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Analysis

Wasteland energy-scapes: A comparative energy flow analysis of India's biofuel and biomass economies

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ABSTRACT

Through a comparative energy flow analysis, this paper examines the energy security impacts of growing biofuels on wastelands in South India. India's National Policy on Biofuels claims that wastelands are well suited for biofuel production because they are empty and unused. However, in rural Tamil Nadu, a *Prosopis juliflora* fuelwood energy economy already exists on these lands and services a mix of rural and urban consumers at household and industrial levels. This *Prosopis* economy currently provides 2.5–10.3 times more useful energy than would the government's proposed *Jatropha curcas* biodiesel economy, depending on *Jatropha* by-product usage. Contrary to the government's claims, growing biofuels on wastelands can weaken, rather than improve, the country's energy security. Further, replacing *Prosopis* with *Jatropha* could engender changes in economic and property relations that could further weaken energy security. These findings are not specific to rural Tamil Nadu as *Prosopis* is widely used as a fuelwood throughout Asia and Africa. Calls to 'develop' degraded lands through biofuel promotion similarly exist in these regions. This study underscores the importance of analyzing wasteland-centered biofuel policies at local levels in order to better understand the changes in human–environment relationships resulting from this policy push.

1. Introduction

In 2009, after nearly a decade of debate, the Government of India enacted a National Policy on Biofuels (Government of India, 2009). The policy restricts biofuel cultivation to 'wastelands', an official government term for marginal lands, but provides no guidance as to how wastelands will be identified for biofuel production. Despite a lack of consensus as to what wastelands are (Baka, 2013, 2014), earlier biofuel policy documents suggested that at least 17.4 million hectares (Mha) of wastelands exist – roughly 4% of India's geographic area – and are available for establishing *Jatropha curcas* (hereafter *Jatropha*) plantations (Government of India, 2003). This paper examines the impacts, in terms of energy service provision, of locating *Jatropha* plantations on lands that are ambiguously defined yet seemingly abundant.

India's biofuel policy is not unique. Calls to locate biofuels on marginal lands have increased over the past decade out of concern over the potential food security and land use change impacts of growing biofuels on arable lands (Fargione et al., 2008; Searchinger et al., 2008; Tilman et al., 2009). Aided by numerous remote sensing analyses estimating the extent of marginal lands 'available' globally for biofuel production (Cai et al., 2010; Campbell et al., 2008; Nijsen et al., 2012), this strategy has been incorporated into biofuel sustainability criteria and various government biofuel policies across the global North and South (Bailis and Baka, 2011). Recent remote sensing analyses have downgraded initial estimates of the extent of marginal lands after ground truthing (Fritz et al., 2012) and in recognition that marginal lands are often used as grazing lands (Gelfand et al., 2013). However, these adjustments do not address the political relations shaping lands or the politics of land classification processes.

Social scientists have long argued that labels such as wastelands are not neutral, unbiased assessments of landscapes, but are social constructions reflecting, and often reinforcing, the (prior) perceptions of dominant stakeholders (c.f. Fairhead and Leach, 1996; Robbins, 2001a, 2004). As such, land classification processes often simplify complex land use practices on the ground (Scott, 1998). Other scholars have questioned estimates of 'spare' lands arguing that such figures often overestimate the availability of cultivable lands by failing to adequately consider the full range of services lands provide (Young, 1999). Lands classified as wastelands by the state are often common property lands used by the rural poor for fuelwood and fodder gathering (Ostrom, 1990). For these reasons, critical scholars of biofuels have challenged calls to locate biofuels on marginal lands arguing that such policies fail to adequately consider the livelihood significance of such lands (Ariza-Montobbio et al., 2010; Borras et al., 2010; Franco et al., 2010).

Yet, to date, little empirical evidence has been offered assessing the livelihood significance of marginal lands in the context of biofuel development. Through the lens of social metabolism, this paper provides

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such an assessment in a subregion of rural India. We find that India's wastelands are dynamic energy landscapes servicing a range of household and industrial consumers in both rural and urban settings. This existing economy, centered on *Prosopis juliflora* (hereafter *Prosopis*), is currently being uprooted to establish a *Jatropha* biodiesel economy. We compare the changes in useful energy this transition would engender through a comparative energy flow analysis (EFA) of the *Prosopis* and *Jatropha* economies. Drawing on political ecology theory, we extend social metabolism literature by analyzing how this transition could reshape human–environment relations in rural India.

In the next section, we review theories of social metabolism and their intersection with political ecology. We introduce the field site and EFA method in Section 3 and present results in Section 4. We discuss the implications of our findings in Section 5.

2. Theoretical Review

Grounded in ecological metaphors, social metabolism, or its synonym, socioeconomic metabolism, analyzes the biophysical exchange processes mediating human–environment relations (Fischer-Kowalski, 1997). This involves studying the material and energy throughputs and associated land use changes required to sustain socioeconomic systems. Interdisciplinary in nature and influenced by a diversity of fields including cultural anthropology, land-change science and industrial ecology, amongst others (Singh et al., 2013), this approach "provides a framework to distinguish cultures, societies or regions according to their characteristic exchange relations with nature" (Fischer-Kowalski and Haberl, 1998: 574).

Many social metabolism studies analyze socioecological transitions, the changes in metabolic profiles accompanying broad economic transformations, such as transformations from agrarian to industrial societies (Fischer-Kowalski and Haberl, 2007). While most such studies have analyzed national or multi-national transitions (e.g. Krausmann et al., 2004; Schandl and Krausmann, 2007; Singh et al., 2012; West and Schandl, 2013), a subsection of studies has analyzed transitions in island or small village settings (Gruenbuehel et al., 2003; Singh et al., 2001).

