Energy for Sustainable Development 32 (2016) 121–129

Contents lists available at ScienceDirect

Energy for Sustainable Development

Insights from an energy poor Rwandan village

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ARTICLE INFO

Article history:
Received 4 November 2015
Revised 22 February 2016
Accepted 9 March 2016
Available online 30 April 2016

Keywords:
Energy poverty
Rural development
Rural electrification
Rwanda
Sub-Saharan Africa

ABSTRACT

We used primary data collected from 163 households in an off-grid Rwandan village to provide insights into energy poverty at the household-level. Informed by the rural livelihoods literature, we constructed a novel asset- and income-based index to disaggregate our results by socio-economic status. We also employed microeconometric techniques to investigate the determinants of household willingness-to-pay for electricity. We found statistically significant differences between households of different socio-economic status for expenditure on lighting and other electricity services, willingness-to-pay for electricity, income-generating activities and food security. Overall, our findings suggest that initiatives aiming to end energy poverty and catalyze rural development should: (1) recognize the different potential impacts of policies on households of different socio-economic status; (2) be sensitive to energy stacking behavior; (3) take a holistic approach to rural development; (4) and ensure that households are able to access modern energy through flexible payment schemes and equitable and sustained improvements in income.

Introduction

Among the 17 Sustainable Development Goals adopted in September 2015 is the commitment to end energy poverty through ensuring "access to affordable, reliable, sustainable and modern energy for all." This commitment to ending energy poverty is a crucial step towards achieving rural development and improving the livelihoods of the approximately 3 billion energy poor[1] individuals in the world today (Holmes et al., 2015).

Ending energy poverty and achieving rural development require stakeholders to make difficult choices on when, where and how to implement programs (Foley, 1992). As a result, concerted efforts by local communities and their champions, academics, the private sector, governments, NGOs and donor agencies are often hindered by a lack of primary data. While fully recognizing the uniqueness of each individual village and the broader macro-context in which it is embedded, an evidence-base of household data from energy poor villages can contribute to the drawing of stylized facts to help ensure that effective policies are put in place to end energy poverty and achieve rural development.

We contribute to the existing evidence-base for Rwanda (e.g. Bensch et al., 2011) and for sub-Saharan Africa (e.g. Kirubi et al., 2009) by analyzing primary data collected from 163 households in Rubagabaga village, Western Province, Rwanda to provide insights into energy poverty at the household-level. Specifically, we collected data on household energy use for lighting, cooking, enterprises and other electricity services, willingness-to-pay for grid electricity, as well as disaggregated gross income, education, health and food security. Informed by the rural livelihoods literature (e.g. Scoones, 2009; Charley and Walelign, 2015) we constructed an asset- and income-based index to disaggregate our results by socio-economic status. This has the added benefit of allowing for a better understanding of the impact of energy poverty and on the expected outcomes of future interventions on different segments of the village population. We also employed microeconometric techniques to investigate the determinants of household willingness-to-pay for (grid-level) electricity.

We found statistically significant differences between households of different socio-economic status for expenditure on lighting and other electricity services, willingness-to-pay for electricity, income-generating activities and food security. Overall, our findings suggest that initiatives aiming to end energy poverty and catalyze rural development will need to: (1) recognize the different potential impacts of policies on households of different socio-economic status; (2) be sensitive to energy stacking behavior; (3) take a holistic approach to rural development; (4) and ensure that households are able to access modern energy through flexible payment schemes and equitable and sustained improvements in income.

Energy poverty and rural development in Rwanda

Energy poverty has a negative impact on rural development at the household-level. This negative impact manifests itself both directly and indirectly and affects a household's ability to earn an adequate

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[1] The energy poor are defined as "…people who live on less than US$1.15 per day and have no access to reliable, safe and efficient energy for cooking, lighting, space heating and mechanical power…[and] who rely upon harmful energy like biomass-generated fire for their cooking and heating (Guruswamy 2011: 140).

http://dx.doi.org/10.1016/j.esd.2016.03.002
0973-0826/

Fig. 1. Rubagabaga.

income, as well as their health, education, food security and quality of life (Zomers, 2003; Sovacool, 2012).

Contemporary (e.g. Kirubi et al., 2009) and historical case studies (e.g. Zomers, 2003; Bhattacharyya and Ohiare, 2012; Van Gevelt, 2014) have shown that ending energy poverty will only significantly benefit rural households when part of a holistic development approach. For example, good roads and built infrastructure, schools, and health clinics are required for rural households to be able to reap health, education and quality of life benefits. Similarly, agricultural extension and business support services are typically required to help households engage in new economic activities and to improve their economic output and productivity (Foley, 1992; Bastakoti, 2003; Cook, 2011).

