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Land use change, fuel use and respiratory health in Uganda

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HIGHLIGHTS

- Land use change affects the quality, quantity and type of biomass fuels rural households use.
- Use of fuelwood from non-forest areas leads to an increase in ARI for children under 5.
- Use of crop residues leads to a decrease in ARI for children under 5.

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ABSTRACT

This paper examines how biomass supply and consumption are affected by land use change in Uganda. We find that between 2007 and 2012 there was a 22% reduction in fuelwood sourced from proximate forests, and an 18% increase in fuelwood sourced from fallows and other areas with lower biomass availability and quality. We estimate a series of panel regression models and find that deforestation has a negative effect on total fuel consumed. We also find that access to forests, whether through ownership or proximity, plays a large role in determining fuel use. We then explore whether patterns of biomass fuel consumption are related to the incidence of acute respiratory infection using a cross-sectional data set of 1209 women and 598 children. We find a positive and significant relationship between ARI and the quantity of fuelwood from non-forest areas; a 100 kg increase in fuelwood sourced from a non-forest area results in a 2.4% increase in the incidence of ARI for children. We find the inverse effect of increased reliance on crop residues. As deforestation reduces the availability of high quality fuelwood, rural households may experience higher incidence of health problems associated with exposure to biomass burning.

1. Introduction

Fuel and cooking technology choices in the developing world are garnering increased attention in the wake of new research about the health impacts of exposure to smoke from burning biomass fuels (Ezzati et al., 2002; Fullerton et al., 2008; Lim et al., 2013; Mishra et al., 2004; Smith, 2000; Sreeramareddy et al., 2011). At the same time, biomass smoke or "black carbon" has been implicated in regional and global climate change (Ramanathan and Carmichael, 2008; UNEP and WMO, 2011).[2] Public investments directed at reducing household emissions from biomass burning are viewed as potentially useful because actions relating to fuel and cooking technology could have large and immediate impacts on both local health and greenhouse gas pollutants (Kandlikar et al., 2009; Smith and Balakrishnan, 2009; Smith et al., 2009). Donors, NGOs and organizations such as the Global Alliance for Clean Cookstoves (www.cleancookstoves.org) are supporting increased public investment in addressing fuel use and cooking technology options in developing countries.

Three billion people, or roughly 40% of the world's population are completely dependent on biomass as their primary fuel for cooking and heating (Foell et al., 2011; Grieshop et al., 2011; Openshaw, 2011; Vlosky and Smithhart, 2011; WHO, 2006). Barnes et al., (2002) estimate that the absolute number of people dependent on biomass fuels will increase through 2030, suggesting that policy makers should be attentive to factors that influence the supply, demand and distribution of biomass fuels. These trends are particularly striking in sub-Saharan Africa where the consumption of biomass fuels is higher than in any other region (Arnold et al., 2005; Bailis

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[2] The terms biomass fuels, solid fuels and traditional fuels are used interchangeably in the literature. These fuels are differentiated from modern liquid fuels (e.g. paraffin, kerosene, liquid petroleum gas) which are more efficient and considered to be less damaging to human health.

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et al., 2005; Nkambwe and Sekhwela, 2006; Vlosky and Smithhart, 2011). East Africa is particularly dependent on biomass fuels; more than 95% of the populations of Burundi, Ethiopia, Rwanda, Tanzania and Uganda use solid fuels for cooking and heating (WHO, 2006; GACC, 2013).[3] This degree of dependence places the region in sharp relief for investigating the environmental and health impacts of using biomass for energy purposes.

While demand for biomass fuels continues to grow in sub-Saharan Africa, rapid land use change is reducing the supply of high quality biomass and leading individuals to shift collection away from forests toward locations such as farmlands and fallows that typically yield much lower per hectare quantities of biomass (Ahrends et al., 2010; DeFries et al., 2007). Such changes in the supply of locally-available biomass fuels have implications for household fuel use and the exposure of women and children to harmful gasses and particulate matter associated with the incomplete combustion of lower quality or wet biomass. These changes also have indirect effects on how women and children use their time, the number of meals that are cooked, and the types of foods that are prepared, which can affect overall food security as well as health and nutrition outcomes. Fuelwood scarcities may lead households to obtain lower quality wood, change their cooking patterns, or work harder to collect wood (Brouwer et al., 1997; Lipper, 2000). Nevertheless, how land use change affects the types, quantities and sources of biomass fuels, and how those in turn affect health and welfare outcomes is poorly understood.

