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Forests, fuelwood and livelihoods—energy transition patterns in eastern Indonesia

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HIGHLIGHTS

- We model household energy use patterns of forest margin communities in Indonesia.
- Fuel subsidy reform increased fuelwood demand for processing agricultural products.
- Household fuel choices are affected by opportunities to sell fuelwood.
- Energy transition of households does not necessarily affect forest conditions.
- Energy alternatives to small industries are needed to improve forest conditions.

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ABSTRACT

The central thesis of the energy ladder model is a unidirectional transition from primitive to advance fuel with increased affluence of households. Although now largely discredited, this assumption remains a foundation of *laissez-faire* policies that anticipate energy transition resulting spontaneous forest recovery with economic development. Our results suggest that such policies can undermine broader policy objectives and actually worsen forest conditions in rural Indonesia. Based on a case study of forest margin communities in eastern Indonesia, we demonstrate that fuel subsidy reform did little to reduce rural household demand for fuelwood, while dramatically increasing fuelwood demand for processing agricultural products. Our results show how household decisions related to fuel sources are affected by non-economic considerations and external factors, such as opportunities to sell fuelwood. We argue that policy interventions that encourage energy transition of households do not necessarily improve forest conditions, as household fuelwood use may be a symptom, rather than a driver of deforestation and forest degradation. Thus policies to improve forest conditions should focus more on addressing the market environment of forest-margin communities, providing energy alternatives to small industries that are often the larger consumers of fuelwood.

1. Introduction

Wood has traditionally been considered a sustainable source of energy. Several developing countries have the potential for producing wood energy safely and sustainably, with relatively low investment and risk, while developing their national economy and creating jobs in rural areas (FAO, 2010a). However, this potential has not been realized due to poor forest management, inability to regulate illegal operations, and lack of reliable data for adequate planning (FAO, 2010a). In tropical Asia, emissions from forest degradation due to unsustainable fuelwood harvest could account for 25–42% of total forest emissions (Griscom et al., 2009). In addition to carbon dioxide emissions from deforestation and land degradation, emissions of black carbon, a portion of soot from inefficient biomass burning, are estimated to be 18% of global black

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carbon emissions (Bond and Sun, 2005). Black carbon, radiative forcing, has particularly serious climate impacts, in addition to being harmful to human health (Foell et al., 2011; Ramanathan and Carmichael, 2008). The International Energy Agency (IEA) estimates that as of 2011, 1.9 billion people in developing Asia (or 51% of the population) still rely on traditional biomass, including fuelwood, as their primary source of energy (IEA, 2013). Over half of the population relying on fuelwood lives in India, China and Indonesia; however, the total forest area in India and China has increased in recent years with economic development and strong government-led programs and policies (Mather, 2007), including the creation of large scale wood fuel plantations (FAO, 2010a).

Indonesia, the world's fourth most populous country, is still experiencing one of the fastest rates of deforestation in the world (more than 1000 km^2/year; Hansen et al., 2013). Indonesia is emerging as one of the major beneficiaries of global negotiations to mitigate climate change through improved forest management, especially related to REDD+[1] (Cerbu et al., 2011). So far, Indonesia has received the largest portion of funding from both multilateral and bilateral channels (Simula, 2010). The forestry sector is expected to achieve more than 50% of its ambitious greenhouse gas emission reduction target, which is 26% below business-as-usual projections by 2020 (Cerbu et al., 2011). However, the extent of unsustainable fuelwood collection and their effects on forest conditions in Indonesia is largely unknown (Budya and Arofat, 2011). Emissions from forest degradation remains as a controversial topic in global climate negotiations (Griscom et al., 2009).

Since 2005, Indonesia has been promoting energy transition from kerosene to more efficient, less subsidized liquefied petroleum gas (LPG) in households and micro-businesses (IISD, 2014). There are many reasons to encourage household energy transition with policy interventions, including human health (WHO, 2014) and social/gender inequity concerns (Cooke et al., 2008; Köhlin et al., 2011). Although clean household energy is expected to ensure environmental sustainability (WHO, 2014), our understanding about the links among energy transition, fuelwood consumption and forest conditions is limited (Heltberg et al., 2000; Lewis and Pattanayak, 2012; Pattanayak et al., 2004). To design appropriate policy interventions to encourage energy transition and/or improve forest conditions, we must be able to discern the potential impacts of such interventions. Therefore, we ask in this paper: (1) if household energy transition in forest margin communities affects forest conditions, (2) to what extent their energy choices are due to the internal characteristics of household and external factors, including fuelwood markets, and (3) what are the extent of non-domestic fuelwood consumption and its potential effects on forest conditions.

