INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

CGIAR
INITIATIVE ON
NEXUS Gains

IFPRI Discussion Paper 02224

December 2023

Closing the Gendered Energy Technology Gap in Rural Ethiopia

A Qualitative Study

Tiruwork Arega

Mastewal Yami

Rahel Deribe

Claudia Ringler

Marc Jeuland

Natural Resources and Resilience Unit

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), a CGIAR Research Center established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

AUTHORS

Tiruwork Arega (tiruarega21@gmail.com) is a PhD student at UNU MERIT, Maastricht University and a former IFPRI staff.

Mastewal Yami (mastewalyami@yahoo.com) is an independent consultant.

Rahel Deribe Bekele (rahel.bekele@duke.edu) is a postdoctoral associate at Sanford School of Public Policy, Duke University.

Claudia Ringler (c.ringler@cgiar.org) is the director of the Natural Resources and Resilience Unit at the International Food Policy Research Institute.

Marc Jeuland (marc.jeuland@duke.edu) is a professor at Sanford School of Public Policy and Duke Global Health Institute, Duke University.

Notices

ABSTRACT

Much has been written about energy poverty, but there is relatively limited evidence of what determines the gender gap in energy poverty and how it can be overcome in rural areas. This study used Focus Group Discussions, in-depth interviews with farmers and Key Informant Interviews to analyze gendered information, access, adoption and use of rural energy technologies in the domestic and productive spheres. We find striking differences in how men and women adopt and use energy technologies in both spheres. Substantial asymmetries exist between women and men regarding knowledge of energy technologies, as most information about them is directed to men in the household. Even so, women are typically the primary decision-makers regarding energy technology adoption for domestic use, while men dominate decision-processes in the productive energy technology space. Women remain largely excluded from the adoption and use of agricultural energy technologies, even though they are heavily engaged in agricultural production systems. Our study highlights the need for tailored mechanisms that reach women with information on and means to acquire energy technologies as well as changes in gendered norms to ensure that women benefit equally from their use.

Keywords: gender gap, energy technology, adoption, sustained use, rural areas

ACKNOWLEDGMENTS

This work was carried out under the CGIAR Initiative on NEXUS Gains, which is grateful for the support of CGIAR Trust Fund contributors: www.cgiar.org/funders. The CGIAR Initiative on NEXUS Gains (https://www.cgiar.org/initiative/nexus-gains/) works at the critical intersection of food, energy, and water security while preserving the ecosystems underlying food systems in selected transboundary river basins.

The authors thank all study participants (farmers, *kebele* and *woreda* level key informants) for their time and sharing their experiences. Any and all errors are the sole responsibility of the authors.

1. Introduction

Affordable and dependable clean energy sources can increase agricultural productivity and support rural economic development, by powering agriculture, supporting rural industrial development, including agro-processing, and by increasing the wellbeing of households. However, Sub-Saharan Africa (SSA) is critically affected by energy poverty (Mohammed et al., 2013; Dagnachew et al., 2017; Nhamo et al., 2020): more than 600 million people, mostly in rural areas, lack access to even basic electricity (IEA, 2022). As a result, Africa accounts for only 6% of global energy demand and just over 3% of global electricity demand. Bioenergy is the largest energy source in Africa, accounting for more than half of final energy use; this has devastating impacts on the continent's health, environmental sustainability, and economy (IEA, 2019). Underinvestment in rural energy infrastructure has stymied the development of manufacturing and has also limited the absorption of labor from rural areas (Mueller and Thurlow 2019). It has also limited the development of irrigation infrastructure, rural agro-processing centers, and cold storage. As of 2021, electricity access[1] was 23% in rural areas of SSA; with adverse impacts from the resulting exposure to household air pollution (IEA et al., 2023; IEA, 2019).

Ethiopia is no exception. Only 42% of the rural population has access to electricity (World Bank, 2023), largely through the national grid, while 55 million people had no access (IEA et al., 2023). Much of the rural electricity can only be used for lighting due to low voltage. Moreover, even in an electrified village, not all households are connected to electricity, thus, village-level electricity access does not guarantee household-level access. As a result, use of many technologies that require electricity, in both the domestic and agricultural domains, remains limited in rural areas. And while rural communities have started to bridge the gap in access to clean energy by using off-grid solar technologies and LPG, others remain wholly reliant on biomass energy. A relatively

[1] Electricity access is defined as having a source of electricity that can provide for basic lighting and charge a phone or power a radio for four hours per day.

small share of agricultural households also uses costly polluting energy sources such as diesel for powering irrigation pumps or small-scale processing activities.

As with other technologies, energy technology decisions and uses are highly gendered (Das et al. 2023). Domestic energy technologies, such as improved cookstoves and appliances, can improve women's time management, freeing up time for productive engagement, such as in agriculture, for childcare or for leisure (IEG, 2008; Kumar and Rauniyar, 2018). Using electricity or other energy sources can also support water extraction from domestic wells, reducing children's and women's drudgery with domestic water supply (Allouhi et al., 2019). Owning or making decisions over energy appliances can also improve women's access to information and agency, with potential spillover effects for family wellbeing (Annan et al., 2021).

In the agricultural sphere, improved energy access directly supports agricultural intensification, for example, switching from manual irrigation practices to motorized irrigation technologies, such as diesel or solar-fueled irrigation pumps, increasing profitability of irrigation investment and reducing drudgery of women who are often responsible for watering. As such, energizing agricultural water management can enhance farmers' management of limited labor resources by reducing time spent watering plots, and thereby enhancing labor productivity and advancing gender equality (Dyer and Shapiro, 2023).

However, gendered heterogeneities in terms of information on, access to, and adoption and use of improved energy technologies for both agricultural and domestic purposes in rural areas remain under-studied. Many studies focus on initial technology adoption decisions (for example, Foster and Rosenzweig, 2010; Guta, 2018), but fail to consider gendered constraints, or overlook the complex dynamics of sustained use of modern energy technologies, which tend to require substantial maintenance and upkeep. Studies that have examined the gendered energy access and use divide, have identified a gendered lack of information manifested by fewer opportunities for training and education (Pueyo & Maestre, 2019; Guta, 2020), a gender gap in decision-making at intrahousehold and community levels (Winther et al., 2018; Wiese, 2020), and gendered differences in access to productive resources (Van der Kroon et al., 2013). Prior studies have also typically treated domestic (such as Gebregziabher et al., 2012; Beyene and Koch, 2013; Guta,

2018) and productive energy technologies (Getacher et al., 2013; Namara et al, 2013; Gebregziabher et al., 2014) independently, neglecting the fact that domestic and agricultural uses of energy are often deeply intertwined. A separate analysis of these two sides of rural household energy security fails to consider the interrelations between domestic and productive energy technologies, which are particularly important to understanding gendered aspects of energy poverty.

Our research contributes three novel insights to the increasing body of knowledge on rural energy access and use. First, we provide an integrated, in-depth analysis of domestic and agricultural energy uses at the intra-household level for several locations in Ethiopia. Second, we assess gendered energy poverty across key steps of the adoption process, including awareness, adoption and continued use (Theis et al., 2018). Third, we identify measures to increase inclusivity in both productive and household energy technologies.