This paper focuses on two questions relevant to these global concerns. First, we ask whether land use change in Uganda is precipitating changes in household fuel portfolios. We do this by measuring the relative shares of different types of fuels consumed by households over time. A typical fuel portfolio in rural Uganda includes fuelwood of varying qualities, charcoal and crop residues. In addition to cataloging the types of fuels being used, we also measure the quantities and identify the sources of these fuels, in particular whether fuels are being collected from forests or elsewhere. We hypothesize that forest degradation and loss may be leading households to substitute fuel from non-forest environments, including fallows and bush land, in place of higher-quality forest-based fuels. We also hypothesize that forest degradation and loss reduce overall household fuel consumption. To test these conjectures we use a balanced panel of data from 451 households in western Uganda, collected in 2007 and 2012. These data include detailed information about the types, quantities and qualities of biomass fuels consumed, and allow us to measure changes in these features over time and how they are correlated with land use change.

Our second research question focuses on how patterns of biomass fuel consumption affect health outcomes for women and children. Specifically we test two hypotheses. First we study whether the quantity of fuel used by a household is correlated with the incidence of acute respiratory infection (ARI). Second, we test whether the incidence of ARI is correlated with lower quality biomass fuels (sourced outside of forests). For this stage of the analysis we use data from the 2012 wave of our survey which recorded symptoms typical of ARI among children under age 5 and adults – typically women – involved in cooking.[4] Our sample includes 1823 women and children that were residing within the 555 households included in the 2012 survey. We estimate a series of regressions that take into account household-level characteristics known to influence health outcomes and compute the marginal effects of changes in the quantities and types of fuels used on the reported incidence of ARI.

Our findings confirm that rapid deforestation is changing the fuel portfolios of rural households. We find evidence of a major shift to fuelwood sourced from non-forest areas including fallows, agricultural plots and bush lands. Crop residues are also increasingly common. We also find evidence of a link between biomass source and the incidence of ARI. Controlling for other characteristics of the household, individuals living in households that sourced their fuel from forests had lower overall rates of ARI, compared with those living in households that are more dependent on fuel from non-forest areas. Our findings confirm that deforestation plays a role in altering household fuel portfolios and suggests that ongoing changes in fuel use have implications for human health.

2. Linking biomass supply to health outcomes

Our analysis rests on assumptions about a two-stage causal pathway. In the first stage, forest quality, forest proximity and overall patterns of land use influence fuel availability; in the second stage, the types and quantities of fuels used by households influence respiratory health outcomes for women and children.

2.1. Land use and biomass availability

With almost half of the global population relying on woody biomass as their primary fuel source, the implications of land use change that results in reductions in biomass availability and quality are hard to ignore. Over the past several decades, researchers have explored the links between fuel use, deforestation, and energy poverty in developing countries, largely focusing on the hypothesis that biomass fuel harvesting is a driver of deforestation and degradation. Research addressing the sustainable harvest of fuelwood and other sources of woody biomass falls into two groups: the first asserting that fuelwood harvesting is a major contributor to global forest degradation and has severe negative environmental ramifications (e.g., Eckholm, 1975); and the second asserting that the impacts of non-commercial fuelwood harvesting are not necessarily negative, and that harvesting can sometimes even improve environmental robustness (Arnold et al., 2005; Foley et al. 2005; Masera et al., 2006; Nkambwe and Sekhwela, 2006; Naughton-Treves et al., 2007; Openshaw, 2011). In many rural areas, gathering wood for fuel has been shown to not have a detrimental impact on land, but in more densely populated areas where natural resources are less abundant, the demand for land and resources can lead to higher degree of degradation (Nkambwe and Sekhwela, 2006).

Several studies have noted the lack of information about fuelwood harvesting practices, fuelwood quality, and the dynamics of fuelwood use, specifically with respect to woody biomass availability within different land uses (Foley, 2001; Hiemstra-van der Horst and Hovorka, 2009; Masera et al., 2006; Smeets and Faaij, 2007). For example, much of the material like fallen branches, dead wood and material from shrubs that serve as an important sources of fuel for rural populations are not necessarily included in overall assessments of biomass stocks. Furthermore, it is difficult to synthesize what information is available due to the range of methods employed to characterize the stock of woody biomass throughout tropical regions. For example, biomass inventories frequently ignore biomass stocks outside forest regions (Foley, 2001; Smeets and Faaij, 2007; Turyareeba et al., 2001). Our study seeks to quantify and characterize biomass fuel use by rural households in Uganda. We view this as an important contribution toward understanding the role of biomass supply in household decisions regarding fuel use.

[3] The Food and Agriculture Organization of the United Nations (FAO) estimates that, in 2008, 6.15 billion square meters of fuelwood were harvested in Africa, more than one-third of which were in East Africa (FAO, 2012).

[4] Ninety-eight percent of cooks in the sample are female. Henceforth we use the terms “women” and “cooks” synonymously.