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Food versus fuel: examining tradeoffs in the allocation of biomass energy sources to domestic and productive uses in Ethiopia

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1. Abstract

Rural households in Ethiopia have limited options to meet their domestic energy needs because they lack access to modern fuels and technologies. This study looked at the tradeoff between the use of biomass such as cow dung, fuel wood, and crop residues for domestic cooking and heating purposes, instead of leaving the biomass on the field to improve soil organic matter. The results show that the use of dung as a domestic fuel source has reduced farm productivity in Ethiopia, as soil organic matter is being removed from the field to meet household energy demand, a problem that is not solved by increased use of chemical fertilizers due to complementarities in chemical fertilizers and soil organic matters. Farm households, particularly women and girls, spend quite significant number of hours a week in search for fuelwood to meet domestic energy demand, a time that could have been used in productivity-enhancing activities. The amount of time households spend in search of fuelwood, cow dung, and crop residues does not meaningfully differ by households' access to electricity because in many households, electricity is being used primarily for lighting purposes. On the other hand, the use of on-farm fuelwood is associated with increased value of agricultural output. On-farm production of fuelwood appears to increase the value of crop output and provide labor savings, by making fuelwood collection more convenient for households. Policy interventions to support the expansion of agroforestry and increase access to new energy-efficient technologies are needed to ensure that agricultural productivity can be both increased and sustained (Mekonnen et al., 2017).

2. Context and challenge, including key interactions (range and nature) the case study addresses

More than 80% of Ethiopia's population relies on wood for cooking and 79% depend on fuelwood as their primary energy supply (FAO, 2014). Furthermore, as of 2016, only 27% of the rural population in Ethiopia had access to

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electricity, which is significantly lower than the 85% access in urban areas in the same year (World Bank, 2018). The significant expansion of rural electrification in the last decade, albeit from a low base, has not significantly changed the number of households that rely on biomass energy sources for domestic cooking and heating. The data collected by IFPRI and CIMMYT in 2013 on energy use in agriculture in the Nile Basin of Ethiopia showed that the amount of labor days per year that households spent to collect fuelwood, dung, and crop residues to satisfy domestic energy needs does not vary by households' access to electricity (Table 1). Women without access to electricity spend about 125 hours to collect fuelwood from neighbors' woodlots or community forests, 88 hours a year from own woodlot, 95 hours a year to collect dung, and 57 hours a year to collect cow dung and these figures are not statistically different between those with and without electricity. Men spend comparable amount of time as women to collect fuelwood on own woodlots and crop residues, though they spend less time in the collection of dung and fuelwood from neighbors' woodlots or community forests. The time men spend on biomass collection for domestic energy purposes does not vary by the households' access to electricity. The role of alternative modern energy sources, such as kerosene or gas is limited as 90% of in the IFPRI/CIMMYT data indicate that they have traditional fuelwood/dung burning stoves, the remaining 10 percentage point split between charcoal and modern energy sources.

Women's average collection time (hours/year)				
Fuel Source	Without electricity	With electricity	Difference	p-values
Wood from own woodlot	88.80	87.11	1.69	0.84
Wood from neighbors' woodlots or community forest	129.09	116.46	12.62	0.33
Dung	96.93	92.00	4.93	0.51
Crop residue	58.23	54.72	3.50	0.62
N	783			

Men's average collection time (hours/year)				
Fuel Source	Without electricity	With electricity	Difference	p-values
Wood from own woodlot	90.10	82.25	7.85	0.19
Wood from neighbors' woodlots or community forest	105.51	115.74	-10.23	0.75
Dung	65.78	53.52	12.27	0.43
Crop residue	55.26	69.33	-14.07	0.51
N	447			

