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Urbanization, the energy ladder and forest transitions in India's emerging economy

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ABSTRACT

Urbanization is currently a major force in tropical land use transitions as economic activities aggregate in urban centers, particularly in Asia. This paper examines relationships among urbanization, household energy source, and forest cover at the state level in India using available census, survey, and remote sensing analysis from the 1990s and 2000s. Central questions include (1) how rapidly are urban and rural households switching from traditional to modern fuel sources; and (2) what are the consequences of changing household energy sources for fuelwood demand and forest cover. Country-wide, 30 and 78% of urban and rural households respectively used fuelwood for cooking in 1993. In urban households, the percentage decreased to 22% by 2005 with a shift towards liquefied petroleum gas (LPG). The shift occurred across almost all income classes. In rural areas, the use of LPG increased fourfold but 75% of households still rely on fuelwood. Despite the decline in percentage households using traditional fuels, fuelwood demand continued to increase from 1993 to 2005 at a national scale due to an increasing total number of households. However, 25% of states and union territories experienced declines in rural fuelwood demand and over 70% declines in urban fuelwood demand. Forest cover has remained steady or increased slightly over the time period, reaffirming the conclusion that fuelwood demand may lead to local degradation but not large-scale deforestation. At the state level, increases in percent forest cover between 2000 and 2004 are positively associated with percent of total households that are urban (corresponding to fewer percentage households using wood) but not related to changes in fuelwood demand. Plantations are a primary cause of increases in forest area, where benefits to ecosystem services such as biodiversity and hydrologic function are controversial. Results suggest that households will continue to climb the energy ladder with future urbanization, resulting in substantial development benefits and reduced exposure to indoor air pollution. Implications of reduced fuelwood demand for forest cover are less certain but the limited data suggest that urbanization will promote a transition to increasing forest cover in the Indian context.

Introduction

Urbanization and its associated changes in energy use and consumption patterns are currently a dominant force for land use change in India and other Asian countries (Montgomery, 2008). Consequences of this urbanization for human well-being and ecosystem services are multi-faceted, including social consequences for health, income, and access to services, as well as ecological consequences for habitat and other ecosystem services (Birthal et al., 2007; McGranahan and Marcotullio, 2005). An unanswered question is whether urbanization increases pressure on ecosystems in the hinterlands via higher demands for food, water, and other services or decreases pressure via intensified production on less land.

The shift from rural to urban lifestyles generally accompanies reduced reliance on local resources. In India, the vast majority of rural populations rely on locally collected traditional biofuels for cooking and heating. Fuelwood is the dominant source for traditional biofuels. Fuelwood use in urban areas is also common but has reduced dramatically in the last few decades (Fig. 1).

Traditional biofuels have several harmful effects. In terms of human health, Smith (2000) estimates that exposure to indoor air pollution from cooking with traditional biofuels is a major risk factor for respiratory and other diseases, causes 400–550 thousand premature deaths of women and children under five, and accounts for 4–6% of the national disease burden in India. Moving up the energy ladder from traditional biofuels to modern fuels is critical

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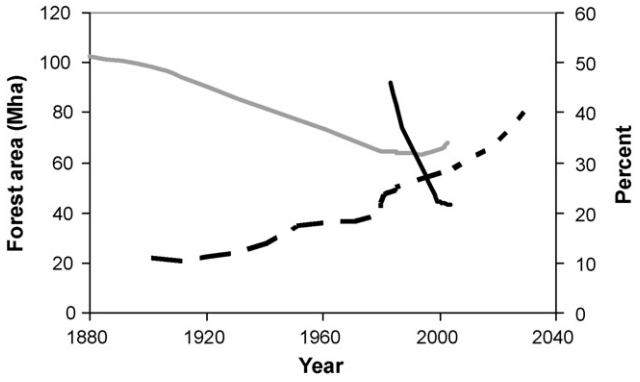

Fig. 1. Historical forest cover (Chhabra and Dadhwal, 2004; Forest Survey of India, 1999, 2005) (gray line), historical percent urban population (Datta, 2006) and projected to 2030 (UNEP, 2007) (dotted black line), and percent of urban households using wood as primary energy source for cooking (National Sample Survey Organisation, 1997a, 2001b, 2007a) (black) in India.

for reducing exposure to indoor air pollutants (Fig. 2). In terms of global-scale atmospheric emissions, Yevich and Logan (2003) estimate that emissions of carbon monoxide (trace gas associated with smoldering combustion) from biofuel use in the developing world are 156 Tg (about 50% of estimated global emissions from fossil fuel use and industry CO per year). In terms of atmospheric emissions of total carbon, van der Werf et al. (2003) estimate that fuelwood consumption emitted 0.5 Pg C per year from 1998 to 2001, compared with 2.6 Pg C for all tropical fires. Traditional biofuels are now thought to be the major contributor to black carbon over the Indian Ocean, with implications for exacerbating global warming at the regional scale as aerosols absorb solar radiation (Ramanathan and Carmichael, 2008; Venkataraman et al., 2005).

