CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems
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RESOURCE RECOVERY & REUSE SERIES: SPECIAL ISSUE

ISSN: 2478-0529

SPECIAL ISSUE

Recovering Bioenergy in Sub-Saharan Africa: Gender Dimensions, Lessons and Challenges

Edited by Mary Njenga and Ruth Mendum

Urban Food Plus

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Resource Recovery and Reuse (RRR) is a subprogram of the **CGIAR Research Program on Water, Land and Ecosystems (WLE)** dedicated to applied research on the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams. This subprogram aims to create impact through different lines of action research, including (i) developing and testing scalable RRR business models, (ii) assessing and mitigating risks from RRR for public health and the environment, (iii) supporting public and private entities with innovative approaches for the safe reuse of wastewater and organic waste, and (iv) improving rural-urban linkages and resource allocations while minimizing the negative urban footprint on the peri-urban environment. This subprogram works closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU) and many national and international partners across the globe. The RRR series of documents presents summaries and reviews of the subprogram's research and resulting application guidelines, targeting development experts and others in the research for development continuum.

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Recovering Bioenergy in Sub-Saharan Africa: Gender Dimensions, Lessons and Challenges

Edited by
Mary Njenga and Ruth Mendum

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Recommended citation

Njenga, M.; Mendum, R. (Eds.). 2018. *Recovering bioenergy in Sub-Saharan Africa: gender dimensions, lessons and challenges.* Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 96p. (Resource Recovery and Reuse: Special Issue). doi: 10.5337/2018.226

keywords

/ resource recovery / resource management / bioenergy / gender / role of women / equity / poverty / energy generation / energy demand / energy resources / renewable energy / cooking / heating / waste management / human wastes / excreta / fuels / briquettes / business enterprises / marketing / sanitation / urban areas / households / refugees / supply chain / production factors / health hazards / economic impact / biogas / biochar / biomass / investment / empowerment / living standards / farmers organizations / biodigesters / gasifiers / community involvement / research and development / case studies / Africa South of Sahara / Uganda / Ghana / Kenya /

ISSN 2478-0510 (Print)
e-ISSN 2478-0529 (Online)
ISBN 978-92-9090-877-7

Language editor: Robin Leslie
Designer: Julio César Martínez G.
Cover photo: Burning briquettes in a refugee camp in Northern Kenya
Photo credit: Takeshi Kuno

Acknowledgments

The editors would like to thank all the authors of the chapters for making this publication possible. The hard work carried out by the chapter reviewers is greatly appreciated. The guidance and input by Dr. Pay Drechsel (IWMI), the WLE Flagship leader and RRR series editor were most helpful. We would also like to acknowledge the participation of ICRAF scientists in the Eastern and Africa region in the survey presented in Chapter 10.

The publication received financial support from the project UrbanFoodPlus, co-funded by the German Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Economic Collaboration and Development (BMZ), under the initiative GlobE—Research for the Global Food Supply. While UrbanFoodPlus is analyzing the use of biochar for soil fertility enhancement and water purification, this study looks at biochar as fuel for food preparation based on examples from East and West Africa.

Thanks go to the CGIAR Research Program on Water, Land and Ecosystems (WLE), which supported (i) this output under its Rural-Urban Flagship program as well as (ii) Mary Njenga's participation at the Gender Research and Integrated Training (GRIT) events in June 2016 and June 2017 at Pennsylvania State University. Her participation at this two-year capacity development program supported by the CGIAR and implemented by Pennsylvania State University not only enhanced her skills in gender integration, but also established collaboration with Ruth Mendum, the co-editor. Further collaborations were established between the two editors, and the social and gender scientists who participated in the GRIT events and have been instrumental in reviewing the chapters of this document. Finally, the travel support provided to Ruth Mendum by the Office of International Programs, College of Agricultural Sciences, Pennsylvania State University for work in Africa is greatly appreciated.

Collaborators

International Water Management Institute

World Agroforestry Centre (ICRAF)

Office of International Programs, College of Agricultural Sciences, Pennsylvania State University.

Donors

This research was carried out as part of the CGIAR Research Program on Water, Land and Ecosystems (WLE) and supported by Funders contributing to the CGIAR Trust Fund (https://www.cgiar.org/funders/).

Source: ICRAF.

CONTENTS

FOREWORD

According to the World Energy Council, sub-Saharan Africa (SSA) accounts currently for 13% of the global population, but only 4% of the global energy consumption. Whereas in industrialized countries most energy consumed takes the form of electricity delivered through a centrally controlled grid, this is true only for a small portion of SSA.

In the absence of an electric grid or widespread use of forms of fossil fuels such as liquefied petroleum gas (LPG), roughly 750 million people in the region rely on the traditional use of low-cost biomass, which makes up about 60% of the energy consumed. This gives rise to a number of challenges, not least to the health of the women and children who collect the biomass or must suffer resulting indoor air pollution when it is burned for cooking.

Things are set to change though: In the coming decades, wind, photovoltaics and hydro-energy are likely to continue to grow their share of a growing energy 'pie' in SSA. Another new, promising source of energy is tapping the steadily growing volumes of waste, especially in urban centers where energy demand is highest. Such resource recovery and reuse opportunities at household or community levels offer both a complementary technical option, as well as a social benefit as waste-based fuel does not disrupt the decentralized, culturally acceptable cooking and heating systems that currently exist.

Decentralized, low-cost options for rural households can build on crop and forestry residues, animal or human manure or market waste, for the production of fuel pellets, briquettes or biogas. Such waste-based bioenergy sources have several distinct advantages over coal and wood because they are cleaner, nearly free from incombustibles, have lower ash and moisture contents, are easy to handle and are cost-effective. For example, using waste materials to supplement existing fuel systems protects women and low-income households from becoming dependent on energy sources requiring cash incomes. Using waste materials also allows entrepreneurs to operate in places where trees and shrubs are in short supply, while offering women and youth employment opportunities not requiring any particular education or larger start-up capital, except for biogas production. Although the waste-to-energy options are very promising the amounts of solid biomass energy produced may not meet the cooking and heating needs of the growing population and it is therefore equally important to improve on the wood-based energy systems.

The case studies in this document discuss a range of options available to improve biomass use, especially in locations and among populations who currently depend on conventional fuels like firewood or charcoal. They analyze implications for roles and responsibilities of men and women in the adoption of new technologies, looking carefully at initiatives that have the potential to increase women's bargaining power. The book concludes with placing the challenges and lessons learned into the larger context of gender integration in the field of Research for Development so as to discuss how barriers can be overcome. In sum, the book presents a highly valuable contribution to the management of the nexus of energy, food and natural resources, with a clear focus on gender roles and implications. While most answers will be context specific, the provided examples demonstrate that generalizable options exist to improve energy access, reduce waste, protect our soils and empower women.

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EXECUTIVE SUMMARY

Structure and approach

This document describes the role of gender in the recovery and reuse of organic resources for energy. The document comprises: chapter 1 (introduction); chapters 2 to 8 (seven case studies on resource recovery and reuse [RRR] for energy); chapter 9 (gender as a key in community participation); chapter 10 (challenges and solutions for gender integration in research and development (R&D); and chapter 11 (a summary of take home message on why gender matters in RRR for energy). The general chapters were written by researchers involved in gender work. The case studies were written by practitioners involved in projects relevant to the scope of the document who were provided with guidelines on how to focus their contributions. All chapters were reviewed by gender and social scientists, before being language edited.

Introduction

Chapter 1 introduces the nexus between gender and energy, women's roles in centralized and decentralized energy cooking systems, access to and use of cooking and heating energy and the predicted scenarios following sub-Saharan Africa (SSA) rapid urbanization. The chapter synthesizes information from the case studies and concludes that RRR for energy offers an alternative to conventional centralized grid projects which, while attractive to investors and large-scale enterprises, do not necessarily provide job opportunities for marginalized communities. Reusing locally available waste materials in small enterprises allows women and youth who lack business capital to begin modest, locally viable businesses. The case studies offer concrete examples of small-scale solutions to energy poverty that can make a significant difference to the lives of women and their communities, as opposed to large-scale interventions that would require unsustainable investment capital and expertise not always available among disenfranchised groups. Moreover, the relatively low-tech, low-overhead, local and regional businesses discussed here offer viable energy access in circumstances where consumers cannot yet afford centrally generated, grid-based energy. Rather than wait for some indeterminate moment in the future when incomes rise such that the majority of the population can afford electric or fossil fuel cookers, these various biomass-related approaches and the related financial and informational support services, offer a credible, pragmatic intervention that can be implemented using local resources, skills, time and cultural knowledge.

Chapter 2 discusses the use of charcoal briquettes made from human waste, a source of fuel that is attractive in impoverished urban and refugee conditions where other sources of biomass energy are unavailable. Charcoal briquettes are a solid fuel made from compacted carbonized (burned under controlled oxygen) dried biomass material which is used like firewood or charcoal. Charcoal briquettes from human waste have higher heat than firewood and burn with lower emissions than conventional wood charcoal. The chapter describes the enterprises by Sanivation in informal settlements in urban Naivasha, Kenya and Kakuma refugee camp in northwestern Kenya. The business model involves provision of urine-diverting dry toilets (UDDT) to households at a service fee of about USD 2.00 per month, most of the beneficiaries being single mothers/ladies who do not have to go out at night to use pit latrines and the faecal sludge goes into briquette production.

Chapter 3 presents experiences in charcoal briquette-production by Green Heat in Kampala, Uganda. The briquettes made by Green Heat are produced from agricultural waste that is carbonized (burned under controlled oxygen) by farmers using drum kilns, which are provided by the company on credit. The charcoal dust is

ground and mixed with molasses as a binder. The mixture is then compacted using electrical machinery and dried under the sun. The briquettes are sold in grocery kiosks mainly run by women, and the profit is shared between Green Heat and the sales agents at an agreed ratio.

Chapter 4, a case study by IWMI in Accra, Ghana, indicates that switching from firewood to briquettes by women fish smokers would result in savings of 10% on energy and 26% on expenditure on fuel. The highest level of education for the women fish smokers was secondary school; older women were less educated and ran large- to middle-scale businesses, while younger women were more educated but ran small-scale businesses due to lower ability to provide capital investments.

Chapter 5 is a case study of small-scale farmers in Embu County, Kenya who produce biogas from cattle waste for cooking; the bioslurry is used as biofertilizer or mixed with feed for pigs and poultry. The households have biodigesters installed in their homes by trained artisans/masons through an initiative by the Netherlands Development Program (SNV). Women have expressed the need to be trained as artisans/masons, skills that will help them to generate income and reduce dependence on hired masons for maintenance services. The biogas reduces expenditure on cooking fuel and frees up time for women, thus allowing them to be more involved in domestic chores and community development projects.

Chapter 6 is a case study based on research carried out in 2016 by IWMI and partners that assessed the gender dimension of the investment climate in waste-to-energy (WTE) (briquette, biogas) enterprises in Kenya. The enterprises were largely informal or casual and failed to make use of bank- and donor-supported funding opportunities. The study revealed that women entrepreneurs were less educated than their male counterparts and depended more on informal sources for capital such as from friends and family members for their enterprises. The women were found to be intimidated by the applications, procedures for borrowing money from banks or funds from funders. One good example that may work well for women who need to borrow money is the mobile phone lending system such as Mpesa which is highly successful in Kenya.

Chapter 7 describes women's participation in the improvement of cooking systems using biochar-producing gasifier cooking stoves that use firewood and crop residues as fuel in a project run by the World Agroforestry Centre (ICRAF) and partners in rural Kenya. The gasifier stoves burn under controlled oxygen delivery and produce charcoal/biochar as a by-product. The gasifier stoves save fuel and burn cleaner, thus improving the kitchen environment. The work also includes community training on the use of the gasifiers, and biochar for soil improvement. The chapter describes a process in which women, as the main household cooks, are part of the research team that studies the benefits and shortcomings of the new stove and how it fits into their cooking culture.

Chapter 8 describes how capacity development for women in renewable energy entrepreneurship is necessary if their involvement in higher profit sections of the value chain is to be achieved. The Partnership on Women's Entrepreneurship in Renewables (wPOWER) conducted a training of trainers course in Kenya for its partners from Kenya, Rwanda, Uganda, Tanzania, Nigeria and India on sustainable clean energy entrepreneurship. The 27 (18 women and nine men) graduates of the course conducted grassroots training, reaching 320 women and 33 men at the local level in seven counties in Kenya. Seven percent of the participants so far have launched their own businesses. Financial resources and level of education were the main factors that determined whether or not beneficiaries became involved in the business after undergoing training.

Chapter 9 reviews the critical role of gender in community participation. While it is generally agreed among development practitioners and researchers that community engagement and input are important, finding the time and funding to meaningfully engage inclusively with community members proves to be far more difficult. As early as 2001, Argwal's work outlined the six levels of community involvement beginning with nominal participation and ending with interactive engagement. In instances where reaching all members of a given community may be constrained by strict gendered social roles, achieving interactive engagement requires time to build trust and establish ground rules that respect existing social norms and allow some room to consider integrating helpful interventions. At its core, development as a concept presumes that technological and economic interventions produce positive and desirable social change. While this may sometimes be true, in other instances, especially in projects that touch on the intimate sphere that is the household, technologies or practices that alter long-held cultural norms, may be met with fierce resistance or utterly apathy. One clear example of this challenge in the energy arena is the history of improved cookstoves which have simply not been adopted in large numbers despite considerable investments by donors. This means that projects which seek to improve living conditions by reducing household energy poverty, must set aside considerable time and funding to understand the diversity of views that every community is built of, before attempting to alter the fabric of social relationships. Even projects such as the Green Heat initiative in Uganda which capitalizes on women's knowledge of cooking as preparation for sales jobs, struggle with women's needs to fulfil domestic duties in ways that limit their working lives. The attitudes and cultural norms around gender roles and appropriate behaviour for gendered classes of people impact researchers as well as energy practitioners.