The remainder of the paper is structured as follows. Section 2 provides the energy access context for Ethiopia. Section 3 describes the analytical framework of the study. Section 4 discusses sampling, data, and methods. Section 5 discusses the results, and Section 6 concludes.

2. Country energy context and portfolio

Ethiopia, located in the Horn of Africa, has a large renewable energy potential, with the ability to generate around 60,000 megawatts (MW) of electricity from hydropower, solar, wind, geothermal, and biomass sources. Less than 5% of this potential is being used, with 90% coming from hydroelectricity, 8% from wind, and 2% from geothermal sources[2]. The current installed electricity generating capacity is 4500 MW, reaching 95% of the urban and 42% of the rural population. The rural population is still largely disconnected from the electricity grid (ITA, 2023; World Bank, 2023).

[2] https://www.eep.com.et/en/power-generation/

To address the low per capita energy production and consumption in the country (Yalew, 2022), the National Electrification Program (NEP) was initiated in 2017 and revised in 2019 with the goal of providing national universal electricity access by 2025. The NEP aims to connect 65% of the country's population with grid electricity and 35% through decentralized energy production. The NEP also notes that access to electricity supports women's 1) access to labor-saving mechanized community services; 2) engagement in productive activities; and 3) income from the production, distribution, retail, and maintenance of solar technologies (FDRE, 2017). The NEP aims to support both domestic energy end uses (lighting, cooking, and heating) and productive uses by powering agricultural and non-agricultural businesses.

Without clean energy access, households rely heavily on fuelwood, livestock dung, and crop residues to meet their domestic needs, especially related to cooking. Fuelwood is the major energy source for cooking, whereas kerosene, electricity, pico-solar, and biogas are commonly used for lighting (Wassie et al., 2021). Wassie and Adaramola (2021) and Gebreselassie (2022) note increased adoption of solar technologies for household uses. For example, Gebreselassie (2022) finds that nearly 2% of households in Tigray have home solar systems and 10.5% of households adopted solar lanterns for lighting. However, such technologies are limited to lighting and powering low-voltage appliances such as radios and mobile phones.

In Ethiopia, energy demand for cooking is bifurcated. It includes smaller cooking activities, such as coffee making and cooking stews that can be accomplished with small appliances and lower energy needs; but also, *injera* (flatbread, an important staple food) and bread baking, which account for about 60% of residential fuel demand (Eshete et al., 2006). *Injera* is traditionally baked on an open-fire tripod using a 20-30 mm thick clay griddle (called a *mitad*). Most efforts on clean cooking have aimed to replace the open-fire tripod stove. Despite some attempts to develop solar cookstoves suitable for the Ethiopian setting (Tesfay et al., 2014; Tucho and Nonhebel, 2017; Mekonnen et al., 2020), suitable technologies have not yet reached rural households.

Energy use in agriculture, on the other hand, mostly relates to motorized irrigation pumping. Most pumps run on petrol or diesel fuel, and these technologies are playing an important role in agricultural intensification and resilience against climate variability and change (Eshete et al.,

2020). Given the high cost of pumps, high and variable fuel prices as well as maintenance challenges, farmers are increasingly interested in switching to solar technologies. However, the cost of solar pumps remains out of reach for most farmers. At the same time, the government of Ethiopia is seeking to greening the rural economy. A clear sign of this was the outright ban of new petrol or diesel pumps for irrigation in May of 2023 (Addis Standard May 9, 2023). Little is known about how irrigation technologies can reach, benefit, and empower women farmers, but it is clear that, a priori, solar irrigation technologies might well increase the gap in resources, agency and achievements between women and men farmers (Lefore et al., 2019).

3. Analytical framework

Although energy technology use and adoption have been widely studied, frameworks that incorporate gender and focus at the micro level are lacking (Das et al., 2023). Existing frameworks focus on actors and benefit streams that a clean energy transition could generate (WEF, 2018; IEA, 2020; Sarno and Siano, 2022). For example, WEF (2018) proposes two interlinked frameworks focusing on systems performance and transition readiness, respectively. Systems performance, in turn, relates to secured energy access, economic development, and environmental sustainability, while transition readiness encompasses structural, human, and physical capital, regulatory, and infrastructural requirements.

This study analyzes the potential for closing the gendered rural energy technology gap using the awareness, adoption and continued use framework (Theis et al., 2018). Women face particular constraints regarding the awareness of energy technologies, their adoption, and in benefiting equally from these technologies once they are in use (ibid). While awareness is typically necessary for initial adoption (phase 1), and initial adoption is necessary for continued use (phase 2), reaching the first of these does not necessarily lead to the second phase. Many energy technologies that have been piloted might never be used or abandoned following initial adoption, as has been widely documented in the improved cookstove sector, for example (Ruiz-Mercado et al., 2011; Pine et al., 2011; Pillarisetti et al., 2014).

Moreover, women might face particular problems in all phases of technology adoption and use. Dissemination of new technologies, such as solar irrigation pumps, might unintentionally exclude women, or energy promotion efforts may only focus on specific services (e.g., productive uses in agriculture), disregarding the interlinked effects on other important aspects of life (e.g., the use of irrigation pumps for collecting domestic water). In terms of initial adoption, women may be aware of technology solutions, but feel that they do not fit their needs, or, if they do, that they lack the financial resources or other means to acquire such solutions. In terms of continued use, intrahousehold relations or social norms and traditions may limit women's agency over technology use, and thereby prevent women from fully benefiting from technology, leading to dis-adoption or an increase in the gender gap of resources and achievements.

This study applies the awareness, adoption and continued use framework to the study of rural energy technologies in Ethiopia and uses the framework to identify solutions toward increased social inclusion in energy access and use, focusing on gender dimensions.

4. Methodology

a. Sampling and data

The primary data sources for this study are qualitative data collected in Ethiopia from June to July 2023 as part of the CGIAR Initiative on NEXUS Gains. The data protocol was designed to examine rural energy portfolios, develop insights on gendered constraints to energy access and use, and identify entry points for reducing the gendered gap in energy technologies in the domestic and productive spheres. Data were collected from a purposeful sample of households in three regions, six districts, and 10 *kebeles*[3] of Ethiopia that had been identified as control and intervention areas for the evaluation of a decentralized rural energy program that the government of Ethiopia is pursuing. The regions and *woredas* included Amhara (Dera and Fogera), Sidama (Shebedino) and SNNPR (Arba Minch Zuria). We oversampled *kebeles* in the Tana Beles sub-basin of the Blue Nile Basin that form part of the NEXUS Gains basin focal region: six of the 10 study *kebeles* are

[3] Kebele is the smallest administrative unit in Ethiopia.

in the Tana-Beles region (Appendix Table A1). A total of 199 women and men farmers participated in the study as well as 47 key informants.

