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Policies for a Sustainable Biomass Energy Sector in Malawi: Enhancing Energy and Food Security Simultaneously

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SUMMARY

Biomass energy still dominates the energy sector in Sub-Saharan Africa, in particular as the main cooking energy source in rural and urban areas. The strong linkages to food security and the environment place biomass energy at the heart of sustainable development, a fact that is largely ignored by policy makers in favor of modern energy. At the same time, population and GDP growth are exacerbating already existing supply–demand imbalances in highly populated countries such as Malawi. These trends make it imperative to identify policy interventions that promote sustainable biomass energy while simultaneously considering linkages with other sectors. We use new data on demand and supply for biomass energy in Malawi and develop a model that estimates fuelwood demand based on actual diets and project demand in future years. We simulate how demand side interventions in the form of improved cookstoves affect biomass demand and built a behavioral model to analyze the potential of agroforestry for promoting a sustainable biomass energy sector in Malawi. Our findings show that policy measures aimed at increasing cooking efficiency are not enough to decrease demand for cooking energy due to high population growth. Supply side interventions like agroforestry on the other hand will not only increase sustainable supply, but can also enhance food security and protect the environment. We find that biomass energy can be inherently sustainable and should be an integral part of every energy sector strategy in developing countries as well as of the Sustainable Development Goals.

1. Introduction

Sustainable energy is a key focus of the Sustainable Development Goals (SDGs) with SDG 7 seeking to secure access to renewable, "sustainable and modern energy" (UN, 2015). Sub-Saharan Africa's energy sector remains to be dominated by solid biomass in the form of firewood and charcoal, which as renewable but traditional sources of energy are not targeted by the SDGs.[1] SDG 7 rather aims at universal electrification with electricity produced from renewable sources such as hydro, wind, and solar, but biomass and biogas are also promoted as feedstock for generators (UNDP, 2016). Even though SDG 7 seeks a departure from solid biomass energy, including biomass in the SDGs is an important signal to countries in Sub-Saharan Africa. Wood-based energy has long been perceived as backward and harming the environment and studies making the point for renewable and sustainable biomass energy remained largely unheard by policy makers (e.g., Owen, van der Plas, & Sepp, 2013; World Bank, 2011).

This is a dangerous oversight considering that almost 75% of people in Sub-Saharan Africa rely on biomass energy for their daily food intake (IEA, 2014), making biomass a decisive factor for SDG 2 "achieving food security and improved nutrition" (UN, 2015) in terms of food utilization. Moreover, sustainable biomass energy is at the heart of SDGs 15 and 13 focusing on sustainable forest management and climate change mitigation. These strong linkages of biomass with other sectors make it imperative to ensure sustainable biomass energy while simultaneously tackling the goal of more modern energy sources. In light of unprecedented pressure on scare resources through population and economic growth, overcoming the tendency to solely focus on a single sector is crucial to find policy measures that minimize trade-offs and increase synergies for all sectors. Our study aims at fostering integrated development policy by seeing the biomass energy sector from a holistic point of view, considering the linkages with the environment, the economy, and social well-being, with particular attention to food security.

[1] LPGs and petroleum are also prevalent energy sources in urban areas of Sub-Saharan Africa (IEA, 2014), but are neither targeted by SDG 7 as non-renewable fossil fuels.

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Malawi makes an important case study for energy sector development in Sub-Saharan Africa in several ways. It is one of the poorest and fastest growing countries in Africa in terms of population with a heavy reliance on biomass energy for food security, since biomass is the predominant cooking fuel of 97% of the population, affecting the utilization dimension of food security (NSO, 2012). There are already divergences between demand and supply of biomass energy in the Southern region of Malawi (Owen, Openshaw, van der Plas, Matly, & Hankins, 2009). Due to high population growth and total GDP growth at around 5% per year, this gap could be aggravated in the coming decades if there is increased demand for food and cooking energy without any fuel switching to higher value fuels such as LPGs. These trends will also reduce supply indirectly through land clearing as a consequence of growing demand for agricultural land.

In the absence of policy action not only are energy and food security placed at risk but also environmental quality—measured through the impact on forest eco-system services such as watershed protection and carbon sequestration. Demand-side measures to increase cooking efficiency have already been initiated but might not be enough considering the projected growth in population. Supply-side measures such as reforestation are inhibited by conflicting land uses for forestry and agriculture. These conflicts could be avoided, if rural households produce their own wood simultaneously with food on their fields. Agroforestry has the potential to increase biomass energy supply, while protecting forests and increasing food security through fertilizer trees (Garrity *et al.*, 2010). Yet, agroforestry policies will mean additional work for already labor-constrained farmers and might not bring the intended benefits if the constraints facing farmers are not taken into account. Our study analyzes how demand and supply for biomass energy in Malawi will evolve in the coming years and which policy measures could ensure a sustainable biomass energy sector. We develop a new methodology with minimum data requirements to estimate demand based on actual diets and cooking habits and project future demand following GDP and population growth. This methodology is expanded to capture effects of efficiency increases in cooking appliances on energy demand. Moreover, we develop a behavioral model for agroforestry adoption considering constraints of rural households in Malawi to analyze the actual potential of agroforestry. Our goal is to show that biomass energy can foster sustainable development and should be an inherent part of energy sector strategies in developing countries.