Chapter 10 analyzes information presented in the case studies and existing literature and in addition the chapter makes use of the results of a quick survey conducted in August 2018 among ICRAF researchers working in the Eastern and Southern Africa (ESAf) region who identified the challenges they face in integrating gender in their work and their proposed solutions. The researchers gave ten possible barriers to integrating gender issues into their work, including for example such important issues as education levels and land tenure patterns. By far the most significant issue according to these experienced working researchers, was culture and mindset. This outcome points to the painful reality that our capacity to produce innovative products, new technologies or even effective policies, can be undermined if we do not take the time to learn what matters to others and the logic that supports their belief systems. Even among research teams, culture and mindset, in particular the tolerance for social change, remain a heated issue.

Chapter 11 synthesizes take-away messages on how RRR for energy presents opportunities for simple innovations in cooking energy with benefits that remain in the communities and regions they serve. The most powerful message is that of hope and optimism. Energy poverty constrains the ability of individuals and communities to flourish in ways that are sometimes less visible to outsiders. The scope of the problem is exemplified by underserved areas like SSA and rural India just to name a few regions underserved by the existing energy markets, and can seem demoralizing and overwhelming. At the household level, the public health impacts of unimproved biomass use affects millions of women and children. Despite these facts, the case studies shared in this document offer a variety of practical, successful models for addressing energy poverty in a manner that is both sensitive to community norms and economic capacities while at the same time, allows some wiggle room for women to expand their working lives. There may come a day when all human communities are served by robust, large-scale grid-based energy systems that everyone can afford. On the other hand, decentralized, renewable, waste-reducing approaches may fill the energy poverty gaps in ways that do not contribute to climate change by using fossil fuels.

Source: ICRAF.

Source: Gitau J./ICRAF.

CHAPTER 1

Gender and Energy and the Rationale for Resource Recovery and Reuse (RRR) for Energy

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1.1 Placing Gender and Energy in Dialogue

A common conception of energy in the modern world is of a centralized system, linked to a grid with large energy production facilities fired by fossil fuels supplemented by renewable sources such as large-scale wind farms, hydrogeneration plants attached to dams or industrial solar installations (Sovacool 2016; Burger et al. 2011; Capellán-Pérez et al. 2017; Anderson 2016). These large-scale systems are conceived of as neutral, disembodied technological models of progress because they supply energy indiscriminately to private residences, governments and industry. This easily leads to the illusion that power itself is a sociocultural neutral force that various types of people (men, women, youth, the elderly) simply use as their needs and wants dictate. By assuming a rhetoric of choice for individual users this hides how commercial energy systems impose certain requirements on their users such as the need to purchase and maintain devices like stoves, washing machines or heaters. In addition, it disguises how the cultural positions of particular groups differ, for example the impact of paying the electricity bill; individuals are affected differently depending on their access to financial technologies, space and resources.

Globally, women's employment has mostly taken place in the informal or unpaid sector. Informal care work for children and the elderly, cooking food and general housework are jobs typically done by women that go unremunerated and can place women outside of infrastructures to access large-scale energy systems. Thus, by paying attention to who has access to what types of energy are needed for daily life and how they access their energy needs can illustrate the gendered relationships and social norms that are structuring energy use or dis-use beyond the flick of a switch.

1.2 Gender and Energy in the Global South

In much of the southern hemisphere, Latin America, sub-Saharan Africa, Southeast Asia and some rural parts of China, the grid infrastructure used elsewhere has not been fully created and implemented (Hou et al. 2018; Bonjour et al. 2013; Mensah and Adu 2015; Chikulo 2014). Industrial and home energy tends to be generated locally or regionally (Burger et al. 2011). In many of these locations, an energy

grid may be used for specific purposes: lighting, cell phone charging and entertainment and may encompass as few as five-to-ten up to hundreds or thousands of customers. However, in many communities the private or public energy grids may not be affordable or accessible to all community members. Thus, the core energy use within the home, such as cooking and, when necessary, heating, tends to be achieved using traditional biomass sources: firewood, charcoal and sometimes dung by women or other subordinated individuals. In communities where decentralized energy production is the norm, their energy systems support fundamentally more different social infrastructures than the typical market economy model. For example, a grid-based system frees all users from needing to allocate household time to the sourcing of fuel. Energy access thus becomes a consumer product that is delivered in exchange for money but requires no direct effort. At the same time, the ability to purchase energy morphs quickly into the need to generate sufficient income to pay for centralized energy which may fall equally on men and women or disproportionally on the male or female head of a household, depending on cultural gender norms. The option to individually substitute unpaid household labor for cash is reduced and can mitigate the burden on women who typically do the unpaid household labor. The decentralized energy system, depending upon the biomass used, requires significant time of the user, who is frequently a woman, to find, carry, store and prepare the fuel for use. Cooking time may itself be constrained by the necessity to haul firewood by back, for example. The physical burdens of the woodfuel system seem extreme when compared to centralized energy and yet, one very real benefit of such a system is the relatively low cash price. Depending on the cost and accessibility of centralized energy the impact on men and women's lives is quite different and cannot be assumed to be neutral and affecting all users equally.

1.3 Provisioning vs. Use of Cooking and Heating Energy

When we consider energy provisioning and use, the question of who is primarily responsible for activities that require energy needs to be at the forefront of our considerations. In centralized systems, those who acquire energy may be separated from those who use it. For example, if energy acquisition is primarily a function of paying for access, any individual who earns money and contributes to household expenses can be said to be involved in the energy acquisition process. If household members include those who earn paid incomes and those who do not, the division may emerge between those who purchase energy and those who consume it. Another way to think about this would be, if one joins a centralized, monetized energy system, an electric grid, for example, the cost of buying electricity may shift from women who keep biomass fires burning for lighting, to men who earn formal incomes.

By contrast, when energy provisioning is decentralized to the household level, as is frequently the case in homes where biomass is the primary or exclusive energy source, the responsibility for fuel acquisition may fall more closely on the shoulders of those who are designated as responsible for household maintenance. It is important to note that this reality can play out in many ways. It may be that biomass must be purchased even when it is used at the household level and thus, as with centralized systems, those who earn an income will carry primary responsibility for obtaining energy needed by everyone. If, however, a source of biomass is available that does not cost money, the responsibility for acquisition may shift to household members who are not wage earners and who thus can be understood to have free time. It is critical to understand that non-wage-earning individuals' efforts constitute a cost, even if this cost is discounted or undervalued by others. Children, for example, who spend time collecting firewood for home cooking use, could be spending time on a less burdensome and potentially dangerous chore when they could be more fruitfully occupied in studying or gaining mastery in a trade or other skillset. Similarly, in circumstances where women are farm laborers who on any given day may not be able to find paid employment, the time they spend collecting firewood may go unrecognized as contributing resources to the households' well-being and decrease their social status in the family.

Collecting fallen wood is a common source of firewood in biomass-using regions. Women who are engaged in unpaid childcare, home maintenance and cooking for their families, are frequently the family members designated to collect fuel as well as how to use it. In these cases, switching from biomass energy to a centralized energy system such as electricity, has far ranging implications. If electricity requires payment, switching energy sources means shifting costs from the labor of the firewood collector to the pocketbook of the income-earning household members. If local norms are such that women are generally responsible for the home and men tend to earn more or be more frequently employed, a shift in energy type means a fundamental shift in gender responsivities and roles. Alternatively, in households where adults are single, a shift in energy use requires that the household be certain that it can continuously obtain sufficient income to pay the bill. Moreover, the bill may include specialized cooking and/or heating appliances which carry an up-front cost as well as ongoing maintenance expenditures. By contrast, the traditional open fire requires little cash input, and allows the user to maintain an autonomous sphere of influence.

While firewood is mainly used in rural areas, charcoal on the other hand is a primary source of cooking and heating fuel for urban and peri-urban households and is also used for small-scale businesses such as restaurants, bakeries and street food stands (FAO 2017). Charcoal is a clear illustration

of a resource that sustains rural-urban linkages as it is mainly sourced from rural areas. The demand for charcoal is predicted to grow in sub-Saharan Africa (SSA) especially given that the population living in urban areas is predicted to rise from 36% in 2010 to 50% by 2030 (The World Bank 2014). Households spend a lot of money purchasing charcoal; for instance a third of the urban household income is spent on charcoal alone in Kampala, Uganda (RoU MEMD 2016). This implies that poor families spend much income on cooking energy at the expense of other basic needs such as food. This necessitates the development of innovations for cheaper and cleaner sources of cooking and heating energy in urban areas and as well as to reduce pressure on tree resources. Briquetting organic wastes/resources has been proposed as one option for alternative or supplementary biomass energy (FAO 2017). Women's participation along the energy supply chain is mainly small scale and largely informal with minimal benefits; as such capacity development aimed at women's empowerment is warranted.

1.4 Rationale for RRR for Energy

Although using biomass can maintain existing arenas of gender-determined responsibility, an increase in cooking and heating households with traditional open-fire technology has implications for public, individual and environmental health. As the case studies that follow show, open fire use of firewood or charcoal cause public health and environmental damage when sustainable harvesting practices are not followed. Less commonly cited is the physical damage to the bodies of generally women and children but also low-income men in some instances, who haul wood over long distances. Charcoal, the most favored woodfuel for urban populations, produces particularly noxious fumes and is increasingly becoming more expensive.

The case studies demonstrate that it is possible to improve woodfuel (charcoal and firewood) systems in a number of ways without disrupting the decentralized, culturally acceptable cooking and heating systems that currently exist. The key to these improvements is the focus on using various kinds of waste materials to generate biomass fuels that are cleaner, less expensive, less damaging to the environment and cost effective. As a significant additional benefit, using waste materials provides a range of benefits to women and children who might not be as well served by centralized systems. Using waste materials allows producers to operate in places where trees and shrubs are in short supply. By using an input which is typically something to be disposed of keeps the cost of production low. This lower cost enables women who earn very little to easily shift to biomass alternatives without requiring additional cash resources that their current circumstances prohibit.

In some communities where wood is scarce, such as in a refugee camp, collecting woodfuel puts women and children at risk from violence. If they can use alternative forms of biomass that are immediately available within their existing space, the risk of gender violence decreases. For example, having a way to produce a burnable product from their own human excrement would prevent refugees, especially women and children, from having to go out and to use pit latrines at night and give them an input for biomass energy; this technology would decrease risk and increase access to cooking energy. Briquette enterprises offer women and youth employment opportunities and a source of income especially in informal urban settlements that typically suffer from higher levels of poverty (Njenga et al. 2013). Recovering energy from organic waste in these settings that often have poor sanitation and garbage collection services would also contribute to improving the health of the community. Additionally, the use of an improved cookstove for some portion of the cooking process reduces the amount of firewood needed and improves soil productivity.

Using waste materials to supplement and enhance existing biomass systems protects women and low-income households from becoming dependent on energy sources requiring cash incomes. While all household members benefit when smoke levels decrease, and energy collection takes less family time, women in particular are favored economically and physically from improved biomass systems that focus on recycling and reuse. Despite the contributions made by small-scale waste-to-energy enterprises such as those making briquettes, they are largely informal, poorly funded and mainly run by women with low education levels and poor access to resources (Njenga et al. 2013). Nevertheless, the low capital requirements of these enterprises allow women with extremely limited incomes to start businesses with little or no capital at all. Further these types of enterprises give women the power to make decisions and run low-risk businesses with benefits going directly to their households.

Further use of cleaner fuel, such as the use of biogas produced from animal waste in rural settings, promotes men's participation in cooking, thus reducing women's workloads. Although the installation capital is high it has multiple benefits in the long run. In rural Kenya, average, expenditure on firewood declined 71% per household per week among biogas users (Dohoo et al. 2013). Other reduced household expenses include those on chemical fertilizers and medical expenses from illnesses associated with indoor air pollution (Smith 2012).

The case studies in this document discuss a range of options available to improve biomass use in locations and among populations who currently depend on conventional fuels like firewood or charcoal. In addition, they take into consideration local gender norms by analyzing implications for roles and responsibilities of men and women in the adoption of new technologies. While specific contexts inform each organization and approach, these examples demonstrate that options exist to improve energy access, reduce waste and empower women.

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Source: ICRAF.

CHAPTER 2

Human Waste-to-fuel Briquettes as a Sanitation and Energy Solution for Refugee Camps and Informal Urban Settlements

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2.1 Introduction

2.1.1 Fuel and sanitation situation in the urbanizing town of Naivasha, Kenya

Urban communities in Kenya face the challenges of access to improved sanitation and affordable clean fuel that result in negative implications on health, dignity, food and nutrition security, and the environment. Improved sanitation includes flush, pour-flush toilets connected to a piped system, septic tanks, ventilated improved pit (VIP) latrines and pit latrines (Ministry of Health, Republic of Kenya 2016). For example, the sewerage coverage is estimated at only about 12% with a dismal 5% of the national wastewater being effectively treated (Gakubia et al. 2010). In poor urban settlements, less than 20% of the population has access to sanitation and 80% of facilities are shallow pit latrines that contribute to pollution of the environment (Ministry of Health, Republic of Kenya 2016). In rural areas 32% of the population has access to improved sanitation of which 72% has predominantly simple pit latrines providing varied degrees of safety, hygiene and privacy.

At the same time, over 80% of urban households in Kenya rely on charcoal and unfortunately most of it is unsustainably produced as 99% of charcoal producers use inefficient kilns (Mutimba and Barasa 2005). This is of great concern in the face of climate change where 6-9 kilograms (kg) of CO_2 eq. is emitted during the production cycle of 1 kg charcoal using inefficient systems (FAO 2017). With families spending up to 30% of their income on fuel, alternative solutions for both sanitation services and fuel are in high demand (Sanivation 2016). As with sanitation, there is a high charcoal demand in Naivasha estimated at over 3,000 tons month^{-1} (Sanivation 2016). Households purchase charcoal from local retailers, who, in turn, buy from distributors. Charcoal prices fluctuate from as low as USD 0.30 kg^{-1} to as high as USD 0.60 kg^{-1} depending on the time of year and the current supply (Sanivation 2016). Because of these market dynamics, there is a need for a new fuel source that fits into the current cooking culture, primarily Kenyan cooking stoves, and that is consistent in price, quality and supply.