Qualitative data were collected through Focus Group Discussions (FGD), semi-structured interviews and Key Informant Interviews (KII). We organized separate group discussions for women and men farmers in the 10 *kebeles* for a total of 20 FGDs. Each FGD included around 9–10 participants. FGD participants were purposefully selected to include farmers with experience in irrigation and in alternative uses of domestic energy technologies, in addition to ordinary farmers. All women FGDs included women-headed households. Champion farmers and rich farmers were excluded from the FGDs. Among participants of each FGD, two participants with were asked to participate in follow-on semi-structured interviews. Key informants in each *kebele* included the head of the development agency, a health extension agent, a youth entrepreneur/representative and an irrigation expert, all with at least one year of experience in their posts. A total of 39 KIIs were completed at kebele level. Moreover, in each woreda, interviews were done with a solar or an improved stove expert in the respective Offices of Water and Energy (OWE). In total, 4 interviews were done at the woreda level. At regional and federal level, 4 interviews were conducted with irrigation experts from the Bureau of Agriculture (BoA), and solar/improved stove experts at the Bureau of Water and Energy (BoWE). An interview was also conducted with the irrigation promotion expert at Ministry of Agriculture (MoA).

b. Data collection tools

FGDs discussed livelihoods, main sources of energy for domestic and productive purposes, labor division, particularly for fuel collection and irrigation, information and material access, adoption decisions, challenges, and opportunities, among others. KIIs gathered information on energy technology targeting, dissemination, and context. The discussions were recorded, transcribed, and translated into English. In total, 108 transcripts were used for qualitative data synthesis. Any participant identifiers have been anonymized to maintain confidentiality. Data analysis was carried out manually following the identification of key themes.

The FGDs collected quantitative information regarding key demographic and socioeconomic characteristics of participants to help inform data analysis. This included the respondent's age, family size, land size, types of cookstoves used, lighting sources, irrigation practices and irrigation pump access, and decision-making. We also asked about livestock, land, and mobile phone ownership.

5. Results and Discussion

Based on the basic quantitative data collection, we found a modest difference in average cattle and land ownership between men and women FGD participants. On the other hand, there were substantial differences in mobile phone ownership with 87% of men participants owning mobile phones compared to 39% of women participants (Table A2). The following sections describe rural energy portfolios for domestic and productive uses. They first assess gendered differences in household energy awareness, adoption and continued use, followed by productive use awareness, adoption and continued use. The discussion and concluding sections identify linkages between these two areas.

5.1.Household sources of energy, uses of energy and intrahousehold gender differences

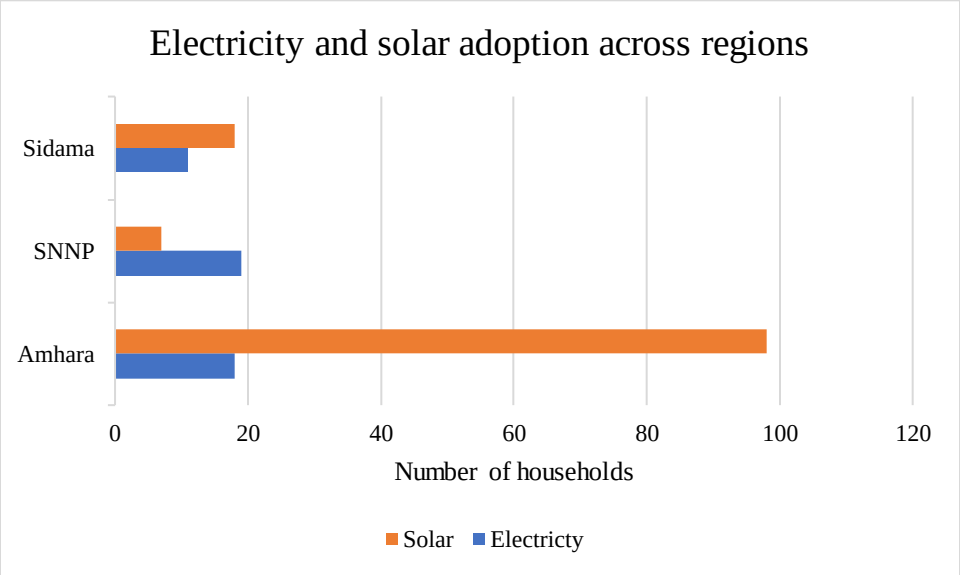
In the domestic arena, Ethiopia's two main energy uses in rural areas are lighting and cooking. Grid-based electricity and solar are the only clean and modern energy sources available in parts of rural Ethiopia; and their use is generally limited to lighting. A male FGD participant from Geladiwos *kebele* in Amhara mentioned:

"We use electricity for lighting and charging mobile devices for domestic use. We are enabled [with electricity] to engage in businesses such as ironing and sewing, haircutting, and mills. Electricity is rarely used for cooking but is often used for television and radio. Refrigerators are not used for domestic use, but for business. We prefer electricity [over other energy sources]. For example, a cooking stove works with fuelwood, but electricity reduces the workload."

Six out of the 10 *kebeles* in the study were connected to the national grid. Moreover, access to the grid does not guarantee that electricity is available. On the other hand, pico-solar and solar kits

(for lighting and small radio/charge) were common sources of electricity for a large number of households. The adoption and use of standalone solar systems (stand-alone solar PV systems such as solar home systems (SHSs) and pico-solar systems) is steadily growing in the study sites, particularly in areas with better market access. Households in this study used SHS technology primarily for lighting and mobile phone charging. Productive uses were seldom mentioned. Participants also noted that solar technologies provide the most convenient, safe, and high-quality lighting.

Figure 1: Lighting sources in use by region and number of households



Source: Authors

The primary cooking fuels in the study area were firewood, crop residues, and dung. Charcoal was seldom used. In rural Ethiopia, crop residues and dung are alternatively used as fertilizers and there are tradeoffs between domestic and agricultural uses (Mekonnen et al., 2017). Women and children, mainly girls, were generally responsible for biomass fuel supply. Women were also responsible for collection of water and childcare, in addition to their contribution to agricultural labor whereas men tended to allocate productive time to income-generating activities, including farm work.

"We have a lot of burden in the house; we prepare food, make injera and wot[4]*, clean the dishes and bathe the children. How can a woman handle all this in a day at the same time? […] how can I express how tedious domestic work is? I have no words or capacity to express the burden we- women- carry. Our children and men consider us as not working hard, devaluing women's contributions. Farm work is easier and more beautiful than domestic work. I am jealous of my husband and my children when they go to the field or outside because the domestic work is endless." Women FGD, Gebtsawit kebele, Amhara region*.