Despite increasing urbanization on the back of sustained economic growth, the overwhelming majority (72%) of the Rwandan population continue to live in rural areas and are energy poor. The national electrification rate is currently 23% (Nyamvumba, 2015) with approximately 1.3% of rural Rwandans being connected to the grid in 2009 (WHO 2009). The majority of rural Rwandans use candles, kerosene driven wick lamps and, more recently, dry-cell battery driven LED torches/lamps[2] for their lighting needs. To date, there has been relatively low penetration of pico-solar lighting solutions (PLS) in rural Rwanda (Grimm et al. 2014). Many rural households own and use battery-powered radios and mobile phones which they charge externally at local village-based businesses (Manning et al., 2015).

Biomass, primarily firewood and charcoal, is the primary source of fuel for between 85% and 94% of the Rwandan population (Mazimpaka, 2014; Nyamvumba, 2015). In rural Rwanda, approximately half of all households use home-made traditional three-stone or mud-construction stoves. The other half of households use improved woodstove mud or ceramic cookstoves produced by local artisans. These improved cookstoves range from US$3–20 and vary greatly in terms of quality. As a result, there is wide variation in terms of efficiency gains and emission reduction (Global Alliance for Clean Cookstoves, 2012).

Rural electrification and the widespread adoption of improved cookstoves are regarded by the Rwandan government as essential components of a larger strategy to connect rural communities to economic opportunity through investment in infrastructure, skills development, and extension service provision. Specifically, the country's second Economic Development and Poverty Reduction Strategy (EDPRS 2) aims to extend grid coverage to rural areas, serve 22% of rural households through off-grid solutions, ensure that 100% of schools and health facilities have access to electricity by 2018, and reduce the dependence on biomass for fuel by 50% by 2020 (Borchers and Annecke, 2005; Republic of Rwanda, 2013; Nyamvumba, 2015).

Table 1
Distance from Rubagabaga to nearest facilities.
Source: Data obtained from authors' survey of village elders.

Facility	Distance	Travel time by most common mode of transportation*
Market	1 km	10 min
Bus stop	4 km	15 min
Police station	20 km	120 min
Primary school	2 km	40 min
Secondary school	3 km	60 min
Vocational school	6 km	25 min
Church	2 km	20 min
Health clinic	15 km	120 min
Hospital	35 km	90 min
Mill	1 km	10 min
Farmers' cooperative	3 km	20 min

* Modes of transportation include by foot, bicycle, motorbike and bus.

Methods

Study site

Rubagabaga[3] is an energy poor, off-grid village located in Binana Cell, Western Province (see Fig. 1). Established in 1930, the village is home to 314 households consisting of approximately 1238 people. Rubagabaga is relatively isolated (see Table 1) and is vulnerable to flooding and mudslides during the rainy season. The main lighting technologies in the village are kerosene lamps and dry-cell battery torches/lamps. The main cooking fuels are firewood and charcoal. The dominant livelihood strategy in the village is farming. Crops include: bananas, beans, cassava, coffee, maize, potatoes, rice, sorghum, soya beans, sweet potatoes, tomatoes and yams. The only agricultural products processed in the village are bananas, with the resulting banana beer being sold both within the village and at the nearest large market. Other livelihood activities include the rearing of livestock, collection of non-timber forest products, farm and non-farm employment, petty business, and public and private transfers (e.g. rental income, remittances). Like most Rwandan villagers, Rubagabaga's inhabitants regularly visit a nearby electrified market center and have a good grasp of electricity and its potential uses (Manning et al., 2015).

Data collection

Data were collected through a household survey. The household survey was based on the livelihoods framework (e.g. Scoones, 2009) and the World Bank's Living Standards Measurement Surveys (LSMS) (e.g. O'Sullivan and Barnes, 2007). The survey included questions on demographics, assets, disaggregated gross income, energy use for household-owned businesses, consumption, health, food security, education, energy access and use for lighting, cooking and other uses, and willingness-to-pay for grid electricity.

Design of the household survey was informed by a scoping trip to Rubagabaga village in March 2015 and a focus group discussion with village elders in May 2015. The survey was translated into the first language of the village population, Kinyarwanda, and field tested

[2] Dry-cell battery LED torches/lamps tend to cost between US$0.82 and US$4.95 with a battery running cost of approximately US$0.01 per hour (Grimm et al., 2014).

[3] Rubagabaga was selected for this study due to impending plans for electrification through a 300 kW run-of-river mini-hydro plant. This affords the opportunity to return in the future to better understand how access to electricity affects development outcomes in the village.