With a population of 180,000 expected to increase to 200,000+ by 2018, Naivasha lacks an efficient sanitation

infrastructure to support its growing population. Naivasha's employed population earns about USD 135 month^{-1} primarily working at local flower farms and residing in poor and high-density settlements. Even though 89% of the population uses on-site sanitation, the local wastewater treatment plant is operational for only 25% of the time (Bohnert forthcoming), leaving most of the population exposed to disease from untreated waste.

2.1.2 Fuel and sanitation challenges in Kakuma Refugee Camp

Sub-Saharan Africa (SSA) generates and hosts the world's largest refugee population. Over 4 million refugees were hosted in the region by the end of 2015, equivalent to about a quarter of the total refugee population under the United Nations High Commission for Refugees (UNHCR) mandate and more than half (2.7 million) were hosted in the East and Horn of Africa region (UNHCR 2016). By then Kenya was ranked seventh in the world, hosting 553,900 refugees of which more than 60% was female and 70% children (UNHCR 2016). Kakuma Refugee Camp, the second largest camp in Kenya, is located in northwestern Kenya in Turkana County. It was opened in 1992 to host a population of 100,000 people, but by early 2018 the number was about 147,240 registered refugees and asylum-seekers, exceeding its capacity by far (UNHCR 2018). The impact of the Kakuma Refugee Camp has been excessive pressure on available resources and both internal and external space within the camp. There has also been notable conflict with the host community due to, among other factors, competition for resources including job opportunities and the role of aid that mainly supports refugees which induces envy by host communities (KISEDP 2017). The UNHCR in collaboration with local NGOs distributes firewood which is brought in from as far as 120 kilometers (km) away (UNHCR 2015). This is a major environmental concern in this arid and semi-arid land. However, the firewood offered to the refugees is scant and women, desperate to put food on the table for their families, exchange maize sufficient to feed the family for five days with firewood that could cook three days' worth of meals (Mendum and Njenga 2018). Another coping strategy is families skipping meals. About 97% of women, who disproportionately bear the burden of fuel collection, wander outside of the camp to collect firewood risking sexual violence and assault. (UNHCR 2015). Cooking with firewood poses severe health consequences with smoke-induced diseases causing 4.3 million deaths worldwide each year (Lim and Vos 2012).

Sanitation is a challenge as most of Kakuma's population relies on pit latrines as their sanitation solution. As these latrines fill, the waste stays in the ground posing a public health threat. In addition, new pit latrines must be dug every one to two years, putting great financial strain on refugees and the little remaining space there is in the camp. The UNHCR and implementing partners provide the supplies for constructing the new pit latrines, costing approximately USD 100 latrine^{-1} year^{-1} in protracted settings like that of Kakuma Refugee Camp (UNHCR 2015). Refugees, however, either have to dig their own pit or pay for the digging service, a service which few can afford. The human waste-to-charcoal briquettes innovation, as discussed later, contributes to the development of affordable and sustainable cooking fuel while improving sanitation services, making refugee and urban informal settlements more habitable.

The human waste-to-charcoal briquettes innovation comprises:

(i) Provision of sanitation service through the installation of urine-diverting dry toilets (UDDTs) in dwellings and
(ii) The waste-to-fuel briquettes innovation.

The aim of the innovation is to improve sanitation and hygiene, enhance access to affordable cleaner energy, create employment for local communities and generate income for the local community and the Sanivation company. This case study illustrates gendered participation and benefits for men and women from adopting the human waste-to-charcoal briquettes innovation to exemplify women and youth empowerment in humanitarian situations and urban high density informal settlements.

2.2 Background on Sanivation's Human Waste-to-fuel Briquette Innovation

2.2.1 About Sanivation

Sanivation is a sanitation social enterprise established in 2014 and headquartered in Naivasha. The organization is committed to providing cost-effective waste-processing services and sustainable fuels in refugee camps and urbanizing communities. "Could I cook on this?" was a question posed to Sanivation's co-founder Emily Woods when she was using a solar concentrator as a means to render human waste safe for reuse. The question made Woods realize that by converting human waste into a biomass fuel, she could solve two problems: 1) the lack of incentives for safe disposal of human waste and 2) the lack of access to sustainable biomass fuels. She, and her co-founder Andrew Foote, proceeded to develop an aspirational, sustainable fuel product from one of the world's oldest renewable sources – human faeces referred to as 'human waste' in the associated charcoal briquette innovation.

To address the demand for sanitation services, Sanivation established and operates fuel factories in urban communities and refugee camps to produce and sell a more affordable and cleaner fuel than wood charcoal. At these factories, Sanivation uses two abundant waste streams to make the charcoal briquettes: fecal sludge and carbonized biomass

residues. Individually, each of these waste products has little value, but together, with the right processing, they can make an aspirational fuel valued at over USD 200 ton^{-1}.

Since its establishment in 2014, Sanivation has already launched two fuel factories, one in the rapidly urbanizing low-income neighborhoods in Naivasha, and the other in Kakuma Refugee Camp in northwestern Kenya. Through these operations, in total, Sanivation has so far treated and transformed 59 tons of waste, sold over 300 tons of charcoal briquettes and achieved a fuel production rate of 20 tons per month. Because of Sanivation's market-based approach, it is able to create employment opportunities, with 74 staff of which 49 are men and 25 are women, in both Kakuma and Naivasha. Included is a paid team of 18 refugees. Sanivation's female employees significantly contribute to the entire sanitation value chain – from installing toilets in people's homes to waste treatment and briquette production to selling briquettes. As women and children are disproportionately affected by the unimproved sanitation conditions and traditional charcoal use, Sanivation focuses on and employs women to design and implement solutions that better meet their needs.

2.2.2 *Gender roles in processing human waste-derived briquettes and the quality of the product*

The charcoal briquette supply chain involves provisioning of UDDT human waste collection and treatment/processing, charcoal briquette production, packaging and sale (Figures 2.1-2.3, Figure 2.5).

FIGURE 2.1. THE THREE MAIN ASPECTS OF HUMAN FECAL-SLUDGE-TO-BRIQUETTES PROCESSING

Sanivation partners with local governments and households in informal settlements in Naivasha and refugee camps for implementation of human waste-to-fuel factories. The households provide Sanivation with human faeces through use of container-based UDDTs that separate fecal material and urine (Figure 2.2a.) In Naivasha, currently, the faeces are collected from households located in Karagita and Mirera informal settlements that have subscribed to Sanivation's sanitation service. While Sanivation's clientele base is diverse, most clients are single mothers. In these households, Sanivation installs and services the UDDTs which are managed by women and the household pays about USD 2.00 per month. Twice weekly, trained Sanivation staff collect the waste and transport it to the fuel factory.

FIGURE 2.2. (A) A WOMAN DISPLAYS HER HOUSEHOLD'S UDDT IN KARAGITA AND **(B)** THE SANIVATION'S FUEL FACTORY IN NAIVASHA, KENYA.

Source: Sanivation. **A**

Source: Sanivation. **B**

For the work in Kakuma Refugee Camp, Sanivation received funding of USD 350,000 in 2016 from the Bill and Melinda Gates Foundation under a contract with the UNHCR. The aim was to capture energy value in human and other organic wastes contributing to improved fuel supply and sanitation. The funds were spent on the building of a fuel factory at Kakuma Refugee Camp. A similar model that was applied in Naivasha is used in the refugee camp in sourcing human waste where the UDDTs are provided to households in the camp and the waste is collected twice a week.

At each location, the fecal waste is transported to Sanivation's centralized fuel factory. The faeces are treated, while the urine enters a soak pit. Within a day, the fecal material is treated, turning it into a safe binding agent for briquette use. Sanivation uses a patent-pending solar-thermal process to treat the faeces at the factory which are then used as binding agent (Figure 2.2b). Sanivation collaborated with the Centers for Disease Control and Prevention (CDCP) in Atlanta, USA to test the effectiveness of the treatment system to ensure that the faeces are rendered safe for reuse.

The charcoal dust, which is considered waste as it cannot be used in its current form, on the other hand is sourced from charcoal traders. Sanivation management is pleased that various organizations such as the Food and Agriculture Organization of the United Nations (FAO) are working with communities to ensure sustainable charcoal production through improved tree management and use of improved kilns (FAO 2017). Charcoal dust or the carbonized biomass residue is crushed into a fine dust using a hammermill. The charcoal fines are then combined with treated human waste and compacted into ball-shaped briquettes, each piece weighing about 10 grams (g) (Figure 2.3). Young men are involved in the pressing and ringing while young women are involved in packaging.

FIGURE 2.3. (A) PROCESSING BRIQUETTES IN KAKUMA USING AN AGROMERATOR, **(B)** BRIQUETTES BEING DRIED IN KAKUMA, **(C)** PACKAGED AND BRANDED BRIQUETTES, **(D)** BRIQUETTE BURNING.

Source: Sanivation. **A**

Source: Sanivation. **B**

Source: Sanivation. **C**

Source: Sanivation. **D**

Sanivation processes faeces collected from 2,000 people per month and each factory has the capacity to produce 50 tons of charcoal briquettes monthly. The company, however, produces an average of 20 tons of briquettes per month which is 50% below the capacity due to the volume of faeces that is collected. As Sanivation scales up sourcing of raw materials, each factory's capacities will be met. This process contributes to providing collection and treatment of fecal sludge, thus offering poor households safe sanitation services, especially for women and children who otherwise risk assault when they have to visit pit latrines at night. It also treats human waste that would otherwise be dumped into the environment in the open or in pit latrines.

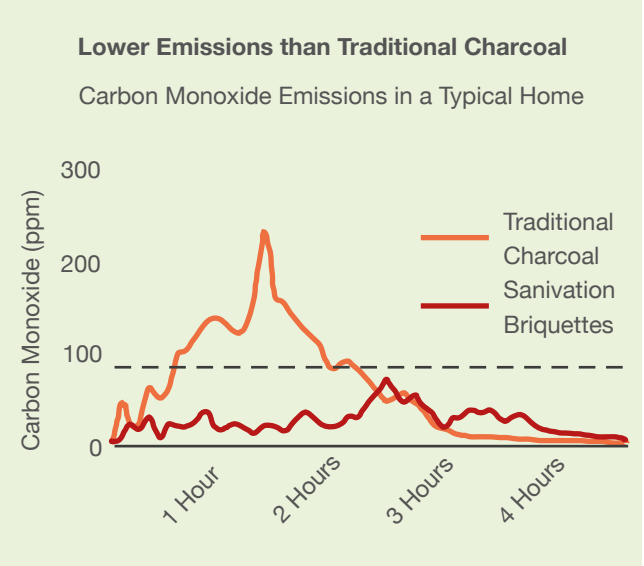
Before they were branded, the briquettes went through a quality assessment at the University of Nairobi for emissions, the Kenya Forestry Research Institute (KEFRI) for combustion properties and latterly the Massachusetts Institute of Technology (MIT). The combustion quality including energy expressed in terms of calorific value produced, ash content and volatile matter of the charcoal+human waste briquettes produced by Sanivation is better compared to that of the charcoal+soil briquettes produced by women's groups in Kibera slum, Nairobi, Kenya (Njenga et al. 2013; Table 2.1). The lower energy and higher ash content in charcoal+soil waste briquettes could be attributable to the non-combustible properties of the soil which was used as a binding agent by the women's groups. The calorific value of the briquettes compared well with that of firewood 14 kJ g^{-1} from various tree species (Fuwape 1993). Hence briquettes are a good source of cooking energy to complement or replace firewood which is the main source of cooking energy in the refugee camps in northwestern Kenya.

TABLE 2.1. QUALITY OF CHARCOAL+HUMAN WASTE BRIQUETTES COMPARED TO CHARCOAL+SOIL BRIQUETTES

	Charcoal+human waste briquettes*	Charcoal+soil briquettes#
Calorific value (kJ g^{-1})	15	13.5
Volatile matter (%)	14.1	18.7
Ash (content)	28.3	34.9

The charcoal+human waste briquettes burn with much lower indoor concentrations of carbon monoxide (CO) compared to traditional charcoal (Figure 2.4) which could be due to the lower carbon content, which is reduced by using human waste as a binder. Sanivation's briquette has been certified by the Kenyan National Environmental Management Authority (NEMA) and the Kenya Bureau of Standards (KBS). This briquette product is currently undergoing testing, in collaboration with the CDCP, to assess if there are any additional health risks with using the briquettes for cooking indoors; however, no data are available to date.

FIGURE 2.4. CO INDOOR CONCENTRATIONS FROM THE CHARCOAL-HUMAN WASTE BRIQUETTES COMPARED TO TRADITIONAL CHARCOAL.



To address health risks that might be associated with use of fecal sludge in briquette production, Sanivation collaborated with the CDCP to test the effectiveness of the treatment system. The results showed effective inactivation of pathogens, like *Escherichia coli* and *Ascaris suum,* in the faeces with the treatment system set at temperatures higher than 73°C for an hour.

2.3 Marketing of the Fuel Derived from Human Waste

Initially, Sanivation began selling the briquettes to small businesses, including restaurants and supermarkets, in order to refine the fuel and demonstrate uptake for a fuel derived from waste products. After selling 70 tons of fuel to small businesses, a superior product called *MaKaa ya Jamii* (Charcoal for the Family) which has been optimized for household use, was launched. Through a door-to-door sales strategy, Sanivation is reaching households in low-income neighborhoods throughout Naivasha. Customers prefer the fuel briquettes compared to traditional charcoal due to their longer burning period and less smoke generated, consequently contributing to savings in income and an improved kitchen environment with a potential positive impact on health and the environment.

In Kakuma Refugee Camp, Sanivation sells the charcoal briquettes to refugee households. As a result, the organization is developing a pull sales strategy – it has already seen customers coming from across the camp to request the briquettes. After nine months of operation in the camp, Sanivation has demonstrated that over a ten-year lifespan, a waste-to-value approach not only is more cost-effective but has the potential to reduce the cost of pit latrines by about 50% (USD 42 $household^{-1}$ $year^{-1}$ compared to USD 88 $household^{-1}$ $year^{-1}$). The Sanivation model demonstrates

that the refugees can pay for the product if it is available at an affordable price. The briquettes cost about a third, KES 15-20 (USD 0.15-0.20) kg^{-1}, compared to charcoal at KES 60 (USD 0.60) kg^{-1}, which enables the end-users to save on cooking energy cost. Refugees are not only searching for affordable firewood alternatives, they are paying for them. The briquettes help to reduce the cooking energy poverty experienced by refugees as they only receive about 10-20% of their fuel needs from the UNHCR. The other benefit of using Sanivation's briquettes is that they are saved from the drudgery of collecting firewood from the neighboring woodlands. The briquettes can be used with current cooking infrastructure and require minimum behavioral change.