Participants noted a series of gendered and intersectional differences in time use. For example, women with young children often traveled long distances to collect firewood and that distance and collection time heavily influenced the time they had for other activities. Firewood was often collected from communally managed forests; and trading of fuelwood and dung cakes was limited. Eucalyptus and endogenous trees were sometimes planted for cash income, particularly to provide construction materials, rather than as a source of fuel. Biogas is another source of cooking fuel and lighting that was known but was generally not in use. Several participants noted the use of multiple fuels to cope with seasonal fuel shortages. For instance, firewood and crop residues were the main fuels used in the dry season whereas firewood and cow dung were the more common combination found in the wet season. Fuel sources for the rainy season were often stored during the dry season. While little variation was mentioned in the limited use of charcoal, its use was preferred during the wet season. Seasonal differences were explained by a woman participant from Mitsile Wagra *kebele*:

"We often collect firewood and leaves for cooking during the dry season. However, in the rainy season, we use cow dung which is prepared during the dry season. In the dry season, it is sunny and everything is dry and very easy and quick to light. During the rainy season, in addition to the difficulty we face to spark a fire, after the fire starts the smoke is worse since the firewood and cow dung become wet."

[4] Wot is an Ethiopian stew that may be prepared with lentil, chicken, beef, variety of vegetables and spices.

To cope with wet-season weather, women also reported using kerosene to start a fire for cooking, due to the fact that fuel types like kerosene have a low ignition temperature, facilitating the lighting of fires and helping wood or dung to reach their required ignition temperatures.

Electricity access was also reported to vary seasonally. Both women and men participants noted that during the rainy season, small rainfall events can trigger power outages that can last hours or days. Participants noted that a lack of reliable electricity access and frequent power cuts made it difficult to start a business. Finally, participants noted that solar lighting, which is replacing kerosene, is less bright during the rainy season, likely due to less effective charging.

Awareness and initial tryout

The vast majority of the literature on rural technology adoption has treated the household as a homogeneous entity, neglecting gendered differences (Magnan et al., 2015; Zhang et al., 2022; Das et al., 2023). However, intra-household dynamics affect overall benefit streams from energy access and use. Regarding awareness, several studies show that women's reduced access to information and formal training can affect energy technology adoption and use. In Ethiopia, cooking falls in a woman's sphere and represents a considerable component of their domestic workload. According to Mekonnen et al. (2022), women spend more than three hours per day on cooking-related activities, including fuelwood collection, and cooking itself. Thus, access, adoption, and use of improved fuel and appliances can substantially impact women's time use, productive engagement, and health. All FGD participants reported using biomass for their daily cooking needs. Only 43% and 29% of the respondents used improved biomass cooking stoves and *injera mitad*, respectively (Table 1).

Table 1: Improved biomass stove/*mitad* use across the sample households.

Do you have an improved biomass *mitad* /cookstove	Injera *mitad*	Cookstove
No	70.9 (139)	56.9 (113)
Yes	29.1 (57)	43.2 (86)
Total	100.0 (199)	100.0 (199)

Source: Authors

Rural households learn about new technologies through social learning and networking, but formal awareness and information channels are gendered. Men tended to have more access to information, had more contact with agricultural experts, faced no limitations in their mobility, and were very likely to own mobile phones, on top of having more spare time for socializing.

Since women are responsible for collecting firewood in the majority of study sites, improved cookstoves could theoretically affect both their domestic and productive time use. Respondents noted that women were expected to identify better technologies for cooking on their own, however. The *woreda*[5] women's forum and health extension workers were their main sources of information on new technologies. Religious gatherings, *Tsebel* (religious festivals), and coffee ceremonies also played an important role for women in accessing information. Women were less likely to obtain information through formal channels and training. Such trainings tended to target women leaders (or models) who were then expected to share information with neighbors and friends.

We also observed gender differences regarding awareness of domestic solar technology. Men become familiar with these systems through participating in social gatherings and formal trainings. Women are not able to do either and therefore were less likely to adopt solar system devices. Men were highly aware of pico-solar devices. As stated by men FGD participants at Dera-Gibtsawit *kebele*:

[5] Woredas (districts) are the third level of administrative divisions of Ethiopia.

"Female-headed households generally do not have the same access to information as men do unless they have a mature son(s) […] In male-headed households, it is mostly men who move freely and communicate with each other. Then, they can tell their wife when there is a new technology […] Of course, if they are directly invited by women's affairs or training providers, they may get the chance. "

In principle, women have the same right to attend trainings that are provided at the *woreda* and *kebele* level as men, but in reality, very few people, and mostly men, are selected by trainers.

Women at Mitsile Wagra *kebele* explained it as:

"Around 10 (male-headed) households from this kebele received training provided by kebele experts. The opportunity was not given to female-headed households […]. The training focused on household hygiene, childcare, and solar. But these trainees have not passed the information on to others."

Adoption

Our results show that women are the most relevant decision-makers for adoption of improved stoves, linked to their primary responsibility for cooking and other domestic chores. Usually, women obtain advanced cookstoves directly from stove producers. Typically, these producers contact kebele health/agricultural extension worker(s) and women to encourage them to register to obtain such appliances. Women FGD participants with such devices noted that improved cookstoves had allowed them to save time, effort, and fuel. For instance, FGD participants in Dera *woreda* highlighted that:

> *"We [women] have a lot of burden in the house. We prepare food like baking injera, cooking stew, making coffee, washing dishes, and caring for children. We even make injera, and cook stew at the same time. We cook and serve breakfast, then we proceed to cooking lunch. We also cook and give snacks for the children in the afternoon. Then, we cook dinner. We have a lot of burdens. Improved stoves help us do all these tasks well." Women FGD, Geregera Gebstawit kebele.*

Men noted that they often purchased domestic solar technologies in exchange for selling livestock or crops. Guta (2020) suggests that men's literacy level is a key factor for their increased adoption of solar technologies compared to women. Other than a few men respondents from Gelaediwos *kebele* (Amhara region) who reported that they had obtained Pico solar credit from a local micro-credit institute, most technologies had to be purchased directly, even though many would have preferred using credit. Women, on the other hand, typically did not have the necessary resources for direct purchases of even small solar technologies. They also lacked decision-making power and mobility to go out and access these solutions.

Continued use

The right to continued use refers to the autonomy of rural women and men to decide who uses energy technology, and this varies by energy technology. Women generally have autonomy for continued use of improved cookstoves, which reduces their energy and time poverty.

In contrast, use rights for solar appliances are generally jointly held and all family members benefit from the technology. Following the return from school, boys tend to support their parents in herding cattle and other agricultural activities while girls help their mothers with fuel collection, food preparation and fetching water. Children from households in this study generally did not have time to study during the daytime. Solar lighting thus allowed children to study at night. Women and men also used solar lights during nighttime. As explained by a woman from Mitsile Wagra *kebele*:

"…When we work on farm fields along with husbands till the sun sets and come back at night, we use the pico solar to do our domestic activities easily and efficiently because solar has more power than lamba[6] or kuraz..."

However, in some places, women noted that their husbands were the ones who would decide on where solar devices would be located within the household, and that they therefore generally kept

[6] Lamba and kuraz are Amharic words referring kerosene lighting.

these devices near to them. Since the kitchen is often separated from the main house, and because men might go out at night, this meant that women had more limited access to lighting. Women would then have to cook or do other household chores using alternative sources of light.