Source: Authors' computation using IFPRI/CIMMYT Energy Use in Agriculture Survey

***Table 1.** Collection time for domestic energy sources, by access to electricity and gender of the main collector*

Given the high reliance of rural households on biomass for domestic energy purposes, the study explores the tradeoff of using fuelwood, cow dung and crop residues with agricultural productivity. These tradeoffs, as summarized in Table 2 below, takes two pathways – the resource pathway and the agricultural labor pathway. The resource pathway indicates that as households remove cow dung and crop residues from farm plots for domestic energy purposes, it is likely to lead to loss of productivity as soil organic matter is being removed from the field, a problem that may not be solved by increased use of chemical fertilizers due to complementarities in chemical fertilizers and soil organic matter. The agricultural labor pathway works through the amount of labor days households spend in the collection of fuelwood, dung, and crop residues, - labor days that could have been used in productivity-enhancing activities. The tradeoffs through the agricultural labor pathway may be minimal if biomass is collected after harvest, or livestock is kept close to the homestead, or household members with primary responsibility of collecting biomass for energy purposes are not heavily involved in agricultural production (Mekonnen et al. 2017). See Table 2 for details.

Table 2. *Possible trade-offs of biomass for domestic energy use versus farm uses*

Fuel resource	**Effect on labor**	**Effect on agricultural production**
Dung	Time spent collecting dung may reduce time allocated to agriculture. The tradeoff may be minimal if cattle are kept close to the homestead.	Using dung for fuel limits the ability of farmers to maintain soil fertility, particularly in the absence of alternative fertilizer sources.
Crop residue	Time spent collecting crop residues may reduce time allocated to agriculture. This may be minimal if residues are collected after harvest.	Removal of crop residues for fuel can contribute to soil erosion and reduce soil fertility as organic matter is not being plowed back into the soil, particularly in the absence of other soil fertility-enhancing inputs. However, the soil fertility loss may be minimal if animals consume crop residues left in the field.
On-farm wood	Time spent producing and collecting wood on farm may reduce labor for agriculture. On the other hand, on-farm production of fuelwood may save labor if it reduces the amount of time spent collecting off farm wood and other energy sources.	The effect can be positive if wood production and sales increases investments in productivity-enhancing inputs. The effect can be negative if tree production reduces allocation of land for food crop production. Also depends on tree choice.
Off-farm wood	Time spent collecting wood off-farm is likely to have only a modest impact on labor supply to the farm as it is mainly undertaken by women and children during the slack season.	No direct effect. It may help households increase agricultural land as it implies less reliance on on-farm wood production.

Source: Mekonnen et al. 2017.

The study explores these tradeoffs empirically using a non-separable farm household model where labor allocation to energy collection and farming are analyzed simultaneously. The econometric estimation uses a system of five structural equations using three-stage least squares and find that the use of dung as a domestic fuel source has negative implications for the value of harvested crops, while use of on-farm fuelwood is associated with increased value of agricultural output. On-farm production of fuelwood appears to increase the value of crop output and provide labor savings, by making fuelwood collection more convenient for households (Mekonnen et al. 2017).

3. How did research efforts deal with the synergies and trade-offs?

a) in the development of the TOC and impact pathways

IFPRI, through the CGIAR Research Program on Water, Land and Ecosystems (WLE), implemented the energy-productivity tradeoff analysis. The project includes links to CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) through the addition of a risk assessment game. The project also includes links to the CGIAR Research Program on Policies, Institutions and Markets (PIM) through a gendered risk component.

b) in the development of partnerships/delivery approaches

The partnership and delivery approach are collaborations to pool resources to undertake a relatively large sample household survey, that otherwise would have been difficult to do both in terms of cost as well as respondents' fatigue. The survey includes a general set of modules that all collaborators are interested in, coupled with specific modules that address the research focus of individual partners. The Association of Ethiopian Microfinance Institutions was a collaborator to implement the survey on the ground.

c) in the development of metrics

No metrics were developed or used in this case study.

d) other

N/A.

4. What kinds of partnerships were critical?

The critical partnership was between IFPRI/WLE and the Association of Ethiopian Microfinance Institutions (AEMFI). The role of AEMFI, was not limited to data collection as its lead researcher, who is also a professor at Addis Ababa University, participated in the research outputs. The data collection collaboration between IFPRI and AEMFI has continued to other projects that came after it.

5. Lessons learnt, including knowledge gaps and good practices in employing these approaches at scale

The risk assessment game by CCAFS could have been made to better link with the energy work if the level of collaboration was deeper that joint data collection. The lesson learned here is that upfront investment in the joint design of research questions, in addition to joint data collection, could have strengthen and sustain research collaboration among researchers and the organizations they represent.

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