planted on degraded forest lands. In addition to providing extra income for the forest-dependent community, Jatropha is intended as a buffer zone for forest protection (though if Jatropha were more profitable forest protection, this could in principle incentivise illegal clearing of the forest for Jatropha). Presently there are four biodiesel plants in the area; the CBDA-installed biodiesel plant has a capacity of 1,000 litres/ day and has so far produced some 30,000 litres of biodiesel (NABARD, 2007). Figures 5a to 7 illustrate Jatropha planting and processing in the state.

Figures 5a, 5b, 6a, 6b, 7 Jatropha cultivation in Chhattisgarh

Jatropha cultivation in Andhra Pradesh

Andhra Pradesh state is situated on the eastern coast of India. Twelve districts of the state were proposed for Jatropha cultivation under the Demonstration phase of the National Mission on Biodiesel. The Government of Andhra Pradesh created the Rain Shadow Areas Development Department in June 2004, to work for the improvement of livelihoods in rain-deficient areas. The remit of the department includes biofuels, in addition to irrigation, cloud-seeding and other water issues (RSADD, 2004).

In terms of biofuel feedstocks, the main emphasis is on Pongamia (*Pongamia pinnatta*) rather than Jatropha, although the cultivation of both is subsidised. For the present study, cultivation sites pertaining to Reliance Life Sciences were visited; this company provides an example of a major Indian firm actively involved in the promotion and cultivation of Jatropha. The company gives seedlings freely or at a subsidised cost, provides technical support and has developed a buy-back guarantee scheme with farmers. The company also has a contract farming agreement with some farmers. Jatropha is grown in 'wastelands', hilly barren land, field bunds and the edges of rice fields, with some intercropping with rice, vegetables and other horticultural crops by both private farmers and non-governmental organisations (NGOs. Jatropha is primarily grown either by farmers with large land holdings or on community-owned common lands, which are pooled according to the caste system. It is the lower caste (Kuruma) that practices cultivation: in this case study, members of some 50 families have pooled their land for Jatropha cultivation, with the company providing technical assistance. The intention of intercropping is to use water, fertilizers and productive land efficiently, with inputs to the agricultural crops also benefitting the Jatropha plants. In some areas Jatropha in the bunds serve as a shelter belt protecting the agricultural crops from the wind. Figures 8 to 9c illustrate Jatropha planting in the state.

Figures 8, 9a, 9b, 9c Jatropha cultivation in Andhra Pradesh

DISCUSSION

From field visits in three Indian states, we identified three main ways of organising Jatropha seed production: (1) where cultivation is principally led by the state or by NGOs; (2) where cultivation is principally led by private companies; and (3) where cultivation is principally led by a mix of the two. Each has commonalities in the way in which cultivation is incentivised, notably via subsidised distribution of seedlings and sometimes technical assistance, and by subsidised (or guaranteed) return on farmers' efforts. The pattern of organisation is further influenced and differentiated by geography and pre-existing land-uses: hence seed production in Chhattisgarh is by people dependent on forests for a substantial part of their income, with production was undertaken in part in buffer-zones to the forest. In all locations, cultivation on low-grade land is encouraged and the extent of this cultivation exceeds a thousand square kilometres across the three states, with plans for on-going expansion. Cultivation on land of high quality was not witnessed – but we certainly cannot claim that this does not take place.

At issue here is the extent to which these patterns of cultivation may have differing potential to affect the rural poor, positively or negatively. Project and policy managers interviewed argue that biofuel-related activity is already catalysing growth-oriented development activity, such as investment in rural areas and increased productivity of underutilised land. However, this activity needs to be seen in the broader context of sustainable livelihoods concepts and

indicators if conclusions about livelihood improvement are to be drawn. Moreover the processes involved need to studied over time – something that we were not able to do in the time available. With reference to the framework in Figure 1, beginning with the *livelihood assets* pentagon, biofuel production as found in the three states has introduced a number of additional assets in the form of subsidised access to Jatropha seedlings, technical assistance and a guaranteed buy-back price for the oil seeds that will eventually be harvested. For some farmers, land has been exchanged for capital via a lease arrangement. However to date we know little about this exchange in detail, nor its long term consequences. The managers whom we interviewed suggested that only low-grade land has been leased and only modest fractions of farmers' holdings used, but independent work has drawn a very different conclusion: in a survey of 49 Jatropha plots owned by 45 households in Tamil Nadu, the large majority (82%) of farmers questioned were found to be previously cultivating food crops on land now occupied by Jatropha (Ariza-Montobbio and Lele, 2010; Ariza-Montobbio, Lele et al., 2010). Moreover, in half of the latter sample, the Jatropha plot covered more than 50% of the total landholding of the household. This raises serious questions as to the long-term consequences (ibid) but also raises questions as to either the reliability of project and policy managers' judgement in this matter, or of the information to which they have access.