"In female-headed households, the woman can make the decisions alone. However, in male-headed households, men dominate decisions, especially when it comes to the utilization of resources. At nighttime, when they return from work and want to rest or sleep, they may not want to be disturbed from their sleep and may turn off the light." Men FGD, Ganta Kanchamo kebele.

Furthermore, respondents reported that even if all household members had equal rights to use solar for charging mobile phones or the radio, men were the ones more likely to own mobile phones or to have the spare time to listen to radio programs.

Regarding management rights, men were commonly responsible for decisions on the utilization of most assets and equipment owned by the household. However, in the case of pico-solar and cookstoves, due to the nature of the appliances, in most study areas, women had some management rights. At the adoption stage, both men and women reported that their households would come to joint decisions after discussion and exchange of ideas, but men would usually have the final say. This suggests that there exists some degree of interhousehold bargaining prior to the adoption of domestic energy technologies. This is reflected by a male FGD in Morocho Negasha *kebele*, Sidama:

"*A decision will be taken following the discussion by family members, but the final decision will be taken by the household heads (men). In male-headed households, men are the decision-makers. However, in female-headed households, women take charge of all aspects, from planning to decision-making. Women become the center of their households, […] when their husbands pass away, taking on numerous responsibilities in addition to household responsibilities and caring for the children. She is the sole decision maker."*

Fructus and alienation rights

Fructus rights relate to knowledge of household income and subsequent bargaining power over use of earnings. Our findings indicate that household members have different levels of fructus rights depending on the type of improved domestic energy technology. These rights are determined by who (1) decides what to produce and sell and (2) receives the revenue from those sales. In every FGD, both men and women across the study area noted that they use improved domestic technologies for non-agricultural businesses. For instance, women sometimes used the improved stove for preparing local drinks, baking injera, bread and making pastry for sale. However, women generally could not make decisions on how to use the income they generated from the improved energy technology on their own. Instead, they had to get permission from their husbands concerning how to spend their savings. As described by a woman interviewee from Mitsile Wagra *kebele* who wanted to buy a cookstove:

"The money belongs to the household […]. If the husband is not willing and does not understand her problems, she must justify her reason in front of the community elders to convince her husband and to get permission."

Concerning alienation rights, since the technologies have only been introduced recently in the study communities, we could not obtain robust insights on the right to transfer energy technologies by sale, lease, gift, or inheritance. However, in the above discussions and patterns of alienation rights over other assets owned by households, men were likely to dominate alienation rights.

5.2.Households' sources of energy for irrigation

Productive energy technologies are key to increasing farm productivity and overall rural wellbeing (Cabraal et al., 2005; Kaygusuz, 2011). The main productive energy technology in rural Ethiopia are motor pumps for lifting water for irrigation. Overall, and partly owing to the sampling design and focus on locations where irrigation is practiced, 63% of FGD participants reported irrigating one or more of their plots; this included 74% of men and 52% of women participants. About 49% of irrigators used motorized pumps for lifting water; however, only 20% of women used pumps to lift irrigation water, compared to 65% of men, highlighting a substantial gender gap in access to

productive use energy technologies. Furthermore, irrigation practices and pump use showed substantial regional variation with a wider gender gap seen in the north compared to the south (e.g., comparing Amhara to Sidama and SNNP). This apparently wider gap is largely driven by the fact that fewer farmers irrigate in the SNNP and Sidama areas, however, and therefore should not be perceived to indicate greater gender equality in the south (Figure 2).

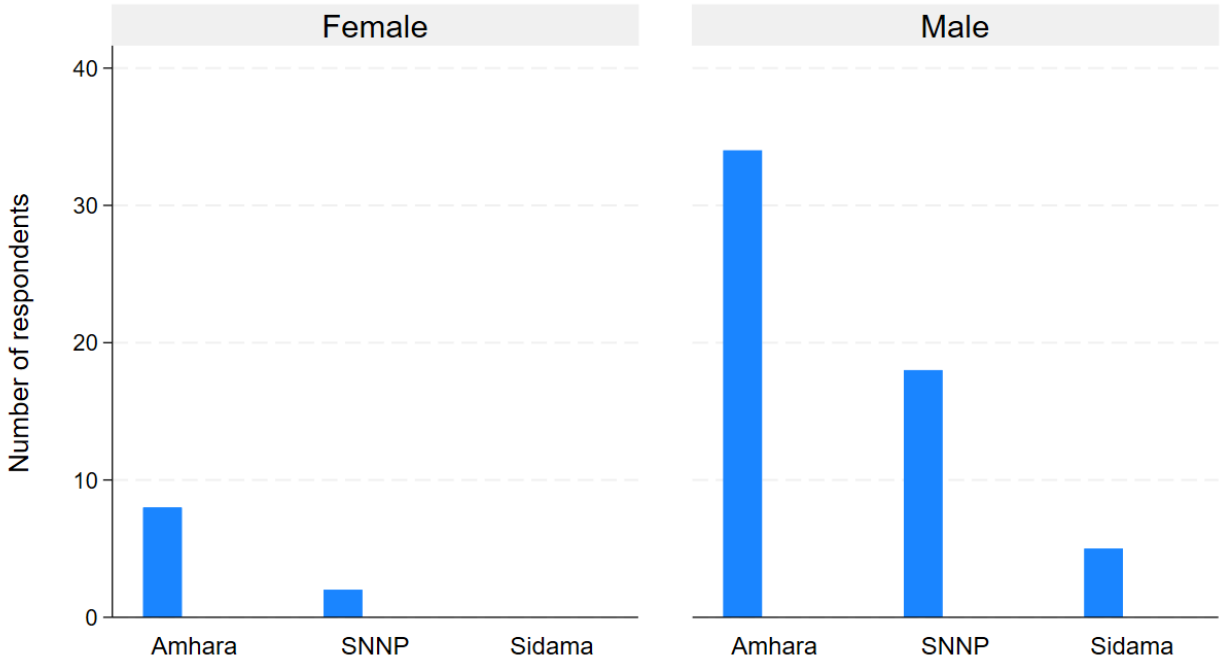


Figure 2: Pump ownership by sex and region

Source: Authors.

Across the study sites, FGD participants noted that diesel pumps were preferred across all pump types due to their greater capacity to irrigate large areas, the availability and affordability of diesel, their manageable fuel consumption, the availability of spare parts in the market, and their relative safety. This preference is likely due to the fact that farmers who purchase solar pumps can generally only afford under-sized pumps that irrigated smaller areas. However, gasoline pumps were noted to have preferred characteristics of lighter weight and lower maintenance costs compared to diesel pumps.

Pump ownership included both (i) private ownership by households and (ii) group ownership by groups of 3-5 farmers who jointly purchased a motor pump. Pumps were either directly purchased with existing funds or by taking loans from financial institutions. When pumps were owned by several farmers, they took turns using them.