The following section briefly examines the energy sector in Malawi and the ongoing trends. Section three explains our methodology for estimating and projecting demand for biomass energy as well as results for future demand, section four examines supply side estimations. Section five analyzes the potential of demand side policies in the form of improved cookstoves to decrease demand for biomass energy. Section six explains our model for agroforestry in Malawi and explores how a supply side measure could promote a sustainable biomass energy sector, while section seven concludes.

2. Background: Energy sector development in Malawi

As in most developing countries in Sub-Saharan Africa, Malawi's energy sector is dominated by biomass. In 2010, 97% of households used biomass energy in the form of firewood, charcoal and crop residues as their main fuel for cooking (NSO, 2012). Biomass constitutes 90% of total energy use, while other energy sources continue to play a minor role (Owen *et al.*, 2009): Electricity use is limited mainly to the sugar industry and to urban areas with only 8% of households being connected to the grid (NSO, 2012). Imported fossil fuels are expensive and rarely used except for the transportation sector. Therefore, biomass will clearly remain the dominating energy source in Malawi in the near future, but is faced with increasing divergences between demand and supply.

Several studies have analyzed Malawi's biomass energy sector and warned about diminishing forest cover for decades (e.g., Orr, Eiswerth, & Finan, 1998; Zulu, 2010). These studies underestimated supply by omitting trees outside forests and overestimated demand by overlooking fuel substitution behavior of households from firewood to more inferior energy sources such as crop residues. More recent studies paint a less pessimistic but still alarming picture: Owen *et al.* (2009) come to the conclusion that sufficient supply of fuelwood is given on a macro level, but find large regional imbalances already in 2008, especially in the overpopulated South where demand exceeds sustainable supply by 10%. A more recent forest valuation study by Hecht and Kasulo (2013) calculates that demand for firewood in the Southern region in 2010 exceeded sustainable yield of forests by a factor of 5, but omitted trees outside forests as well as alternative biomass energy sources. Regardless of the actual magnitude of deviations, the sustainable supply–demand situation is likely to be aggravated in the coming decades by several trends as examined in the following.

(a) Population growth, income growth and urbanization

The household sector represents the largest consumer of biomass energy in Malawi with a share of 92% of total demand, the rest is made up of a few industries such as tobacco processing and brick burning (Owen *et al.*, 2009). Within the household sector, biomass energy is almost exclusively used for cooking, heating and water boiling. Malawi's population is growing rapidly at 3% per annum, urban growth rates are slightly higher with 4% (Dorosh, Pauw, & Thurlow, forthcoming). At the same time, GDP is growing at around 5% each year, increasing incomes and the demand for food and cooking energy. These developments will not only increase overall demand for biomass energy, but the composition of the energy mix is likely to change as people move to urban areas and demand more urban fuels, predominantly charcoal. Higher charcoal consumption will mean an over proportional increase in demand for wood due to conversion inefficiencies. While these trends increase demand for wood directly, they also reduce supply indirectly by increasing demand for land for agriculture. Land clearing for agriculture remains the main reason for deforestation and recent analyses of land cover change in Malawi show that forest cover decreased by the same share by which agricultural land increased in the last 20 years (FAO, 2013).

Figure 1 illustrates the effects of population and GDP growth on demand and supply of biomass in a simple model. On the demand side increasing demand for food $\boldsymbol{D_{food}}$ (quadrant I) directly increases demand for cooking energy $\boldsymbol{D_{cook}}$ (quadrant II), which translates into increased demand for biomass $\boldsymbol{D_{wood}}$ depending on the cooking technology used (quadrant III). While traditional cooking appliances such as the three-stone fire need a lot of firewood, improved cook stoves are more efficient and can significantly reduce the demand for biomass energy. In quadrant VI, demand for biomass comes together with sustainable supply $\boldsymbol{S_{sustainable}}$, which is in turn reduced by population and GDP growth through land clearing for agriculture. For illustration, we assume that demand for biomass using a traditional cook stove $\boldsymbol{D_{wood0}}$ and sustainable supply of biomass are in equilibrium in 2010 at point $\boldsymbol{A_0}$, but will be in disequilibrium once population and GDP growth increase the demand for food beyond the level of 2010. Using an improved cooking technology rotates the wood demand curve to $\boldsymbol{D_{wood1}}$, leading to a new equilibrium at point $\boldsymbol{A_1}$ and ensuring equilibrium beyond 2010. However, as soon as population and GDP growth exceed point $\boldsymbol{B_0}$, demand for biomass exceeds sustainable