The company sells the briquettes through door-to-door sales, an activity that is carried out by women who are hired by Sanivation or through retailers who own kiosks and are mainly young men (Figure 2.5). Along with charcoal, these retailers sell other products like groceries and toiletries. Sanivation sells the briquettes for KES 20 kg^{-1} and the retailers resell at their own decided price (usually KES 25 kg^{-1}) compared to charcoal at KES 60 (USD 0.60) kg^{-1}. At the refugee camp, Sanivation sells the product to over 20 retail shops.

2.4 Impacts of the Human Waste-to-briquette Innovation and the Role of Women

Sanivation's innovative model using waste to generate a cleaner cooking fuel has the potential to achieve wide-reaching impacts on the environment, finances, livelihoods and health.

Environmental conservation: The briquette innovation contributes to reduction of the environmental and

FIGURE 2.5. A RETAILER SELLING SANIVATION'S FUEL IN KAKUMA REFUGEE CAMP.

Source: Sanivation.

health impacts associated with using traditional cooking fuels. Current biomass cooking energy production and consumption are unsustainable and inefficient resulting in loss of tree cover, forest degradation, climate change and illnesses associated with smoke in the kitchen (FAO 2017). In Kenya, over 80% of urban households rely on charcoal, yet most of it is unsustainably sourced although most of the wood used in charcoal production comes from private farms owned individually or by communities, mainly in drylands (Mutimba and Barasa 2005). The unsustainability in charcoal production and use is (1) due to felling of trees without replanting and (2) inefficient traditional earth kilns, employed by about 99% of charcoal producers in Kenya. These processes have low yields of about 10% of the original weight of the wood resulting in wood wastage and air pollution (Mutimba and Barasa 2005; Okello et al. 2001). Sanivation's contribution to mitigating environmental impacts are twofold. By displacing traditional charcoal, the briquettes save trees otherwise cut done for cooking fuel and also they lower carbon emissions from cooking, hence, combating deforestation, mitigating against climate change and reducing health risks associated with smoke in the kitchen.

Reduced household expenditure on cooking energy: In Naivasha, for example, households spend about 30% of their income on cooking fuel. At USD 0.20 kg-1, Sanivation's briquettes can save families over 50% of income spent on charcoal. This is a significant reduction, freeing up finances for other expenses like school fees. As such, Sanivation launched a door-to-door sales strategy to reach as many households as possible with its affordable and sustainable fuel. Customers, especially women who are the predominant purchasers, see the briquettes as a cleaner and modern fuel of choice. They prefer them due to their longer burning time and less smoke generated compared to traditional charcoal, saving them time and money, as well as improving the kitchen environment. Additionally, the lower smoke and soot means customers use less water in washing pots, which is an additional value where water is a scarce resource. Anecdotally, fuel users have reported less coughing and chest pain when using the briquettes compared to firewood use. These benefits would be enhanced when combined with improved cooking stoves.

Source of employment for young men and women: The waste-to-energy factories employ 49 men and 25 women in both Kakuma and Naivasha. These include a paid team of 18 refugees, thereby giving refugees a source of income in the camp. Possibly, this also contributes towards security in the camp as jobless youth may resort to theft, drug abuse or recruitment to gangs that are a threat to national and international security while jobless women may be tempted to source income through prostitution.

Food and nutrition security: Briquettes are cheaper and hence less income is spent on cooking fuel, saving money that can be spent on buying food. Women in Kakuma exchange the little relief food they receive for firewood or sell the food to buy cooking fuel; given that the briquettes are cheaper this problem could be attenuated. Households also skip meals due to lack of fuel to cook, a challenge that cheaper fuels like briquettes could help to address.

Women and children's well-being: In Kakuma Refugee Camp, women travel long distances to collect firewood from the surrounding area. Through discussions with women at the refugee camp they expressed concern that this activity exposes them to risks of assault and rape cases have been noted. The refugee women thought that conflicts with the local community could be attributable to envy generated by the relief aid they receive and that locals consider refugees as contributing factors to environmental degradation. Affordable briquettes will reduce refugee women's workload, a risks of assault and will also improve relations with the host community as they will no longer be considered as instruments of environmental degradation. The portable toilets inside their dwellings allow women and children to relieve themselves at night reducing the health risks associated with holding urine for long periods of time, something they practice to avoid going out at night. They also reduce risks of attack and rape, especially for single women and children when nature calls.

Potential health benefits: Sanivation's briquettes have important health impacts. The briquettes burn cleaner as they have lower indoor concentration of CO than traditional charcoal. This improves the kitchen environment including air quality and thus reduces health risks associated with smoke which mainly affect women and children as they spend much time in the kitchen. Ensuring that human waste in a community is safely treated and reused improves safety and the health of the community, which in the long run will reduce diseases associated with poor sanitation.

2.5 Conclusions and Recommendations for Gender Inclusion

The Sanivation waste-to-energy initiative is a cost-effective, win-win innovation with multiple benefits related to energy, the environment, health, hygiene and sanitation. Through the provision of improved sanitation services such as household UDDS, Sanivation's model is able to improve hygiene and safety for women and children by preventing the need to go outside at night to use pit latrines. Provision of affordable, cleaner and safer cooking fuel near dwellings reduces women's workload and the need for women to travel long distances to collect firewood – a laborious activity that carries the risks of attack or rape. Time saved by women

can thus be used in other productive activities. Sanivation has employed a women-led sales approach, where the organization focuses on recruiting and hiring women to sell briquettes in the communities thus providing a source of income for them. Briquettes can be easily sold by young men who run retail shops in the refugee camp. The briquettes are a source of cleaner and cheaper cooking fuel which contributes to alleviating food and energy insecurity. Involvement of women in briquette technology in the refugee camp offers them an opportunity to be self-reliant as opposed to relying on relief aid, while equipping them with skills that can be used once they return home. Some limitations have been faced during the implementation of this innovation. Firstly, household income is challenged by installation of the UDDT. Considering the toilet subscription is 2% of the household's monthly income (USD 100), it is difficult for some families to justify the expense. Though they like the toilet, they often prefer using the free pit latrines instead because they cannot afford the extra expense. Secondly, the sales team is led by women and in Kakuma Refugee Camp the women are also expected by their families to take care of the family. As a result, when there is an outbreak in the camp, such as malaria, briquette sales decrease because women are at home taking care of their families. Concomitantly, in Naivasha a mainly female sales team sells briquettes to kiosks, restaurants, schools and households as well.

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Acknowledgments

The authors are grateful for the support offered to Sanivation by the Bill and Melinda Gates Foundation and the UNHCR for the work in Kakuma Refugee Camp. We also acknowledge the workable partnerships established with local communities and other stakeholders.

Source: ICRAF.

CHAPTER 3

The Impact of Gendered Roles in the Briquette Production and Supply Chain: Lessons Learned from Green Heat Ltd, Uganda

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3.1 Introduction

3.1.1 Background information

According to the Ministry of Energy and Mineral Development, 94% of Ugandans burn biomass to meet their basic energy needs, consuming roughly 20 million tons of wood each year (NEMA 2010; RoU MEMD 2014a). With only 10% of the rural population having access to electricity, an annual population growth of 3.2% (2017 est.) and annual growth in energy demand of 7.5%, pressure on biomass resources in Uganda and the associated negative health impacts on the population are expected to dramatically increase (CIA 2018; NEMA 2010). Such biomass consumption involves firewood and charcoal, referred to as woodfuel, and crop residues. This biomass provides all the basic needs for cooking and heating in rural areas and for most urban households. It is also the main source of energy for rural small- and medium-sized enterprises and contributes significantly to the rural economy. Biomass is traditionally sourced from natural forests and unsustainable harvesting has led to the destruction of large swathes of forest cover across the country. Most woodfuel-harvesting technologies are wasteful and their use does not meet demand. For example, only about 10% of all households use efficient stoves (RoU MEMD 2014b) which contributes to excessive fuel consumption and land degradation.

The collection of firewood for household use is an activity performed mainly by women and girls (daughters). Women and/or their children collect small bundles of stems, branches or pieces of wood less than 10 kg (kilograms) in weight on their way home, usually after gardening work. Others usually select a day within the week when they go out to gather/harvest firewood. Firewood is usually collected from bushlands covered by scrub, thickets or densely interlaced woody vegetation (Department of Forestry 1992). Some people collect from plantation forests. A few households sometimes buy firewood or charcoal, especially during the wet season or if they have some disposable

income. Distances covered and time spent during firewood collection depend on how accessible the firewood is. Firewood is normally collected many times each month, with most people collecting daily, once a week or once every two to three weeks.

Firewood collection increases the burden on women and the biomass generates high concentrations of air pollutants if burned in efficient stoves that are inhaled during cooking activities. This also affects the productivity of schoolchildren as they are too tired to read or do any homework.

People in urban and peri-urban centers use more charcoal than firewood. Making charcoal is mainly performed by men and production usually increases during the dry season when there is less agricultural activity. Some men carry out charcoal production after clearing the land when a considerable amount of wood is available, or in the case of young boys, during the school holidays. The charcoal produced is usually sold to intermediaries who transport it to urban centers for sale. Most of the Ugandan population's main livelihood activity pertains to agriculture which generates various waste streams. The woody stems/branches are used as firewood or for making charcoal; organic waste, on the other hand, is utilized as either fodder or left to rot in the fields and provide mulch and nutrients for the soil.

The main objective of our enterprise is to effectively utilize organic waste by turning it into briquettes for energy supply, income generation and environmental management. The briquette enterprise contributes towards relieving Uganda's high unemployment rate among young people (15-24 years) which is at 83% (Rehfuess et al. 2006) the highest in the world. This rate is higher for those who have formal degrees and live in urban areas due to the disconnect between the degree achieved and the vocational skills needed for the jobs that are in demand for workers (The World Bank 2008). Those without a degree are also unable to obtain jobs because they lack the skills needed for the position or they lack resources such as land or capital. As a way to escape poverty, many young people in rural areas look for better opportunities by migrating to urban centers. Indeed, migration to urban areas is unavoidable and even desirable as a way to improve allocation of human resources, especially in land-scarce countries. This sequence is making it difficult for Uganda to break out of the poverty trap. Young women who conceive at an early age often have to stay at home in a maternal role from a very young age which limits their ability to work (Daumerie and Madsen 2010). To address poverty and unemployment, many people are venturing into the briquette business. For example, according to the Global Village Energy Partnership (GVEP) report of 2012, biomass briquettes emerged as one of the top three traded energy products within East Africa and Uganda with 705 energy enterprises currently in the Developing Energy Enterprises Programme (DEEP). From the 885 active businesses within the program, 169 were briquette businesses, 139 (82%) of which were operating in Uganda (YLTTPA 2011). From the 139 briquette entrepreneurs receiving mentoring from the GVEP in Uganda, 68 and 32% were women and men respectively. It was observed across the program that women were generally more involved in businesses that require a low capital start-up, are immobile in production at the micro scale and deal in products that they can sell to immediate markets, which could partly explain their greater number in briquette businesses (YLTTPA 2011). The cumulative impact of DEEP briquette entrepreneurs in Uganda amounts to over 3,000 beneficiaries.

The number of beneficiaries was calculated based on factors such as the average number of people per household (who will benefit from the purchase of the briquettes) and the longevity of the briquettes. Much as the project assumed that briquettes were used exclusively by these households, it is worth noting that households often use a mixture/combination of different fuel types (for example briquettes, firewood and charcoal) so briquettes may provide partial fuel substitution for a much larger number of households.

3.1.2 About Green Heat Limited

Green Heat is a renewable energy company which produces pillow-shaped fuel briquettes (Figure 3.1), a form of alternative biomass energy, to tackle waste management. Green Heat was established in 2011. Green Heat applies the **reduce, reuse and recycle principle** commonly referred to as the 3Rs in managing the ever-increasing waste in the slums surrounding Kampala, Wakiso and Mpigi. Green Heat converts waste into energy to reduce the reliance on non-sustainable biomass energy among Ugandan consumers and contributes to reduction of deforestation around the Kyambogo area. Green Heat's production plant is at Matugga along Matugga- Kapeeka Road, in Wakiso, Uganda. The factory is surrounded by a rural slum.

FIGURE 3.1. PILLOW-SHAPED FUEL BRIQUETTES.

Source: Green Heat Ltd.

Green Heat objectives include:

- Being a provider of affordable clean energy cooking solutions of choice.
- Increasing usage of affordable clean energy solutions for low-income households and institutions in Uganda.
- Contributing to improvement of health for people in low-income households and institutions that rely on firewood and wood charcoal for cooking and heating in Uganda.

Green Heat's first complement of personnel included the directors and three officers whose roles were to spearhead production and marketing of briquettes and biogas. It is possible that the hiring of men for these roles was attributable to selection of personnel to work in the company based on friendship and referrals. However, this has now changed with the growth of the company and hiring is based on formal applications to fill available vacancies. Over time, Green Heat later recruited a woman to manage the recruited sales agents.

The idea for starting Green Heat was conceived by Gabriel Okello and Vianney Tumwesige together with a Cuban exchange professor, Perez Diaz, then based at Kyambogo University; the motivation was to address increasing solid waste generation, disposal challenges and widespread poverty. Further there was a critical need to address social and environmental problems associated with dependency on biomass energy.

Green Heat assets include a briquette factory, briquette press, crushing machine, mixer, drying beds, sewing machine and 30 kilns located on various farms. Funding to purchase the equipment was supported by the International Climate Initiative of the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through SEED.