"We purchased the motor pump by selling our produce, mainly rice. We usually harvest rice during December. To purchase a motor pump, sometimes farmers sell their crops at a low price. We bought a diesel-powered motor pump at a cost of 21000/22000 [Ethiopian] Birr and a 150-meter hose. Farmers who do not have the financial capacity to buy a motor pump as well as a 150-meter hose by themselves, they mobilize themselves and buy the equipment in groups to use it on a sharing basis. Another related problem is diesel. After we have the motor pumps and hoses, due to a shortage of diesel, the crops may be damaged. Because searching for and bringing back the diesel takes time." Men FGD, Wagetera kebele, Amhara region.

The gendered context of agricultural energy technology can be better understood by following the framework of technology adoption.

Awareness and Tryout

Uptake, adoption, operation, and management of irrigation equipment require substantial knowledge and skill training. Our results suggest a gender gap in all of these areas. In addition to gendered institutional, information, and knowledge-related constraints, women reported facing additional constraints in terms of access to information and formal training as a result of gender norms and traditions. The contact of married women with extension workers or their attendance at farming meetings is deemed unnecessary. This limits their awareness of energy technologies in the productive use space.

> *"It is not acceptable in our culture […] mostly women get information from us (from their husband) […] [a] married woman is not willing to participate in different meetings unless her husband is also part of the meeting. The husband doesn't feel comfortable even if she attends the meeting with his close friends. Women usually fear local taboos. For example, if my wife*

is invited to attend a meeting, she will not be willing to attend the meeting. However, different organizations advocate for equal participation of women in different meetings." Men FGD Gelawdewos kebele.

Some men indicated that women could participate in any meetings and that they could be as successful as men with irrigation. For example, a man from Gelawdewos *kebele* noted that *"we saw women in different meetings. If they get the chance, they can participate in different meetings."*

In male-headed households, however, women were generally not involved in the purchase of productive use energy technologies, a space that is controlled by men, who were also the ones typically able to obtain credit. Women also lacked sufficient time to seek and access information on how to obtain clean energy technologies for agricultural production.

In terms of deciding to try out the energy technology, in all the discussions, both men and women respondents reported that both the wife and the husband would usually consult and make a joint decision. Upon further probing, however, respondents of both genders explained that final decisions were typically made by men, even if there were prior discussions. Furthermore, men had the agency to make adoption decisions without consulting women when women were not around, whereas the opposite was not true... *"…she must not purchase without his agreement, it may result in a divorce. Though women may have a better know how, the final decision should be made by men."* (man farmer, Gelawdiwos *kebele*). Women's agency over agricultural technology uptake appears stronger when they are household heads, though such women also tend to face significant land, labor and financial constraints.

Adoption

One of the main problems leading to the low uptake of improved agricultural technologies is lack of finance. Men and women FGDs described a lack of access to credit for purchasing motor pumps. Financial institutions play a role in motor pump investments. To facilitate credit, the *woreda* agricultural office sometimes provided support letters to farmers. Even then, the credit facility was

not equally accessible to all irrigating farmers, and some farmers had to sell livestock to purchase motor pumps. For instance, FGD participants in Dera *woreda* emphasized that they bought motor pumps either by selling cattle or from what they had produced in the previous year using small-scale irrigation.

Use and management rights

By law, female- and male-headed households have equal rights to use irrigation water with whatever lift and application technology they choose. However, women in male-headed households are considered as secondary labor providers in agriculture. Their labor is needed even more in irrigating households due to the increased volume of agricultural activities linked to irrigation. Arrangements for access to and control over labor and the product of labor are crucial structuring principles in the intra-household organization of agricultural production. FGDs provided a series of reasons of why women were not operating motor pumps. These ranged from them not possessing the required skills; to the physical requirement to move and operate the pump; and the high cost of fuel to run the pump.

"Of course, it is not easy for a woman to do anything like men. Most women do not have even the capacity to buy a motor pump by themselves, they would ask for help from their male neighbors or relatives [...] They are not strong enough like men to carry the motor." Men FGD, Mitselle Wagra kebele

Management rights are directly related to the perception that men are the head of the household, and that they have every right to take decisions on agricultural inputs, including on the irrigation technology. Women are largely dependent on men for access to farmland. Women participating in the study considered themselves as secondary labor providers on the farm, and as the main role players in the domestic sphere. While use decisions reflected the gender distribution of labor in the household between domestic and productive responsibilities, the right to manage irrigation corresponded to the gendered division of agricultural labor.

"Women mostly participate when they are needed to create gender equality, otherwise, because everything needs capacity, men are more educated than women, [… and therefore] the agriculture sector [is] mostly inclined towards men." Men FGD, Miteselle Wagra kebele.

6. Interlinkages between domestic and productive energy access and use

Women's access to improved cookstoves can reduce their time poverty, allowing them to dedicate time to other activities, such as working in the field or with livestock (Krishnapriya et al., 2021). At the same time, solar lighting and other lighting technology was mentioned as expanding women's availability to allocate effort in the agricultural sphere, as domestic chores could instead be completed in the evening. As such, more reliable and cleaner energy access may help shift the traditional perception that women need to be sequestered in the household and fully occupied with domestic chores, though this may also lead to a phenomenon known as the "second shift" that increases their overall labor burdens (Das et al., 2023). Domestic energy "push" factors are complemented by productive use energy "pull" factors that enhance labor productivity in agriculture, based on enhanced production in the rainy season supported by more stable water supply, as well additional dry-season production. While women respondents noted that they would prefer to expand their mobility and sphere of operation into the agricultural production space, the doubling up of domestic and productive energy technologies might well further increase women's time poverty, without affecting men's time use.

A second theme is women's agency over energy technologies. While women reported having agency over the use of energy technologies related to cooking, when a change of energy technology is associated with a financial outlay, decision-making was dominated by men. This also applies when women generate income from improved energy technologies in the domestic sphere and highlights the wide gender gap related to agency over adoption and fructus rights over continued use of improved energy technologies.

A third theme relates to structural inequities that are pervasive and prevent women from benefitting equally from energy technologies. This includes women's more limited access to education, adult training opportunities, extension, finance, and decision-making over energy technologies. To

overcome these challenges and to assure that both women and men benefit equally from energy technologies, it is important to engage with both women and men on the benefits and challenges associated with changes in energy technologies. Highlighting the role of improving women's agency over energy technologies in generating benefits can help strengthen the case for such gendered interventions.

7. Conclusion and key lessons

The study described challenges around gendered energy awareness, adoption and continued use in three regions of rural Ethiopia. While adoption of improved stoves was found to be dominated by women, adoption of motor pumps for irrigation was dominated by men. But men were often involved in taking final decisions over energy technologies even in the domestic sphere and decided over the use of income from domestic energy technologies. Awareness, adoption and continued use of energy technology are thus highly gendered, in both the domestic and productive use domains. While men obtain information through formal channels and can access training opportunities on energy technologies, women farmers are more likely to obtain information through informal cultural or religious gatherings. Furthermore, norms and traditions limit women's agency and achievements in the energy technology space. Given women's dominance over cooking, they can often access improved cookstoves once these become available within a community. However, women are not fully able to make decisions over income generated using improved cookstoves.