An additional concern with fuelwood has centered on the consequences for forest cover. The literature followed a classic pattern of thesis and antithesis (Arnold et al., 2006; Arnold et al., 2003; Pandey, 2002). Studies in the 1970s and early 1980s concluded that a widening gap between demand for fuelwood and production in forests was rapidly depleting the fuelwood supply in many developing countries. In India, for example, studies suggested that the recorded production of fuelwood was scarcely 10% of the total requirement in 1970 (Anon., 1976). Over-exploitation of fuelwood was considered to be responsible for a number of environmental problems, including deforestation. Projects in community and social forestry were launched to address the perceived "fuelwood gap," including the Joint Forestry Management program in India

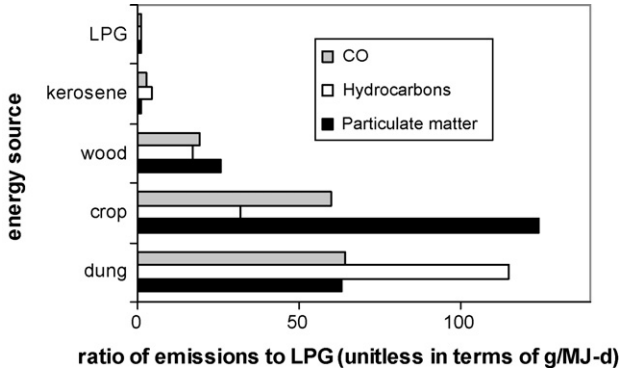

Fig. 2. Steps in the energy ladder from traditional biofuels (dung, crop, and wood) to modern fuels (kerosene, LPG) and pollutant emissions relative to LPG in grams per megajoule delivered to the cooking pot (g/MJ-d) (Smith et al., 2005).

that gave villagers increased participation and claim to revenues from forest resources (Ravindranath and Sudha, 2004).

By the mid-1980s, the projected fuelwood shortfall did not materialize and questions were raised about the earlier projections. Several factors negate the gap theory (Leach and Mearns, 1988), including the recognition that households rely on non-forest fuelwood sources (trees outside forests and twigs, branches, and leaves) that are not generally counted in standard forest volumetric equations; imprecise estimates of fuelwood resources and consumption; and calculations that did not account for regrowth to replenish fuelwood supply (Pandey, 2002). It is now clear that fuelwood collection may lead to local scarcity but not to massive deforestation. Conversely, economic analyses suggest that demand for forest products has stimulated an increase in forest cover in India (Foster and Rosenzweig, 2003). Mather (2007) notes the importance of government policies for afforestation and reforestation in this forest transition, particularly in Asia.

Forest cover in India declined sharply until the mid-1900s but has remained steady or increased slightly in the last few decades (Fig. 1). This forest transition, defined as an initial decline followed by increasing forest cover, follows the pattern in many countries around the world at different times in history (Rudel et al., 2005). As urbanization continues with India's economic growth, households are likely to continue to climb the energy ladder with positive benefits for reduced exposure to indoor air pollution and atmospheric emissions. The implications for a forest transition are less clear. On one hand, forest cover may increase if scarcity fosters forest regeneration or reduced fuelwood collection enhances growth. On the other hand, the forest transition could be curtailed if reduced fuelwood demand alleviates scarcity that would otherwise foster regeneration.

This paper examines relationships between urbanization, changes in household energy source, and forest cover across Indian states for the 1990s and 2000s to address the following questions:

- How rapidly have Indian households switched energy sources in the 1990s and 2000s? How does the climb up the energy ladder vary between urban and rural areas and among geographic regions?
- What are the implications for fuelwood demand as households switch energy sources? Do changes in fuelwood demand affect the forest transition in India?

Materials and methods

The analysis is carried out at the state level using data from the following publicly available sources.

Decadal census of India

The 1991 census (Government of India, 1991) collected, for the first time, data on household amenities including primary energy source used for cooking. Household amenities data include total, rural, and urban, and proportions of households using various types of cooking fuel at the state and district levels. The 2001 census (Government of India, 2001b) collected data on energy sources for cooking, but included different categories than the 1991 census. The difference in numbers of households using different energy sources cannot therefore be inferred by comparing the two decades. We use the census data to obtain the number of urban and rural households for calculating fuelwood demand and for comparing proportion of urban households with changes in forest cover.

The census defines urban as a place satisfying the following three criteria: a minimum population of 5000; at least 75% of male