3.2 Gender and Organizational Management of Green Heat

3.2.1 Management structure and gender distribution

Senior management of the company consists of two male director positions: a managing director, Mr. Tumwesige Vianney and an operation director, Mr. Okello Gabriel. The directors manage the strategic plans, goals and policies for Green Heat, its suppliers and sales partners. They also plan and coordinate departmental work plans and budgets. They are responsible for recruiting and tracking the key performance indicators of the departmental managers. The organization departmental managers constitute middle-level management. They execute the plans of Green Heat in accordance with the policies and directives of the directors. They are also responsible for inspiring other employees towards better performance. They coordinate activities within their departments. The team includes four women aged between 24 and 35 who hold the positions of client relations manager, sales and marketing manager, accountant and financial advisor; and two men aged 20 and 33 who hold the positions of production manager and engineer. Having male directors is a coincidence but lessons from experience show that our female sales agents have performed beyond company expectations. Part of the reason is likely to be the trust among customers who assume that the women have better knowledge or are better placed to advise on cooking fuel because they are believed to have 'experience' in cooking fuels. Our main sales manager is currently being mentored to become a sales director. The education of the women in this team comprises diploma (2) and degree (2) level while that of the men is degree and master's level. The women face the challenges of other family responsibilities which affect their education. For example, the client relations manager dropped out of her degree program because she became pregnant in her first year at university and had to take maternal leave; she subsequently settled for a diploma course. The accountant was under pressure from her family to get married and as such opted for a diploma which was shorter in duration.

The production team consists of four men aged between 18 and 22 years who are responsible for the briquette production process, ensuring that quantities and quality standards are met. They are also entrusted with the responsibility of sourcing inputs (molasses, charcoal dust and domestic charcoal made from agricultural waste) from suppliers. They provide daily reports on briquette production outputs and inputs such as water and electricity. This team ensures that machines and tools are used properly, efficiently and kept in good working condition.

Green Heat products are sold through a network of sales partners. In total, there are 82 sales partners who own kiosks around Kampala including 73 women aged between 18 and 62 years and nine men aged between 22 and 50 years. The sales partners receive briquettes at no cost from Green Heat and after they sell them, the profit from each kilogram is shared at a 60: 40 ratio in favor of the agents. The sales partners already have kiosks and sell vegetables and other items. Green Heat helps in paying half of the rent for the kiosks and also teaches the agents general book-keeping techniques. The sales agents report directly to the sales/marketing manager and client relations manager. Some customers buy briquettes directly from the company. Green Heat plans to build wholesale points in order to lower the overheads of briquette distribution to various locations.

3.3 Briquette Production Procedure and Gender Participation

3.3.1 Day-to-day running of the business

This is governed by a strategic plan which has been compiled by the directors after examination of the various factors

contributing to the business and rigorous consultation with the partners (sales agents, charcoal dust suppliers, home-made charcoal suppliers, packaging material suppliers and so forth). The various departments also use standard operating procedures which are developed by those in charge in different sectors. The company has a code of conduct which every employee follows.

The production team has received basic production and maintenance training from the Uganda Industrial Research Institute. The sales agents have received basic book-keeping training from our accountant.

3.3.2 Sourcing of raw material

Currently Green Heat uses home-made **agricultural waste-based charcoal** plus **wood-based charcoal dust** mixed with **molasses** and **water** in the production of briquettes. The charcoal dust is sourced by leasing kilns to farmers. The agricultural waste is carbonized (burned under controlled oxygen) at farms using the leased kilns (Figure 3.2) and then Green Heat is contacted to collect the charcoal. Green Heat buys the on-farm produced charcoal at USD 0.02 per kilogram from clients who are not in the leased kilns' system and 40% of the product price for the leased kilns. The 60% is used to offset the price of the kilns. This activity is carried out by an almost equal number of men and women. There are 15 male farmers and 12 female farmers with average ages of 35 and 38 years respectively. The farmers have no formal education.

This kiln constitutes a 200- liter (l) oil drum with a top opening for depositing the biomass as well as a cover. The kiln is filled with biomass or agricultural waste. Agricultural waste usually includes maize cobs/stalks, ground nut husks, coffee husks and bean husks. Once the kiln is full, the biomass is lit at the top of the kiln. Once the fire has spread throughout the kiln, the kiln is covered leaving the chimney open. After about 15-20 minutes, the fire will move from the topmost layer of biomass to the bottommost layer. The kiln is then covered completely by closing the lid at the top of the chimney. The kiln is then left to cool for one to two hours until it is safe to touch the exterior. After the kiln has cooled, the charred biomass is emptied onto the ground and is ready for grinding.

Wood-based charcoal dust is sourced from charcoal traders. The production manager contacts them and they pack the dust into sacks. A vehicle is hired to collect both the home-made agricultural waste-based charcoal and wood-based charcoal dust. Charcoal dust dealers are ordinarily charcoal traders who preserve the charcoal dust which comprises small pieces of charcoal resulting from breakages during handling that are not useful in this form. After the charcoal traders collect it in sacks they sell to Green Heat at USD 0.02 per kilogram (kg). Thirty men with an average age of 28 and 26 women with an average age of 25 are supplying Green Heat with charcoal dust. Most of the men are primary school dropouts whereas most of the women did not attend school. Men often have more control over their income and hence they have more money which they spend on buying charcoal for resale. Women on the other hand spend their income on family expenses and as such have little income at their disposal for restocking, thus limiting the amount of charcoal dust generated and consequent income from it. Through basic financial literacy training and book-keeping, the women sales agents in three different peri-urban areas have recently formed a Savings and Credit Cooperative Organization. Possibly such a service should be extended to the women charcoal traders to enable them to increase the volume of the trade and consequently income from both charcoal and the charcoal dust.

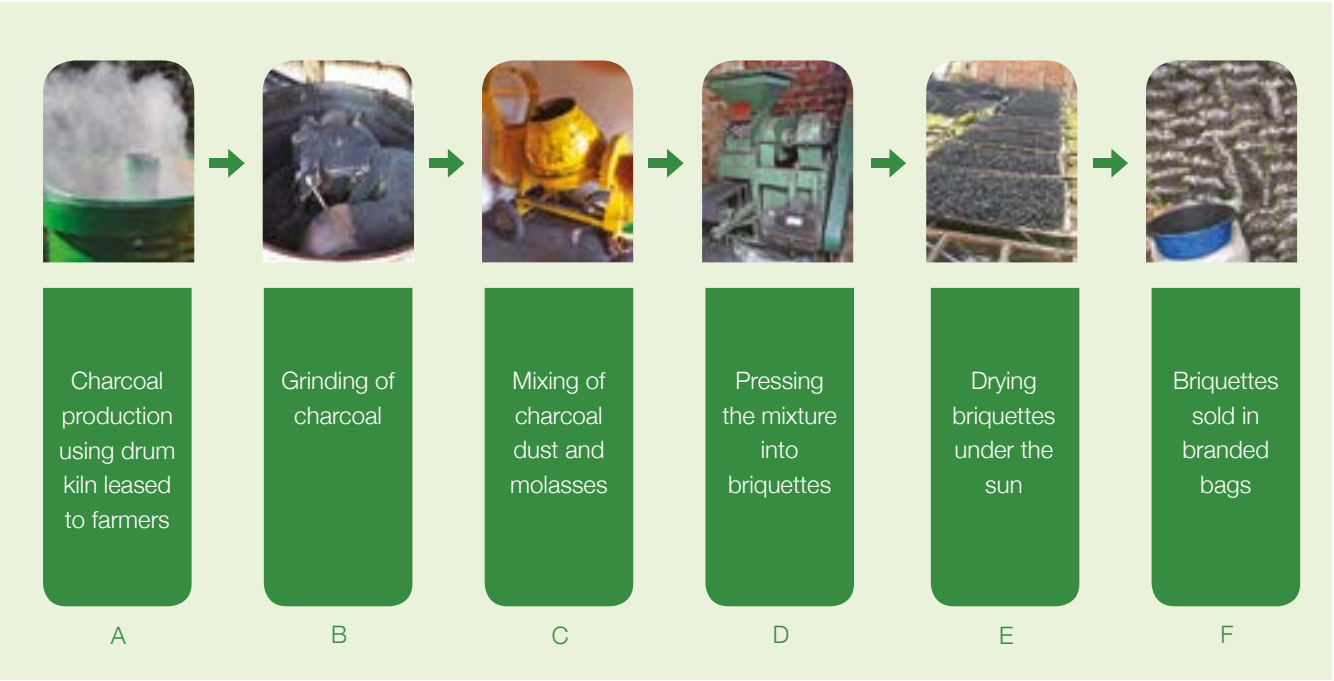
Molasses, which is used as binding agent, is sourced at USD 0.8 l^{-1} from Lugazi sugar factory using a hired vehicle. The re-order level for molasses in the Green Heat factory is two drums (equivalent to 400 l), to ensure continued availability of the molasses at the factory. About 380 l of molasses are used per month.

Green Heat is facing a challenge in increases in prices of the wood-based charcoal dust due to competition from companies treating electrical poles. These companies buy charcoal dust at higher prices and buy in large quantities making it difficult for Green Heat to access the charcoal dust. To address this challenge, the company supplies more kilns to farmers to reduce dependence on charcoal dust sourced from charcoal traders. There is a need for studies to understand the trade off if the agricultural residues could be used as manure or livestock feed.

3.3.3 Processing raw materials into briquettes

On reaching the factory, the home-made agricultural charcoal, the wood-based charcoal dust and molasses are weighed to verify the amounts sourced and recording is carried out. Both types of charcoal are sieved to obtain fine particles. The coarse particles are then crushed using an electric grinder. The fine particles are weighed and placed in an electric mixing machine. Weighed warm water and molasses are added into the mixing machine. The mixing process is carried out for 25 to 30 minutes. The paste is then transferred to the electric briquette machine where the pillow-shaped briquettes are made (Figure 3.2). The briquettes are then placed on drying beds. The briquettes are dried for two to three days during the dry season and four to five days during the wet season. The briquettes are weighed and packed into 10-, 20-, 35- and 50-kg sacks for the various clients and the amounts produced are recorded. The selling prices of the 10, 20, 35 and 50 kg bags are USD 2.70, 5.14, 8.11 and 10.81 respectively. This is approximately USD 0.2/kg of briquettes compared to USD 0.3/kg of charcoal although the price of the latter fluctuates a lot, with higher prices common during the rainy season. The factory produces 25,000 kg of briquettes per month and processing takes place six days per week.

FIGURE 3.2. BRIQUETTE PRODUCTION FLOW CHART.



Source: Green Heat Ltd.

The briquettes in 10-, 20- and 35-kg bags are transported to the kiosks that already have agreements with Green Heat. The 50-kg package is delivered to the clients who the company has contracts with.

3.3.4 Marketing and promotion

Briquettes are delivered to the kiosks. The sales agents sell the briquettes and the proceeds are shared between them and Green Heat at a ratio of 60: 40. As part of the promotion and marketing, sales agents only remit the money for the product they have sold. The company provides the sales agents with note books for record keeping, pens, t-shirts and aprons. The agents also sell other items like vegetables, tomatoes and pens in their kiosks. The company trains the agents on basic book-keeping techniques to help with financial accountability because more than one product is being sold in the kiosks.

Green Heat also provides small buckets to sales agents that can hold 1 kg of briquettes. This is because most clients buy small quantities, ranging from 1 to 5 kg daily. The role of bringing new sales agents/kiosks to partner with Green Heat is handled by two women staff.

Sales agents comprise 73 women and nine men. Men are not so keen on being agents as most of them are involved as motor-cycle taxi drivers (boda bodas) to earn income. Thus women are more comfortable with the selling of the briquettes at kiosks. The biggest challenge is that as women do not have total control of the income in the family, then there is always a risk of diversion of funds by their husbands. Some of the women who sell briquettes in kiosks face the risk of theft of their money and to address this problem Green Heat collects money from the sales agents twice a week and the supply of briquettes does not exceed specified quantities. Sales agents are also encouraged to send money daily, less their commission, using a mobile money platform to avoid keeping too much cash at hand.

Green Heat profit from the briquette enterprise is about 20% of its overall turnover. This has enabled the company to provide continuous salary increments and a staff bonus scheme in which employees are rewarded for targets achieved. The employees who initially joined with diploma qualifications have decided to upgrade their education.

3.4 Gendered Occupational Health Risks and How They are Addressed

Home-made agricultural waste-based charcoal and wood-based charcoal dust dealers are exposed to fine particles from the charcoal dust. The company addresses this by supplying dust masks to the suppliers. Some of the women who sell briquettes in kiosks run the risk of fire outbreak. The briquette sales agents have been trained on basic fire precaution techniques such as ensuring that candles, wick lamps and any cooking fires are turned off before they leave the kiosk. Green Heat trains the sales agents not to cook in the kiosks. Labels on safety precautions and warnings have been developed and supplied to the sales agents. The marketing and client relations managers, who are women, travel on very bad roads to the various kiosks twice a week on motorbike (boda bodas), who ask for a low fee. Thus physical injuries from accidents are possible. To address this problem the company has bought protective gear, such as helmets, which must be worn at all times when an employee is using a motorcycle. The company also pays for a worker's

compensatory insurance policy for all employees from NOVA insurance company.

3.5 Gender Differential Patterns in Access and Control to Resources

The directors have access to all information. The staff have access to information that is applicable to their departments. This includes information on raw materials, equipment, training and bonuses from meeting targets. The sales agents have access to their benefits depending on the sales they make. Women contribute to approximately 91% of the total briquette sales.

Formerly, there was disagreement when agents did not keep sales records. This raised the issue of the amount of money supposed to be shared. The issue was addressed by training the sales agents in record keeping which enables the company and agents to reconcile the stock going out and the remaining stock. Currently the agents keep the records and the Green Heat customer relations manager carries out a bi-weekly reconciliation.

3.6 Conclusions and Recommendations to Enhance Gender Equality in Briquette Enterprises

Briquette making has the potential for incorporating both men and women in the supply chain, however differential challenges that affect both sexes need to be assessed at each stage of the supply chain. Household responsibilities in the home are mostly a burden on women and this reduces the time they have available to participate in training offered by sales agents. In some cases, cultural and religious patterns inhibit women from having direct contact with men outside the family so this also prevents women from becoming involved in ventures such as briquette selling. Culture and inadequate resources often limit women's potential in income generation activities. For example, some men feel insecure if their wives make more income, thus undermining their machismo. Understanding gender roles is important along the briquette value chain to take advantage of the opportunities, resources and strengths of both men and women. Having a gender-inclusive value chain promotes efficiency and competitiveness by promoting access to the best talent regardless of gender.