These gender differences notwithstanding, it was striking to find that neither women nor men farmers participating in the study expressed much agency over the design, promotion and dissemination of alternative energy technologies in their communities. This is perhaps due to a lack of communication between developers of energy technologies and clients and is reflective of the high degree of energy poverty found in rural Ethiopia. Communication is similarly lacking between technology promoters and financial institutions and between financial institutions and farmers. Multistakeholder partnerships across these value chain actors could help increase access to clean energy technologies.

Indeed, the use of energy in rural areas remains limited, despite the fact that the number of irrigators is rising in some regions (and particularly high in our study sample). We identified significant differences between women and men farmers in terms of pump ownership in these locations. When households engage in irrigation, women spend substantial time supporting agricultural production, including planting, weeding, cultivation, sowing, irrigating, applying fertilizer, harvesting and marketing.

Despite the substantial engagement of women in both the domestic and agricultural spheres, women are typically less likely to benefit from modern energy technologies adopted by households outside of the domestic cooking domain. The findings imply that inclusive approaches are needed for enhancing gender equality and women's empowerment in rural energy use. Emphasis should be given to the inclusiveness of decision-making processes in rural energy use by bringing women to the forefront of decision-making processes in the design, promotion, dissemination, and use of alternative energy technologies. Putting in place inclusive processes for alternative energy technologies will not only contribute to gender-responsive designs but also improve the continued adoption of the technologies by rural communities. Moreover, dissemination of information should take a variety of approaches, such as reaching out to women through informal institutions and local meetings in addition to formal channels.

References

Addis Standard. 2023. News: Ethiopia ends import of diesel-powered water pumps in favor of solar, other green energy options. https://addisstandard.com/news-ethiopia-ends-import-of-diesel-powered-water-pumps-in-favor-of-solar-other-green-energy-options/ May 9.

Allouhi, A., Buker, M.S., El-houari, H., Boharb, A., Amine, M.B., Kousksou, T. and Jamil, A., 2019. PV water pumping systems for domestic uses in remote areas: Sizing process, simulation and economic evaluation. Renewable Energy 132: 798-812.

Annan, J., Donald, A., Goldstein, M., Gonzalez Martinez, P., and Koolwal, G., 2021. Taking power: Women's empowerment and household well-being in Sub-Saharan Africa. World Development 140. 105292.

Beyene, A.D. and Koch, S.F., 2013. Clean fuel-saving technology adoption in urban Ethiopia. *Energy economics*, *36*, pp.605-613.

Cabraal, R.A., Barnes, D.F. and Agarwal, S.G., 2005. Productive uses of energy for rural development. *Annu. Rev. Environ. Resour.*, *30*, pp.117-144.

Dagnachew, A.G., Lucas, P.L., Hof, A.F., Gernaat, D.E., de Boer, H.S. and van Vuuren, D.P., 2017. The role of decentralized systems in providing universal electricity access in Sub-Saharan Africa–A model-based approach. *Energy*, *139*, pp.184-195.

Das, I.; Klug, T.; Krishnapriya, P. P., Plutshack, V., Saparapa, R., Scott, S., Sills, E., Kara, N., Pattanayak, S.K., Jeuland, M., 2023. Frameworks, methods and evidence connecting modern domestic energy services and gender empowerment. *Nat. Energy*, *8*, 435–449.

Dyer, J. and Shapiro, J., 2023. Pumps, prosperity and household power: Experimental evidence on irrigation pumps and smallholder farmers in Kenya. *Journal of Development Economics*, *163*, p.103034.

Eshete, D. G., Sinshaw, B. G., and Legese, K. G., 2020. Critical review on improving irrigation water use efficiency: Advances, challenges, and opportunities in the Ethiopia context. *Water-Energy Nexus*, *3*, 143-154.

Eshete, G., Sonder, K. and ter Heegde, F., 2006. Report on the feasibility study of a national programme for domestic biogas in Ethiopia. *SNV Netherlands Development Organization: Addis Ababa, Ethiopia*.

Federal Democratic Republic of Ethiopia (FDRE), 2017. National Electrification Program Implementation Road Map and Financing Prospectus.

Foster, A.D., and Rosenzweig, M.R., 2010. Microeconomics of technology adoption. Annual Review of Economics 2: 395-424.

Gebreegziabher, Z., Mekonnen, A., Kassie, M. and Köhlin, G., 2012. Urban energy transition and technology adoption: The case of Tigrai, northern Ethiopia. *Energy Economics*, *34*(2), pp.410-418.

Gebregziabher, G., Giordano, M.A., Langan, S. and Namara, R.E., 2014. Economic analysis of factors influencing adoption of motor pumps in Ethiopia. *Journal of Development and Agricultural Economics*, *6*(12), pp.490-500.

Gebreslassie, M. G. 2022. Comparative assessment of the challenges faced by the solar energy industry in Ethiopia before and during the COVID-19 pandemic. *Wiley Interdisciplinary Reviews: Energy and Environment*, *11*(2), e418.

Getacher, T., Mesfin, A. and Gebre-Egziabher, G., 2013. Adoption and impacts of an irrigation technology: Evidence from household level data in Tigray, Northern Ethiopia. *African Journal of Agricultural Research*, *8*(38), pp.4766-4772.

Guta, D. D. 2020. Determinants of household use of energy-efficient and renewable energy technologies in rural Ethiopia. *Technology in Society*, *61*, 101249.

Guta, D.D., 2018. Determinants of household adoption of solar energy technology in rural Ethiopia. *Journal of cleaner production*, *204*, pp.193-204.

IEA, 2020. A policy framework for accelerating sustainable energy transitions in heavy industry, IEA, Paris https://www.iea.org/commentaries/a-policy-framework-for-accelerating-sustainable-energy-transitions-in-heavy-industry

IEA, 2022. Access to electricity: data and projection-Analysis. https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity (accessed on November 26, 2023)

IEA, IRENA, UNSD, World Bank, WHO. 2023. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC.

IEG (Independent Evaluation Group). 2008. "The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits." Working paper, Technical Report.

International Energy Agency (IEA), 2019. "World Energy Outlook 2019." Paris: International Energy Agency. https://www.iea.org/reports/world-energy-outlook-2019.

ITA (International Trade Administration) of the US Government. 2023. Ethiopia-Country commercial guide. https://www.trade.gov/country-commercial-guides/ethiopia-energy. Accessed December 28, 2023.

Kaygusuz, K., 2011. Energy services and energy poverty for sustainable rural development. *Renewable and sustainable energy reviews*, *15*(2), pp.936-947.

Krishnapriya, P.P., Chandrasekaran, M., Jeuland, M., and Pattanayak, S.K., 2021. Do improved cookstoves save time and improve gender outcomes? Evidence from six developing countries. *Energy Economics*, *102*, 105456.

Kumar, S., and G. Rauniyar. 2018. "The Impact of Rural Electrification on Income and Education: Evidence from Bhutan." *Review of Development Economics* 22: 1146–1165.