Using a case study in eastern Indonesia, we first examine household energy use patterns and factors affecting the energy choices of rural households in forest margin communities to discern the direct effects of a national policy intervention to encourage energy transition. We then assess the extent of fuelwood demand for processing agricultural products, using tobacco curing as an example to portray the unintended consequences of the policy intervention.

[1] The United Nations Framework Convention on Climate Change (UNFCCC) defined REDD+ as "policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries" (UNFCCC, 2010).

2. Methods

2.1. Literature survey—household energy transition, fuelwood consumption, and forest conditions

Until recent years, academic interest in fuelwood issues has steadily diminished, after the overall consensus was reached that previous concerns for supply gap (discrepancies between fuelwood demand and potential supply) had been exaggerated (Arnold et al., 2003; Arnold et al., 2006). Our own search on the Web of Science™ revealed that the number of peer-reviewed publications related to fuelwood[2] decreased over time until 2007. However, expanding interest in the climate mitigation potential of the forestry sector has renewed interest in fuelwood as a renewable energy source, and in the effects of fuelwood use on forest conditions and resulting carbon emissions.

Household energy choices and transition patterns have been an active research area for more than three decades with much debate about the factors affecting fuel choices and transition (van der Kroon et al., 2013). The 'energy ladder" model conceptualizes a linear transition of household fuel choices from *primitive* fuels (e.g. fuelwood, agricultural and animal waste), to *transition* fuels (e.g. charcoal, kerosene, coal) to *advance* fuels (e.g. LPG, electricity, biofuels) (e.g. Hosier and Dowd, 1987; Leach, 1992; Smith et al., 1994). The conventional wisdom of steady upward climb on the energy ladder with increased affluence has been largely contested by growing empirical evidence, especially for rural households (e.g. Heltberg, 2004, 2005; Hiemstra-van der Horst and Hovorka, 2008; Kammen and Lew, 2005; Masera et al., 2000). Masera et al. (2000) first proposed a multiple fuel choice model, "energy stacking", where households choose to consume a portfolio of different energy options, rarely completely abandoning the old technology at once. They also argued that household fuel choices are not purely economic decisions, that they are often driven by culture and tradition. A study from central Java in Indonesia showed that higher income households have more energy options and choose from a variety of energy sources (Andadari et al., 2014). Thus, more opportunities for energy stacking do not necessarily imply less fuelwood consumption.

Despite various research efforts, household energy use patterns and the factors affecting them are still poorly understood, especially in rural areas in the developing world (Kowsari and Zerriffi, 2011). After extensive reviews of energy studies over the last three decades, Kowsari and Zerriffi (2011) summarized the factors determining household energy choice in two broad categories: *Endogenous* factors (household characteristics) including: (1) economic characteristics, such as income, expenditure, land ownership (e.g. Barnes et al., 1996; Leach, 1992; Pachauri, 2004), (2) non-economic characteristics, such as education, family size, gender and age composition (e.g. Arnold et al., 2006; Bluffstone, 1995; Cooke et al., 2008; Dewees, 1989), and (3) behavioral and cultural characteristics, such as preferences, attitudes, beliefs, and social status (e.g. Farsi et al., 2007; Gupta and Köhlin, 2006; Heltberg, 2005; Masera et al., 2000; Wang and Feng, 2003). *Exogenous* factors (external conditions) including: (1) physical environment (e.g. Bhatt and Sachan, 2004), (2) policies on energy, subsidies, markets, and trade (e.g. Dube, 2003) (3) energy supply factors (e.g. Heltberg, 2005; Leach, 1992), and (4) energy device characteristics (e.g. Leach, 1992). However, the link between higher income and cleaner fuel has been overemphasized in the literature, which may have obscured the effects of other factors (Hiemstra-van der Horst

[2] Three-year moving average of the number of peer-reviewed articles that contain fuelwood, firewood or woodfuel on the title peaked at 13.3 in 1985 then declined to 5.7 in 1996, then jumped to 21–25 since 2011.