The company has made efforts to address the cultural and gender issues that affect women's contributions to the briquette enterprise. For instance, because the husbands of the female sales agents have started attending the basic financial training events, incidents of extravagance or spending of business capital outside of the business have been reduced. This is reflected by the timely payment of the proportion of the profit that belongs to Green Heat. The husbands also understand the importance of business sustainability. During one of the feedback discussions that Green Heat holds with its sales partners, the most frequent feedback was that the money from sales was being used by the husbands of the sales agents. We decided to organize another meeting with the husbands and the feedback from them was that the money was being used to invest in other family ventures. Green Heat had to explain the business model and why it is important for both sides to meet their obligations in order to achieve sustainable growth.

Making use of the different strengths of men and women improves the effectiveness of the whole value chain. For example, hiring a female marketing manager increased our sales in briquettes as she managed to relate well with the sales agents. The feedback we received from the agents was that our female sales manager was more patient in dealing with their challenges than the former male sales manager.

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Acknowledgments

The authors are grateful to Jona Liebl, International Climate Initiative of the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through SEED for the funds to buy some of the equipment and for finance/accounting training events.

Source: ICRAF.

CHAPTER 4

Adoption and Economic Impact of Briquettes as Cooking Fuel: The Case of Women Fish Smokers in Ghana

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4.1 Introduction

In Ghana, much of the population relies on traditional biomass such as firewood and charcoal. Referred to as woodfuel, they are considered the primary source of energy for heating and cooking. In rural Ghana, 73.4% of the households use firewood as the main source of fuel while charcoal is the most common energy source for cooking in urban areas (GSS 2013). The use of firewood is not only limited to rural households as it is also predominant in commercial activities in urban settings. Firewood is used in commercial activities such as smoking fish, bakeries, batik (traditional clothing) making and by street food vendors. A number of negative socio-economic and environmental effects result from the use of woodfuel due to the unsustainable nature of production and use. Deforestation and climate change effects are some examples of the effects on the environment while incomplete combustion and smoke have important health implications for the primary users, who are mainly women and children (UNDP 2014). With projected urban population growth, the use of charcoal for instance will continue to increase as the main source of fuel for cooking among urban households in Ghana. The main reasons for the continued dependence on firewood and charcoal are their affordability, availability and lack of affordable and reliable alternative energy sources. The popularity of charcoal and firewood may also be attributed to their capacity to meet cooking and heating needs as well as local communities' preferences (Mendum and Njenga 2018).

The opportunity to utilize organic wastes more efficiently such as municipal solid waste and agricultural residues has in recent years aroused the interest of developing countries in briquetting technologies. Briquettes are a form of solid fuel produced by compacting dry loose biomass residues into solid blocks that provide energy and are used like firewood and charcoal (Njenga et al. 2013). They can serve as substitutes for traditional biomass energy sources for domestic and institutional cooking such as cooking in schools, hospitals and prisons as well as for industrial processes. Briquettes have the potential to counteract many adverse health and environmental impacts associated with traditional biomass energy (Njenga et al. 2013).

In spite of the advantages of briquettes, their uptake as a substitute for firewood and charcoal in Ghana remains very limited. Furthermore, despite the growing interest in briquettes and their potential for improving the living standards of the poor, there have been limited studies focusing on their adoption potential by end users. The primary objective of this study is to assess the likelihood of adoption of briquettes by women fish smokers and to explore the resulting economic impact on the women. Smoking fish is a commercial activity, predominantly undertaken by women. It is carried out using traditionally-designed stoves with firewood as the main source of fuel. This study explores fish smokers' willingness to adopt briquettes through application of the binary choice probit model using data collected from women fish smokers in the Greater Accra region (Maddala 1992). Respondents for the study came from major fishing communities in three districts. A total of 130 respondents were interviewed using a structured questionnaire in 2016.

4.2 Characteristics of the Fish Smokers

4.2.1 *Sociodemographic characteristics of the fish smokers*

All of the respondents in our sample were female (Table 4.1). The fish smokers buy their firewood on a daily, weekly and monthly basis depending on the scale of the business. The size of the fish-smoking business measured by the amount of fish smoked per month determines the frequency of firewood purchase. Small businesses tend to buy their firewood on a daily basis while medium and large businesses buy their firewood on a weekly or monthly basis. In our survey, 56, 27 and 17% of the fish smokers bought their firewood on a daily, weekly and monthly basis respectively. The businesses were categorized into three groups based on their frequency of firewood purchase: (1) small (buying firewood on a daily basis), (2) medium (buying firewood on a weekly basis) and (3) large (buying firewood on a monthly basis). Data are presented across the three categories. The small-scale traders comprised young people in and around 35 years of age and the majority (65%) had some form of formal education; medium- and large-scale traders comprised women above 40 years of age with the majority (55%) having attended school.

4.2.2 *Inputs and outputs in fish-smoking enterprises*

The main inputs for the fish-smoking business are the fresh fish, labor and firewood (Table 4.2). The average monthly expenditure on fresh fish is GHS 10,510 (USD 2,872 month^{-1}) for small-scale businesses (most of the fish smokers) and GHS 35,691 (USD 9,751 month^{-1}) for large-scale businesses. The total monthly expenditure on labor varies across the different scales with an average monthly labor expenditure of GHS 261 (USD 71 month^{-1}), for small-scale businesses, GHS 454 (USD 124 month^{-1}) for medium-scale businesses and GHS 397 (USD 108 month^{-1}) for large-scale businesses. The proportion of expenditure on firewood in the total cost is similar across the businesses, accounting for on average 6% of the total input cost. The bulk of the cost is the purchase of fresh fish. The total monthly sales value is on average GHS 14,392 (USD 3,932) for small businesses with an average profit margin of 9%. The corresponding figures for the medium- and large-scale businesses are higher with each business reporting profit margins of 13 and 15% respectively. This implies that the profit margins vary across the three categories with medium- and large-scale businesses earning higher margins (they are mainly run by older women); young women, despite being more educated, earn less.

TABLE 4.1. SOCIODEMOGRAPHIC CHARACTERISTICS OF WOMEN FISH SMOKERS (n = 128).

Variable	Description	[1]Small scale (n=71)	[2]Medium scale (n=35)	[3]Large scale (n=22)
Age	Age of respondents in years	35 (11)[b]	44 (12)	40 (9)
Gender	1= Female, 0= otherwise (%)	100	100	100
Education	Level of education (%)			
	1= never been to school	34	66	55
	2 = primary school	55	31	36
	3= secondary school	11	3	9
	4= undergraduate	0	0	0
	5 = graduate/professional	0	0	0

[a] *Scale is based on the frequency of purchase: 1=daily, 2=weekly, 3=monthly.*
[b] *Standard deviation.*

TABLE 4.2. INPUTS AND OUTPUTS IN FISH-SMOKING ENTERPRISES (MEAN VALUES) (n=128).

Description	Small scale	Medium scale	Large scale
Expenditure on fish (GHS month^{-1})	10,510 (11,015)[a]	32,894 (69,966)	35,691 (30,894)
Labor cost (GHS month^{-1})	261 (225)	394 (323)	397 (327)
Proportion of firewood expenditure (%)	6 (8)	7 (11)	5 (3)
Total value of fish sales (GHS month^{-1})	14,392 (14,682)	28,302 (35,026)	45,536 (38,767)
Profit margin (%)	9 (25)	13 (19)	15 (17)

[a] *Standard deviation. Exchange rate USD 1.00 = GHS 3.66.*

4.2.3 Energy sources for smoking fish

The firewood is sourced from Kumasi in the Ashanti region. There are about 200 fish smokers in the three categories who obtain firewood in logs of about 45-50 kg (kilograms). The logs are split into smaller pieces, a process mainly undertaken by men because this requires intense physical energy (Figure 4.1a and 4.1b). Smoking of fish is carried out using traditionally-manufactured stoves with firewood as the only source of fuel (Figure 4.2a and 4.2b). The average monthly quantity of firewood used varies across the fish smokers from 1,354 kg month^{-1} for small-scale businesses to 6,614 kg month^{-1} for large-scale businesses. Similarly, the price of firewood varies across the three categories with large fish smokers purchasing firewood at a lower price than the smaller fish smokers (Table 4.3). In addition, small business operators buy their firewood on a daily basis from retailers due to low income levels while large business operators buy on a weekly or monthly basis from wholesalers. This translates into a variation in the price of firewood purchased by the small and large businesses in favor of the latter. Buying firewood in bulk from wholesalers receives a price discount, hence the costs are reduced. This indicates that prices paid for inputs such as fish and firewood and the resulting profit margins vary among the three categories implying heterogeneity within the women's group.

FIGURE 4.1A AND **4.1B.** SPLITTING OF FIREWOOD TO BE USED FOR SMOKING FISH.

Source: Sena Amewu (IWMI). **A**

Source: Sena Amewu (IWMI). **B**

FIGURE 4.2A AND **4.2B.** TRADITIONAL STOVE USED FOR SMOKING FISH **(L)** AND TRADITIONAL STOVES **(R)**.

Source: Sena Amewu (IWMI). **A**

Source: Sena Amewu (IWMI). **B**

TABLE 4.3. SOURCE, AMOUNT AND PRICE OF ENERGY FOR SMOKING FISH (n=128).

	Description	Small	Medium	Large
Quantity of firewood	Monthly firewood quantity used (kg month^{-1})	1,354	4,353	6,614
Price of firewood	Price of firewood purchased (GHS kg^{-1})	0.363	0.292	0.285
Place of purchase	Place of firewood purchase (%)			
	1= source of production			
	2= retailer	99	51	5
	3= wholesaler	1	49	95
	4= obtained freely			
Firewood supply	Rating of fuel supply throughout the year (%)			
	1= adequate, 0= otherwise	77	77	82
Credit access	Mode of payment for purchase of firewood (%)			
	1= if fish smoker buys firewood on credit	30	34	36
	0= if fish smoker buys only on a cash basis			
Future price	Perception of trends in future price of firewood (%)			
	1= will remain constant	7	6	23
	2= will decrease in future	3	0	14
	3= will increase significantly but will continue to buy it	69	51	36
	4= will increase significantly so will switch to another source	21	43	27

The survey collected information on respondents' perceptions about the supply of firewood throughout the year and the future price trends. The response across the three categories was uniform for firewood supplies and most fish smokers believed that their firewood supply was adequate throughout the year. However, perceptions on the trend in future prices of firewood varied across the three categories. More than 90% of the small and medium businesses believed that the price of firewood would increase significantly while the proportion among the large-scale businesses who believed the same was lower (63%). This also indicates that more than one-third of the large-scale businesses believed that the price of firewood would either remain constant or would decrease in the future. Of those who believed that the price of firewood would increase, 69% of the small, 51% of the medium and 36% of the large businesses stated that they would continue buying it while the remainder wished to switch to another alternative fuel source. It is possible that the small and medium businesses who believed that the price of firewood would increase significantly were more likely to switch to alternative sources of cooking fuel. Moreover, there are also business traders who are spending more on firewood and need cheaper fuel to increase their profit margins.

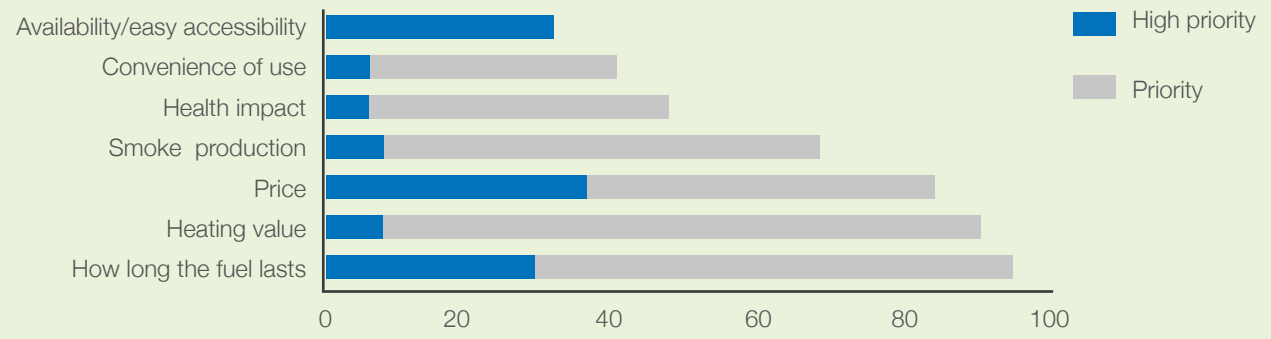
4.3 Preferred Energy Attributes and Fish Smokers' Purchasing Behavior

To determine the most important factors that influence their energy source choices, respondents were asked to rate seven attributes. These attributes were rated based on their level of importance prior to purchasing fuel (Figure 4.3). Burning time (how long the fuel lasts) (95%) and heating value (91%) were ranked as the most important product attributes. Price was ranked third (84%) followed by smoke production (68%). Thus burning time, heating value and price are the most important attributes that influence fish smokers' choice of fuel. Health impacts and accessibility modes were ranked as the least important factors in making fuel purchase decisions. This implies that, although fish smokers are aware of health implications associated with burning fuel, they do not consider them to be an important factor when choosing their fuel, possibly because of related economic benefits and their purchasing power. Therefore, more affordable, good quality and cleaner sources of cooking fuel are needed.

4.4 Estimating Likelihood of Adoption

Respondents were asked if they would be willing to adopt briquettes as an energy source for smoking fish and 77%

FIGURE 4.3. FACTORS INFLUENCING FISH SMOKERS' PURCHASE OF FUEL.



agreed. However, when their willingness to pay for the briquettes was raised, most (more than 90%) of those willing to adopt replied negatively until they could assess the performance of the briquettes and compare it to their current source.