Lefore, N., Giordano, M., Ringler, C., and Barron, J., 2019. Sustainable and equitable growth in farmer-led irrigation in sub-Saharan Africa: What will it take? Water Alternatives (12)1: 156-168.

Magnan, N., K. Gulati, T. Lybbert, and D. Spielman. 2014. Gender dimensions of social networks and technology adoption in eastern Uttar Pradesh, India. http://cega.berkeley.edu/assets/cega_event s/61/3B_Role_of_Gender_in_Networks__Bargaining__and_ Employment.pdf

Mekonnen, B. A., Liyew, K. W., and Tigabu, M. T., 2020. Solar cooking in Ethiopia: Experimental testing and performance evaluation of SK14 solar cooker. *Case Studies in Thermal Engineering*, *22*, 100766

Mekonnen, D., Bryan, E., Alemu, T., and Ringler, C., 2017. Food versus Fuel: Examining Tradeoffs in the Allocation of Biomass Energy Sources to Domestic and Productive Uses in Ethiopia. Agricultural Economics. 48(4): 425-435

Mekonnen, D.K., Arega, T. and Yimam, S., 2022. Intra-household decisions on cookstove choices and impacts on the welfare of women and girls. *EEG Working Paper*.

Mohammed, Y.S., Mustafa, M.W. and Bashir, N., 2013. Status of renewable energy consumption and developmental challenges in Sub-Sahara Africa. *Renewable and Sustainable Energy Reviews*, *27*, pp.453-463.

Mueller, V. and Thurlow, J. 2019. Youth and jobs in rural Africa: Beyond stylized facts. New York: IFPRI and Oxford University Press.

Namara, R.E., Gebregziabher, G., Giordano, M. and De Fraiture, C., 2013. Small pumps and poor farmers in Sub-Saharan Africa: an assessment of current extent of use and poverty outreach. *Water International*, *38*(6), pp.827-839.

Nhamo, G., Nhemachena, C., Nhamo, S., Mjimba, V. and Savić, I., 2020. Energy poverty in the midst of plenty: a harsh reality for Sub-Saharan Africa. In *SDG7–Ensure Access to Affordable, Reliable, Sustainable and Modern Energy* (pp. 233-262). Emerald Publishing Limited.

Pillarisetti, A., Vaswani, M., Jack, D., Balakrishnan, K., Bates, M.N., Arora, N.K. and Smith, K.R., 2014. Patterns of stove usage after introduction of an advanced cookstove: the long-term application of household sensors. *Environmental science & technology*, *48*(24), pp.14525-14533.

Pine, K., Edwards, R., Masera, O., Schilmann, A., Marrón-Mares, A. and Riojas-Rodríguez, H., 2011. Adoption and use of improved biomass stoves in Rural Mexico. *Energy for sustainable development*, *15*(2), pp.176-183.

Pueyo, A., and Maestre, M. 2019. Linking energy access, gender and poverty: A review of the literature on productive uses of energy. *Energy Research & Social Science*, *53*, 170-181.

Ruiz-Mercado, I., Masera, O., Zamora, H. and Smith, K.R., 2011. Adoption and sustained use of improved cookstoves. *Energy policy*, *39*(12), pp.7557-7566.

Sarno, D. and Siano, P., 2022. Exploring the Adoption of Service-Dominant Logic as an Integrative Framework for Assessing Energy Transitions. *Sustainability*, *14*(15), p.9755.

Tesfay, A. H., Kahsay, M. B., and Nydal, O.J., 2014. Design and development of solar thermal Injera baking: steam based direct baking. *Energy Procedia*, *57*, 2946-2955.

Theis, S., Lefore, N., Meinzen-Dick, R., and Bryan, E., 2018. What happens after technology adoption? Gendered aspects of small-scale irrigation technologies in Ethiopia, Ghana, and Tanzania. *Agriculture and human values*, *35*, 671-684.

Tucho, G. T., and Nonhebel, S., 2017. Alternative energy supply system to a rural village in Ethiopia. *Energy, Sustainability and Society*, *7*(1), 1-14.

Van der Kroon, B., Brouwer, R., and Van Beukering, P.J., 2013. The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and sustainable energy reviews*, *20*, 504-513.

Wassie, Y. T., and Adaramola, M.S., 2021. Socio-economic and environmental impacts of rural electrification with Solar Photovoltaic systems: Evidence from southern Ethiopia. *Energy for Sustainable Development*, *60*, 52-66.

Wassie, Y.T., Rannestad, M.M., and Adaramola, M.S., 2021. Determinants of household energy choices in rural sub-Saharan Africa: An example from southern Ethiopia. Energy, 221, 119785.

Wiese, K. 2020. Energy 4 all? Investigating gendered energy justice implications of community-based micro-hydropower cooperatives in Ethiopia. *Innovation: The European Journal of Social Science Research*, *33*(2), 194-217.

Winther, T., Ulsrud, K., and Saini, A., 2018. Solar powered electricity access: Implications for women's empowerment in rural Kenya. *Energy research & social science*, *44*, 61-74.

World Bank, 2023. https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=ET.

World Economic Forum (WEF), 2018. Fostering Effective Energy Transition. A Fact-Based Framework to Support Decision-Making. Insight report (accessed on December 2, 2023) https://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_report_2018.pdf

Yalew, A.W. 2022. The Ethiopian energy sector and its implications for the SDGs and modeling. *Renewable and Sustainable Energy Transition*, *2*, 100018.

Zhang, A.T., Patnaik, S., Jha, S., Agrawal, S., Gould C. F. and Urpelainen, J., 2022. Evidence of multidimensional gender inequality in energy services from a large-scale household survey in India. *Nat Energy* **7**, 698–707. https://doi.org/10.1038/s41560-022-01044-3

Annexes

Table A1: Study sites

Region	Zone	Woreda	Kebele	Number of farmers
Amhara	South Gonder	Fogera	Wagetera	19
			Mitsile Wagra	20
		Dera	Alember	20
			Gelawdiwos	20
			Gibtsawit	19
			Tana Dinbiso	21
SNNP	Gamo Gofa	Arbamich Zuria	Ganta Meyiche	20
			Ganta kanchame	20
Sidama	Sidama	Shebedino	Asaredo Mero	20
			Morocho Negasha	20
Total	3 Zones	4 districts	10 kebele	199 farmers

Source: Authors.

Table A2: FGD participants cattle, land size and mobile ownership by gender

	Mean	Standard Error	[95% confidence interval]	
Number of cattle owned				
Women	7.83	0.45	6.95	8.71
Men	10.37	0.32	9.73	11.01
Land size in ha				
Women	7.66	0.35	7.01	8.30
Men	8.44	0.36	7.74	9.15
Mobile phone				
Women	0.39	0.05	0.29	0.49
Men	0.87	0.03	0.80	0.96
N				199

Source: Authors.

ALL IFPRI DISCUSSION PAPERS

All discussion papers are available **here**

They can be downloaded free of charge.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
www.ifpri.org

IFPRI HEADQUARTERS

1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org