To the extent that so-called wastelands and degraded forest land were minimal assets, these will likely have been enhanced via Jatropha cultivation. However, the converse would be the case if this land was actually of use to people; in any case, the land may have had potential alternative value, given the same investment in a different crop (timber, ground-nut etc). Ariza-Montobbio et al (2010) review the controversial history of the term 'wasteland' in the Indian context, tracing it back to its colonial roots, when it denoted land that did not generate revenue for the British Government (Gidwani, 1992). The extent to which land used for Jatropha is actually of little use to local people (not to mention the local ecology) is an absolutely fundamental issue for further investigation.

Similarly a guaranteed buy-back price is only valuable if a crop is harvested and the value exceeds the value (monetary or otherwise) of what would otherwise be cultivated. It should not be forgotten, in this regard, that a high yield from Jatropha requires inputs of fertiliser and water, as well as land and labour. While it is likely that roadside and rice paddy bund cultivation with zero direct cost seedlings have few potential disadvantages, even these activities are subject to opportunity time costs, so it is necessary to take into account any activities foregone, in addition to income from sales, before concluding net positive benefits. Ariza-Montobbio and Lele (2010) found that Jatropha could not provide an economically viable return for farmers until several years had passed, as would be expected from a shrub crop.

In terms of *vulnerability*, at issue is the extent to which Jatropha cultivation increases or decreases vulnerability to natural hazards, changing market conditions, any adverse changes with respect to family and community support and so on. As above, a key issue is the actual and potential alternatives that Jatropha cultivation may be replacing. Jatropha is inedible – aside from incidental services such as a shelter, it is only of use as a cash crop or for its oil content, which has traditionally been used for soap, oil-lamps and cooking fuel in addition to its potential as an engine fuel (Openshaw, 2000). While small scale trials show Jatropha to be capable of fuelling a diesel generator for the provision of small-scale local electric (or other) power (Luijten, and Kerkhof (2010) providing an example of the use of Jatropha cake (solid waste) in addition to Jatropha oil), this obviously requires a suitable engine and the ability to

maintain this. Hence it is important that if cultivation of Jatropha leads to any direct or indirect loss of food production, that its sale provides the individuals who experience that loss the means by which to purchase replacement food of at least the same nutritional value.

Another implication of Jatropha being a cash crop rather than a crop directly useful for subsistence is that it necessarily engages farmers in a market and in the case of biofuels, a market that, is for the time being, politically protected and supported, but which also has potential linkages to international markets for fuels and oils that are more volatile. If the guaranteed buy-back price comes to be eroded or removed in future, particularly if this involves competition with overseas producers, then this has the potential to change the balance of benefits to those involved in cultivation. Similarly, if firms that lease land or contract farmers disinvest or suffer financial difficulties – and we know that commercial disinvestment has taken place in relation to the cultivation shown in Figure 5a since we visited the site – then this obviously raises questions of farmer vulnerability.

In general, the project and policy managers interviewed (Appendix 1) considered that the problems with Jatropha production to date are ones of schemes under-performing in their own terms, rather than having unwanted, perverse consequences of other types. Centrally sponsored schemes for Jatropha production were perceived as having had a number of short-comings, but these were seen as being (at least in part) related to actions taken by labourers and farmers to avoid adverse consequences, rather than experiencing them. Such difficulties are, though, perceived as arising in part from a lack of bottom-up participation by the farmers involved in implementation. Even the Panchayati raj, a decentralized form of Government whereby each village is responsible for its own affairs and the foundation of India's political system, was considered to provide an ineffective implementation vehicle in some villages.

As noted by Saxena and Ravi (2007), with respect to Indian development projects in general, "most often the Pradhan/Sarpanch[1] selects the project which suits his needs or for which he is pressurized by dominant castes/clans. Participation of the poor especially women is missing." Indeed, others have previously noted that the Indian government has tended to implement projects with very little involvement by local people, particularly women (e.g. TERI, 2004). The Ministry of Rural Development (MoRD, 2006) has also previously noted that there are problems in reaching the target groups of India's development policy and in dispersing development funds without leakage and delays. An additional, general problem noted by the planning commission of India is that rural employment activities have often focussed on construction activities, with limited attention to institution and capacity building, resulting in generally unsustainable programmes (Planning Commission of India, 2006). While the National Rural Employment Guarantee Scheme (NREGS) was introduced to remedy such issues, by giving weight to participatory planning and implementation, as noted, those project and policy managers interviewed were unconvinced that biofuel policies as of 2009 were sufficient to produce economically useful quantities of biofuel.