Table 4.4 shows that neither age nor education influenced fish smokers' willingness to adopt briquettes. Notably, the price and total monthly quantity of firewood negatively influence fish smokers' willingness to adopt briquettes. This implies that large-scale fish smokers using large quantities of firewood per month are less likely to adopt briquettes as they purchase firewood in bulk and get a discounted price. On the other hand, small-scale fish smokers buying firewood more frequently from retailers are more likely to adopt briquettes as they get no discounts and make their purchases in small quantities on a daily basis which is costly. Moreover, income from smoking fish has a positive and significant effect on fish smokers' willingness to adopt briquettes. This indicates that as income from smoking fish increases, the likelihood of briquette adoption increases.

TABLE 4.4. FACTORS EXPLAINING WILLINGNESS TO ADOPT BRIQUETTES.

Variable	Coefficient	Z-value
Age	0.011	0.78
Education	-0.027	-0.11
Firewood price	-1.417	-3.98***
Firewood quantity	-0.0008	-1.74**
Income from smoking fish	0.847	1.63*
Credit access	-0.162	-0.49
Future price	0.561	3.00**
Source - frequency	0.686	2.37*
Constant	-1.726	-1.85*
Log likelihood	-43.54	
LR Chi2	47.14	
Prob > Chi2	0.000	
Pseudo R2	0.35	

* *Significant at 0.10 level; **Significant at 0.05 level; ***Significant at 0.001 level.*

Table 4.5 shows that the impact of a change in firewood price would have a greater effect on the likelihood of adoption than a change in quantity of firewood used. Furthermore, a change in income from smoking fish has a larger impact on the likelihood of adoption after the price of firewood. For instance, an increase in the firewood price by one unit decreases the likelihood of adoption by 0.366 which seems counterintuitive and difficult to explain. However an increase in income from smoking fish by USD 1.00 increases the likelihood of adoption by 0.219. Furthermore, trends in the future price of firewood show that a higher score in the perception variable increases the likelihood of briquette adoption. This indicates that fish smokers who believe that the future price of firewood may increase are more likely to adopt briquettes.

TABLE 4.5. MARGINAL EFFECTS OF FACTORS INFLUENCING LIKELIHOOD OF ADOPTION.

Variable	Coefficient
Age	0.003
Education	-0.007
Firewood price	-0.366
Firewood quantity	-0.0002
Income from smoking fish	0.219
Credit access	-0.042
Future price	0.145
Source - frequency	0.177

4.5 Economic Impact of Briquette Use

4.5.1 Savings from reduced expenditure on energy

Replacing firewood with briquettes has the potential to minimize costs on energy incurred by fish smokers (Table 4.6). The energy content in 1 kg of briquette is 16.8 MJ (megajoule) while the energy content in 1 kg of firewood is 13.8 MJ (Hu et al. 2014). Thus, less briquette by weight is required for the same amount of heat compared to firewood. In addition to the calorific value of the energy sources, the

replacement value of briquettes to firewood depends on the efficiency of cookstoves used (Roy and Corscadden 2012). The stoves that the women fish smokers use are made from metal containers fitted with iron rods and with an opening to provide oxygen helping ventilation to light the firewood. These stoves are assumed to have an efficiency of 45% when firewood is used compared to 50% when briquettes are used (Young and Khennas 2003). Based on these assumptions, the actual price per MJ of useful energy is GHS 0.051 (USD 0.014) in firewood equivalent and GHS 0.047 (USD 0.013) in briquette equivalent. Switching from firewood at GHS 0.33 kg^{-1} (USD 0.09 kg^{-1}) to briquettes at GHS 0.44 kg^{-1} (USD 0.12 kg^{-1}) has the potential to reduce the cost of energy for fish smokers by 10% as fewer briquettes are required for the same amount of heat compared to firewood. The saved income could be used for other purposes including expanding the business and improving livelihoods for women and their families.

4.5.2 Saving income from reduced cost of labor in splitting firewood

In addition to reduced expenditure on energy, switching to briquettes would enable the women fish smokers to save income spent on paying for labor to split firewood. Based on our survey results, the average cost of labor for splitting firewood is GHS 0.11 kg^{-1} (USD 0.03 kg^{-1}) which could be avoided if briquettes are used. The average quantity of firewood used by one fish smoker is 36 tons per annum at an average purchasing cost of USD 0.09 kg^{-1} and splitting cost of USD 0.03 kg^{-1} or a total cost of USD 0.12 kg^{-1} (USD 4,320 $year^{-1}$). On the other hand, the average quantity of briquettes used by one fish smoker to replace the same amount of firewood per annum would be 26.6 tons at a cost of USD 0.12 kg^{-1} (USD 3,192 $year^{-1}$) resulting in a 26% reduction on energy expenditure for the fish smoker.

4.5.3 Health and climate change impacts

Burning biomass energy produces pollutants that have negative impacts on human health and the environment, a situation exacerbated when inefficient cooking appliances are used. Coughing, sneezing and headaches are common among women who work in smoky kitchens, while bronchitis, lung cancer, asthma and tuberculosis have also been linked to smoke from indoor combustion (WHO 2006). Smoke from burning biomass for energy is a serious concern as globally, over 4 million deaths occur annually from illnesses related to the smoke generated by indoor combustion, which mainly affects women and children (Lim and Vos 2012). Methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (NO_2) among other gases emitted when burning biomass energy cause air pollution that contribute to climate change (FAO 2017). However, briquettes produce lower emissions owing to the raw materials and processing techniques used (Njenga et al. 2013). Using briquettes addresses health risks faced by the fish smokers and reduces demand for firewood hence saving trees and reducing air pollution. Better results will be achieved from a combination of using briquettes in more efficient cookstoves.

4.6 Conclusions

Technologies for briquetting are well researched and ready for use in practice. However, the use of briquettes as a source of cooking fuel is not common in Ghana. This study assessed the likelihood of adoption of briquettes by women fish smokers in Ghana. The results of this study are useful for policy-makers, technology developers and distributors in identifying what determines the decision-making behavior of potential end users, specifically women fish smokers. Moreover, it can contribute to identifying key technology attributes that need to be targeted for improvement if adoption is to be achieved at scale.

TABLE 4.6. POTENTIAL SAVINGS FOR FISH SMOKERS BY SWITCHING FROM FIREWOOD TO BRIQUETTES.

Item	Firewood	Briquette
Firewood replaced by briquettes (ton) (A)	1	1
Heating value (MJ kg^{-1}) (B)	13.8	16.8
Price (USD kg^{-1}) (C)	0.09	0.12
Efficiency of stoves (%) (D)	45%	50%
Actual price per useful energy (USD MJ^{-1}) (E= C/(B*D)	0.014	0.013
Saving from shifting to briquettes:		
Average annual quantity used per fish smoker (ton $year^{-1}$)	36	26.6
Price of fuel (USD ton^{-1})	90	120
Labor cost (USD ton^{-1})	30	0
Total cost of fuel per annum (USD $year^{-1}$)	4,320	3,192
Total annual savings from briquette use instead of firewood (%)	26%	

The main conclusions from the study are:

- Small-scale enterprises were run by younger women with higher education but earning less than counterpart older women with low education as the latter run medium- to large-scale enterprises purchasing inputs in large quantities and at lower cost. There is a need for entrepreneurship support to increase the purchasing power of the former.
- Most of the women surveyed lack awareness and knowledge about briquettes. Thus, an awareness campaign program needs to be carried out to familiarize the target end users on the benefits of using fuel briquettes including a demonstration of the performance of briquettes in comparison to alternative cooking fuels.
- The quality of the product as measured by how long the fuel lasts and heating value are the most important product attributes influencing fish smokers' choices when purchasing fuels. The health impact of fuel was among the factors ranked as the least important, implying that despite fish smokers' awareness of health implications associated with burning firewood, economic-related factors are more important in making decisions on the type of fuels to use in their enterprises. This emphasizes the need for briquettes as they save on fuel consumption and are cleaner than firewood.
- Most of the fish smokers were willing to adopt briquettes. However, switching from firewood to the new type of energy would be informed by practical experience on how the briquettes work in comparison to what they are used to, i.e. firewood. The main factors that influence the adoption of briquettes are quality, income from smoking fish and trends in future prices of firewood; hence, briquettes need to have a competitive or lower price or high reduction in consumption level. Briquette adoption by fish smokers is more likely to occur among small-scale fish smokers rather than among large-scale fish smokers as the latter buy firewood in bulk and get a discounted price.
- The economic analysis of shifting to briquettes showed that at the current price of firewood (USD 0.09 kg^{-1}), using briquettes priced at USD 0.12 kg^{-1} has a potential cost saving of 10% compared to firewood used by the fish smokers. When the cost of buying the firewood and labor for splitting firewood is considered, the total saving by switching to briquettes is estimated to be 26%.

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Acknowledgments

This research presented in this chapter was carried out with funding by the Ghana Netherlands WASH Window – Sustainable Water Fund (GWW-FDW), BMBF-BMZ via Urban FoodPlus and as part of the CGIAR Research Program on Water, Land and Ecosystems (WLE), supported by Funders contributing to the CGIAR Trust Fund (https://www.cgiar.org/funders/).

Source: Kenya Biogas Programme (KBP).

CHAPTER 5

Biogas as a Smart Investment for Women's Empowerment and Livelihood Enhancement

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5.1 Introduction

Globally, over 1.1 billion people live without access to electricity and almost 3 billion people lack clean cooking facilities that are less harmful to human health and the environment (WEC 2013). According to the Global Alliance for Clean Cook Stoves as cited in their website, clean cookstoves and fuels have the potential to reduce deaths from smoke-related illnesses, mitigate climate change and lower air pollution (GACC 2018). They can provide new sources of livelihoods for women, reduce the risk and drudgery of fuel collection and lower household expenditures on cooking fuel. The world's poor are continuously affected by the low availability of sustainable and reliable energy, especially in remote areas. Modern energy services are crucial for human well-being as well as national economic development.

Biogas is one such promising technology. Biogas was introduced to Kenya in 1948 by Mr. Tim Hutchinson. The first biogas digester (biodigester) was built in Kenya by Hutchinson's company, Tunnel Engineering Ltd. in 1957 (Ndereba 2013). Hutchinson discovered that the effluent (or 'sludge', bioslurry or digestate) is an excellent fertilizer and that its application to his coffee trees greatly improved productivity. Two types of biogas systems were introduced: the Chinese fixed dome digester and the Indian floating drum digester. Through initiatives by the Government of Kenya and non-governmental organizations (NGOs) the technology has been promoted in different rural areas in Kenya, mostly utilizing cattle manure as the main substrate (Blanchard 2018).

Biogas is a proven and widely-used global source of energy. There has been a renewed interest in its use owing to rising concerns about greenhouse gas effects, the high prices of fossil fuels and other environmental and health concerns associated with cooking energy in the past decade (WEC 2013). Biogas has been widely adopted even in developed economies such as Japan. Similarly, emerging economies such as Brazil, India and China have promoted the importance of biogas technology (Biwas et al. 2006). In rural Kenya, among biogas users on average, expenditure on firewood declined from KES 384 to 112 (71%) per household per week equal to annual cost savings of €125 (Dohoo et al. 2013). Additional associated savings include those on chemical fertilizers and a reduction in medical

expenses from illnesses associated with indoor air pollution estimated at €249 annually; there are more savings on the former (Smith 2012). Other non-monetized biogas benefits are smoke-free indoor space and cleaner kitchens. The availability of the cooking fuel at the appropriate point and time of use (readiness) is another benefit (Blanchard 2018). Furthermore, from a gender perspective, biogas contributes to less cooking time for women, reduced walking of long distances to buy or collect firewood for women and children and attenuated back pain and other physical injuries from carrying heavy loads of firewood. The saved time is utilized for children's education and women can attend to other activities such as community development. There is also increased revenue from agricultural crops and biogas use also provides opportunities for the establishment of women's small-scale businesses such as sale of compost fertilizers and horticultural produce, among others (Warnars and Oppenoorth 2014).

With a judicious mix of approaches, solutions and technologies, the Netherlands Development Organization (SNV) works with public and private partners to empower rural and peri-urban communities to access cleaner cooking solutions. SNV is an international development organization that provides capacity development services to local institutions and organizations. Founded in the Netherlands in 1965, SNV has built a long-term, local presence in Asia, Africa and Latin America. SNV has been present in Kenya since 1967 and aligned with Kenya's Vision 2030, supports initiatives in three key sectors: agriculture; renewable energy; water, sanitation and hygiene. Under the renewable energy sector, SNV works to disseminate three renewable energy technologies to households in Kenya namely improved cookstoves (ICS), solar and biogas power. The three technologies aim at ending energy poverty and ensuring that everyone has access to clean modern energy services.

5.1.1 About the biogas initiative

SNV provides technical assistance to the Africa Biogas Partnership Programme (ABPP) supporting national programs on domestic biogas in Ethiopia, Kenya, Tanzania, Uganda and Burkina Faso (*http://www.africabiogas.org*). The ABPP's mission is to contribute to the achievement of the Sustainable Development Goals (SDGs) through the dissemination of domestic biodigester technology as a sustainable energy source for rural and peri-urban households through the development of a commercially viable market-oriented biodigester sector.

So far, the ABPP has trained 544 people (masons) in biogas construction technology in Kenya, with some of these masons now building sustainable biogas businesses across the country. Since inception in 2009, over 18,000 biodigesters have been installed across the country. The establishment of a further 30,000 biodigesters over the next three years is expected to be achieved through a market-oriented environment. A viable market-oriented biogas sector will thrive in a vibrant private sector with sufficient awareness of biogas, a team of biogas experts and an efficient quality control mechanism.

5.1.2 Methodology

This case study is based on SNV's introduction of biogas to farmers in Embu County, a coffee and tea producing area of highlands in Central Kenya. The case study approach as the preferred methodology was based on the need to obtain in-depth appreciation of the biodigester technology in its natural real-life context among the farmers concerned, especially women. The respondent was selected from the program database. The rationale for selection stipulated that the respondent must be a woman user, using both biogas and bioslurry for not more than five years. The data were collected through in-depth face-to-face interviews, observations, telephone interviews, review of the farmer's records and review of other biogas-related literature. This methodology ensured that in-depth work was undertaken in gathering relevant information on the role of biogas in improving livelihoods. However, it is important to note that other biogas users could be doing better than the selected respondent. Biodigester users tend to master the use of the technology and harness greater benefits over time so we therefore cannot claim to have followed the entire case to conclusion.