To date, most of these studies have focused on the biophysical dimensions of socioecological transitions with limited research on the associated socio-political factors shaping and shaped by these transitions. An emerging strand of literature has combined ecological economics and political ecology to analyze how a changing global social metabolism can lead to conflicts (Martinez-Alier et al., 2010; Muradian et al., 2012). This literature posits that a fundamental transformation in the extraction and provision of natural resources is underway, engendered, in part, by rising food and energy prices and continued population growth. Conflicts can and have been occurring along commodity frontiers as actors seek out new territories for resource provision.

The new bioeconomy (ETC, 2010), the emerging industrial economy centered on bio-based materials and premised on replacing fossil fuels with biomass, represents a fundamental transformation in social metabolism. Many recent studies of the new bioeconomy have focused on the political-economic dynamics of the transformation.

Smolker (2008) argues that substituting biomass for fossil fuels is facilitating a fundamental restructuring of the global agricultural system as it interlocks agriculture, energy, land use, climate change, transportation, trade and human rights policies. McMichael (2012) asserts that the global 'land grab' (c.f. Borras et al., 2011; Fairhead et al., 2012; White et al., 2012; Wolford et al., 2013) marks the beginning stages of this restructuring as it "anticipates the rising value of living biomass" (687). The land conflicts that have resulted, documented extensively by the Environmental Justice Organizations, Liabilities and Trade project (EJOLT, 2011), presage what may result as the new bioeconomy advances. Overall, Birch et al. (2010) argue that the new bioeconomy continues the neoliberalization of nature and knowledge as new innovations and requisite markets and property rights are developed to unlock (and adequately value) the potential of biomass in today's society.

Biofuel production, a component of the bioeconomy, has been a key focus of the social metabolism and political ecology literatures. However, similar to the above, the core of this research has focused on the political dimensions (c.f. Borras et al., 2010) and associated conflicts (c.f. Martinez-Alier et al., 2010; Muradian et al., 2012) of biofuel promotion. Fundamentally, the low energy density and spatial requirements of biofuel feedstocks compared to fossil fuels create new land use pressures as land is now needed to service society's food, fiber and fuel needs (Scheidel and Sorman, 2012). While this literature is too vast to review in this paper, we review the section of this literature relevant to *Jatropha* promotion in Tamil Nadu, India.

In an analysis of Tamil Nadu's *Jatropha*-centered wasteland biofuels program, Ariza-Montobbio et al. (2010) argue that the concept of 'wasteland' is a politically malleable term applied to lands ranging from fallow lands to agroforestry lands. Extending this analysis, Baka (2014) finds a lack of consensus amongst biofuel stakeholders as to what constitutes wastelands in India. Yet, economic incentives motivate the dominant perception of wastelands appearing in biofuel policy documents as 'empty', 'unproductive' spaces. Baka (2013) also finds that this ambiguity has helped to facilitate biofuel-related land grabs of wastelands in Tamil Nadu, which are dispossessing rural farmers. For these reasons, in addition to lower than anticipated seed yields and higher than anticipated water requirements, Ariza-Montobbio and Lele (2010) characterize *Jatropha* promotion in northern Tamil Nadu as a latent conflict between farmers and the state.

Overall, the social metabolism literature on biofuels has primarily focused on the political-economic drivers and potential for ecological conflicts stemming from biofuel promotion. Limited empirical research has examined the biophysical dynamics underlying this energy transition. This study fills this research gap. We analyze the metabolic transition underway in southern Tamil Nadu by characterizing the changes in the quantity and quality of energy resulting from replacing biomass with biofuels. We also examine the resultant socio-political transformations stemming from this transition.

Collectively, this study contributes to the emergent "new geographies of energy" literature (Zimmerer, 2011), which seeks to analyze the multiple political, economic and biophysical processes shaping and shaped by society's current quest for a low carbon, environmentally benign energy future.

3. Field Site and Methods

Fieldwork took place between December 2010 and February 2011 in Sattur Taluk, Virudhunagar District, Tamil Nadu (Fig. 1). This region was selected because of the history of *Jatropha* promotion in the area as well as the prevalence of *Prosopis* in the region. While rainfed cultivation of corn, cotton and pulse farming are currently the main forms of production in the Taluk, Sattur is in the midst of an industrial transition with an increasing number of fireworks and match factories moving into the area (Virudhunagar District Collector, 2009). Average rainfall for the district is approximately 830 mm per year and black soil is the predominant soil class (Virudhunagar District Collector, 2009).

Data was gathered by surveying 158 users/producers of *Prosopis*: fuelwood users (n = 114), a 10 MW biomass power plant (n = 1), charcoal makers (n = 4), brick makers (n = 5), match factories (n = 7), restaurants (n = 11), paper mills (n = 3), oil mills (n = 2), wood traders (n = 11) and 2 *Jatropha* companies: plantation (n = 1) and biodiesel manufacturer (n = 1) in 39 randomly sampled villages of Sattur (Fig. 2). Calorific analyses of various *Prosopis* and *Jatropha* products were conducted to evaluate energy contents (Appendices A–C).[1] Energetic contents for all other parameters were obtained from the literature

[1] The products analyzed were: *Prosopis* charcoal, roots, and stems and *Jatropha* oil and seedcake. Jatropha biodiesel was not available, so values were obtained from the literature.