More specifically, stakeholders were of the view that the state-led biofuel programmes (most of the farmers are employed under the NREGS scheme) suffer from a lack of farmer ownership in relation to planting and maintenance. Most of the labourers involved are employed for only for 100 days/ year, such that they have to look for additional employment

[1] A Sarpanch is a democratically elected head of a village-level statutory institution of local self-Government, the latter being the Gram (village) Panchayat in India and also in Pakistan. The Sarpanch, together with other elected Panches (members), constitute the Gram Panchayat. The Sarpanch is the focal point of contact between government officers and the village community and is an elected position.

to support their families. Yet the Jatropha crop needs a low level of year-round maintenance such as pruning and, if not given proper care, the yield suffers. Another typical problem associated with centrally sponsored schemes is said to be that material costs and wages are often paid late, leading to de-motivated labourers. With rain-fed crops, planting depends on the arrival of monsoon season and any delay in the arrival of planting materials can lead to the failure of a plantation. Managers told us that these types of problems can result in the failure of major programmes: in Tamil Nadu in 2005, the state government distributed large quantities of Jatropha seedlings to rural people under the rural development programme, without any incentive for their maintenance. We were told that only 20-30% of the seedlings were planted, the next state government declared the programme a failure and the programme was stopped, creating a negative reputation for Jatropha.

Attempts to remedy motivational and ownership issues within the constraints of such schemes have met with mixed success. In Chhattisgarh, to give employment opportunities to all of the villages, labourers are employed in a rotational manner, such that one village does the planting, another the pruning and so on. While this provides some form of equality, interviewees commented that the arrangement is not able to create the sense of ownership and responsibility required for careful management of the Jatropha crop. Accordingly, some state governments are giving responsibility for plantation maintenance and harvesting to individual farmers: this is widely practiced in the state of Uttaranchal. In the state of Andhra Pradesh, farmers can take all of the profit from their biofuel crop (in this case, typically Pongamia). The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has implemented another novel approach, requiring the respective District Collectors[2] to declare usufruct rights (the legal right to use and profit) for nearby villagers, who can then collect Jatropha seeds and sell them to the market. Although this does not involve legal ownership of the land or plants per se, it does provide an incentive for the protection and cultivation of Jatropha. In terms of livelihood benefits, it would of course be useful to know a lot more about how access to the crop is distributed.

More generally, central government is seen as the primary risk taker and bearer of any loss in relation to Jatropha cultivation. Those involved in the plantation work, from rural poor to district collector and state officials, are little affected by the failure or success of plantations. There is little incentive for either the state or Panchayat to make good use of the funding from central government. This is seen as often compounded by a lack of competition among service providers, with the national ministry choosing the providers and there being little scope for competition or incentive for improvement. This contrasts with initiatives by states such as Uttaranchal, who were approved of by project managers for putting service provision out to tender. As we describe above, the organisation of cultivation activity is very different in Andhra Pradesh and Chhattisgarh, where, in the latter, there is an active forest community who collect the seeds. In Chhattisgarh, the active Self Help Group and Joint Forest Management Committee group not only collect the seeds but also carry out the plantation programmes. The Self Help group ensures the involvement of women. There are also some moves in states such as Karnataka to establish co-operatives for Jatropha cultivation, similar to dairy co-operatives.

CONCLUSIONS

[2] The District Collector is an Indian Government appointee who is in charge of the governance of a district in a state.

For the project and policy managers interviewed, concerns that Jatropha will replace food crops and expose farmers to the risks of international markets are not borne out in the Indian cases described here. Yet this is still early days for Jatropha cultivation and those interviewed had a close interest in promoting Jatropha. Their understanding that most Jatropha plantations are in unused or little-used land, while corresponding with what we observed, is at odds with other research on land use in relation to Jatropha. Most managers whom we interviewed perceived the problems with Jatropha cultivation to date as being related to low yields and low take-up of subsidies, which some states are remedying through alternative organisation, yet low yield and low take-up are very likely causally related and it is difficult to see how or why small-scale farmers would or will persist with Jatropha under prevailing conditions. There remain many unanswered questions relating to the consequences of Jatropha cultivation in general and in particular, in relation to the alternative models of cultivation that we observed. We have no doubt that these consequences should be investigated further, prior to scaling-up production to level envisaged in the national mission.

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