5.2 Farmer's Organization, Source of Capital and Maintenance of the Biodigesters

The installation of biodigesters in over 18,000 households by the ABPP in Kenya has led to empowerment of household women who can now engage in community projects due to time saved from former laborious chores. One such woman is Mrs. Dionesia Ireri from Embu County who is the chairlady of the New Kirimiri Coffee Farmers' Cooperative Society (CFCS). Dionesia is 70 years old and has nine children, two sons and seven daughters. Her children are all grown up and have families in major cities in Kenya. Dionesia acquired secondary-level education while her children have moved higher by acquiring degrees and diplomas from colleges and universities in Kenya. Dionesia's household comprises six grandchildren (four male and two female) aged between 10 and 21 of whom two are adults above 18 years (male and female) as well as two farm workers (male and female).

The New Kirimiri CFCS had an active membership of 1,085 members, as of November 2017, with 23% being female. Members' ages range from 35 to 85. The CFCS is run by a management committee of which Dionesia is the chairlady. The committee has nine members, two of whom are female. They are all literate and execute activities mandated by the annual general meeting (AGM), which is governed by a Supervisory Committee constituting three male members.

Leaders are elected democratically at the AGM every year. The chairlady has served two terms and hopes that she can earn a third term through her achievements. Dionesia is proud to have recruited another 15 female farmers to install biodigesters.

Funds for installing biodigesters: The CFCS gives cash advances to members to acquire the digesters; the cash advance is based on coffee cherry delivery to the CFCS (in kg [kilograms]). Seven farmers, two women and five men out of the 15 members of the CFCS who have installed the biodigesters, were given a cash advance of USD 0.15 kg^{-1}, which was later deducted at no interest from their payments for coffee cherries. The two women who are members of the CFCS received the money directly. Dionesia's motivation for incentivizing other farmers to install biodigesters was based on the savings she had made on income spent on energy and the bioslurry used on her farm. She considered the biodigester to be a home improvement innovation that every woman should have and embarked on her mission to empower her colleagues.

Dionesia aims to be the highest producer of coffee in her cooperative and, as such, lead by example. "In this male-dominated sector, a woman without actions cannot be heard," she indicated.

Technical support for the maintenance of biodigesters: Dionesia learned about biodigesters when her cooperative was incorporated into the Kenya Biogas Programme (KBP) and she adopted the technology by acquiring a 12 cubic meter digester in 2016. Dionesia, among other farmers in the CFCS, received training on bioslurry use, operation and maintenance of the digesters. In the first year of adoption, she received two aftersales service visits from the KBP (in the third and ninth months). She has access to the Client Support Centre for all biogas users which she can call toll free for support on the technology.

5.3 Role Sharing in the Installation and Management of the Home-based Biodigester

The raw material used in the biodigester is cow dung the disposal of which would be a challenge to farmers especially for those with many zero-grazed cows. Dionesia traps biogas for cooking from the dung produced by her zero-grazed four cows and six pigs. The dung which comes from the cowshed, already mixed with urine, is collected from the cowshed in a pit and fetched using a bucket (Figure 5.1 A). The dung is then mixed with rain-harvested water and at times with water from the nearby Kirimiri River at a ratio of 1:1; the mixture is fed into the digester through an inlet. Dionesia ensures that the mixture is consistent and no lumps or vegetative matter enter the digester (Figure 5.1 B). She understands that the inlet has to be clean to avoid blockages. She feeds the digester on a daily basis and has trained her household members on how to feed it. From her digester, the gas formed from the anaerobic digestion process in the unit is piped into the kitchen and is used for cooking (Figure 5.1 C). In biodigester operations, especially feeding the digester, women find it easy to feed and consistently check on the gas piping system at prescribed intervals. This could be due to their availability at the homestead and because they cook meals for the household. The biodigester is fed once a day with about 60 l (liters) of the dung: water mix and feeding ratios in the biodigesters are dependent on their size.

FIGURE 5.1. RAW DUNG PIT, FIXED DOME DIGESTER, BIOGAS COOKER

Source: SNV. **A**

Source: SNV. **B**

Source: SNV. **C**

Usually biodigester installation within the household is often approved by the husband because he is the owner of the homestead. The challenge with such a decision-making system in a household is that cooking is mainly carried out by women and hence enhancing cooking conditions may not be a priority to the spouse as the decision-maker. Furthermore, promotion, sensitization and marketing meetings are attended by men who most of the time do none of the cooking and hence may not understand the need to shift from cooking with biomass to using biogas. This problem can be addressed by employing a household approach while promoting biodigesters, if possible, holding such meetings with both men and women (this is important). The affordability of the biodigesters is a major hindering factor towards adoption by women because the cost of digesters remains unaffordable to many farmers. On average the cheapest digesters cost at least KES 70,000 (USD 700) which is not viable for many households. The KBP, in collaboration with SNV, has initiatives to address access to credit some of which include stimulating markets for wholesale financing to institutions for onward lending and triggering biogas credit product development in financial institutions through sensitization on biogas. Other initiatives include providing incentives for biogas credit to cushion institutions' transaction costs and attaching technical personnel to institutions to address any concerns that clients raise.

5.4 Benefits and Perceptions on Home-based Biogas Cooking Systems

Saves time: Dionesia says that she has managed to save time as she spends less time cooking since she acquired the biogas cooking system. She also saves time otherwise spent on fetching firewood. She has noticed that the men (husband and sons) in her household are now assisting with cooking. She thinks that their involvement could be because the process is easier, it allows for faster cooking and produces no soot so dirty hands are no longer a problem. Biogas stoves provide instant heat upon ignition, so no waiting is needed for fuel to suitably combust. There are many brands of biogas burners or stoves in the Kenya market, however a typical biogas stove usually needs a heat input of 1-2 kw and provides heat output of around 2-4 kw depending on the brand. There are locally manufactured stoves (*jua kali*) and modified liquid petroleum gas (LPG) stoves. The efficiency of the stoves depends on the manufacturers' specifications, number of cooking points and client usage. The general recommendation is to adhere to the manufacturers' specifications and regulate the burner's flow rate (reduce from high heat to low heat for simmering). Dionesia is highly satisfied with biogas which she also uses to cook all food types including that which takes longer to cook such as maize and beans (*githeri*) without worrying about the cost of energy, which is a common concern for users of LPG or charcoal.

Improves the kitchen environment and encourages men to participate in cooking: The other benefit that Dionesia has found to be very important is cooking in a smoke-free environment which she believes reduces her family's exposure to respiratory illnesses. She also states that cooking with biogas reduces the chances of burns generated by cooking with open fires. Dionesia has made a complete switch to biogas for cooking but still uses firewood/charcoal for heating, hence some soot on the kitchen walls and ceiling is unavoidable.

She thinks that women who have biodigesters have neat kitchens and are always punctual in attending cooperative meetings; also, they are not always pressed for time to run back to attend to their families. She believes that the use of biogas has improved relations in families and men are now helping with cooking, allowing more time for women to conduct community service. In such families, men find it easy to cook, which is not a common practice in the area, as cooking is smoke-free, soot-less and faster. The women using biogas units say they are safe enough for children to cook with but caution should be taken to avoid misuse.

Reduces household expenditure on cooking energy: Dionesia estimates that she saves at least KES 4,500 (USD 45) per month, otherwise spent on buying firewood/charcoal and LPG. She invests these savings in home and farm improvement, decisions made at her own discretion. Such savings are comparable to those reported by other biogas uses (Dohoo et al. 2013).

Bioslurry after biogas extraction is still available for crop production and feeding pigs: She is also happy that after extracting biogas she is still able to utilize bioslurry from the biodigester as organic fertilizer and to supplement animal feed. Bioslurry is the nutrient-rich liquid substrate discharged at the biodigester outlet after gas has been tapped for energy. It is composed of 93% water and 7% of dry matter (Warnars and Oppenoorth 2014). It contains nitrogen, phosphorus, potassium, zinc, iron, manganese, copper and other elements. Wet slurry is alkaline (pH 8.12), odorless and pathogen-free. Dionesia applies bioslurry directly and for composting. She uses bioslurry on coffee, bananas and vegetables. Dionesia has noted early flowering of her coffee shrubs and that the berries mature faster/earlier after applying bioslurry. She fondly refers to the biodigester as a fertilizer factory. She uses bioslurry to supplement pig feed and says that this has reduced the cost of feeding by 25%, making swine-raising more profitable. Dionesia started by introducing one bucket of slurry into pig feed and monitored the results. She then settled on mixing two parts of slurry to three parts of other feeding materials such as maize germ. The pigs like this combination and are less noisy. She has observed that the skin of the pigs is fairer and their rate of growth is faster after adding bioslurry into their feed. The bioslurry is also mixed with other feed for her chickens.

Her coffee farm has become a center of learning where other farmers come to learn about the benefits of bioslurry on coffee cultivation. She has opened up her farm for learning purposes because she would like to improve coffee production by members of the CFCS so that it becomes the leading cooperative in Embu County. Five other women have been convinced to install biodigesters by the learning center and the number is growing. When Dionesia compares her production over the years she estimates that her total coffee production has improved by 20%. She hopes to double production with sustained slurry application.

5.5 Challenges Faced in the Adoption of Biogas Household Cooking Systems

Some unscrupulous constructors (men) tend to make the technology sound very complicated so that this creates dependence on them for technical support by end users, especially women. Poor construction has also been noted resulting in suboptimal performance of the biodigesters. These challenges are addressed by the KBP through proper promotion and marketing, operation and maintenance training and free after sales services within 12 months after installation.

Biogas systems are expensive, which is a challenge for households that have a hard time accumulating the required capital. Other people also find the capital for initial installation of the biodigester to be high although the benefits accrued are worth it in the long term. The challenge of poor access to capital is addressed through a loaning facility that allows members of the CFCS access to money in advance, which is deducted from payments for their coffee cherries and no interest is charged.

One of the misconceptions about the technology is that the biogas production is not safe. This is not true as the cow dung is used to produce biogas and the gas production process is conducted in fixed structures (fixed domes) or tightly closed containers.

5.6 Conclusions and Recommendations to Enhance Gender Equity

The biogas cooking systems improve women's well-being by reducing the workload for collecting firewood and time spent in cooking. They also improve the kitchen environment as there is less smoke and soot formation on cooking pots, ceilings and walls of the kitchen. Such cleanliness and faster cooking capacity now encourages men to help women with cooking chores. This enhances the sharing of cooking roles. If a complete switch to biogas cannot be achieved there is a need to improve the efficiency of the three-stone open fire. This will allow families to continue enjoying the services provided by open fires while addressing high firewood consumption and health risks from smoke in the kitchen. The reduced time in cooking and collecting firewood frees up time for women to participate in other productive work such as attending community development meetings. Bioslurry is available for use as biofertilizer and pig feed after extraction of biogas. To enhance gender equity in the biodigester sector, there are many opportunities to build businesses to create employment for women. Such opportunities include training women as constructors or masons and to build their capacities to operate and maintain the digesters for a fee. Women can also be involved in the biodigester value chain by serving as dealers/suppliers of the appliance. Women can also be mobilizers, plant supervisors and extension service providers for a fee in the village. However, data need to be gathered on gender-differentiated impacts resulting from interventions for scaling up the system and resource mobilization.

There is a need to promote the technology as a home improvement technology rather than a cooking solution as the former approach might receive less attention by men who are the main decision-makers in households.

The initial cost of investing in the biodigester is too high and limits the adoption of the technology so there is a need for the development of greater credit facilities. Awareness-raising on the benefits of biogas needs to target men, as in most cases they are the ones who have access to credit facilities; by so doing they will enable their families to shift to cleaner cooking systems. Projects/programs supporting biogas adoption need to contribute to policies and guidelines for women's empowerment. This includes making budgetary allocations for such activities.

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Acknowledgments

The authors acknowledge the financial support provided to the Kenya Biogas Program by the Ministry of Foreign Affairs of Netherlands Government (DGIS). The program management and technical support provided by Hivos and SNV-Netherlands Development Organization, respectively, is highly appreciated, and also are the advance cash payments to members for their coffee cherry by the New Kirimiri Coffee Farmers' Cooperative Society (CFCS), which helped farmers meet the costs of the installation of the biodigesters. Greatly appreciated, too, is the participation of Mrs Dionesia Ireri in the documentation of this case study.

Source: ICRAF.

CHAPTER 6

An Assessment of the Business Environment for Waste-to-energy Enterprises and How it Affects Women Entrepreneurs in Kenya

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6.1 Introduction

Assessing the gender dimension of an investment climate is important when considering strategies to improve the business environment and promote private sector development in the resource, recovery and reuse (RRR) sector. The term *investment climate* is used synonymously with 'business environment' and can be broadly thought of as an environment where businesses operate and where governance and institutions support entrepreneurship and well-functioning markets in order to help generate growth and development (Hallward-Driemeier et al. 2006). In developing countries, women are more likely to work in informal sectors where they are subject to inefficiencies and limitations (Simavi et al. 2010). Women often find it more difficult than men to formalize their businesses due to low levels of education and business skills as well as sociocultural factors which may restrict the female domain to low-level economic activity and the domestic environment (Simavi et al. 2010). Waste-to-energy (WTE) entrepreneurs are faced with the challenges of accessing space, water, financial support and poor perceptions of their product by potential customers (Njenga et al. 2013). Furthermore, women face unique limitations in accessing resources in the informal competitive environment that inhibit their potential to develop their enterprises. Some constraints may affect men and women's businesses differently and surveys need to be designed to capture these differences. In this study we assess the investment climate for WTE enterprises from a gender perspective.

The investment climate criteria relevant for the WTE sector include *policy and infrastructure, finance, business support* and *markets*. A number of indicators across each of the criteria were identified. Although not all investment climate indicators are specifically designed to capture differences in legal and regulatory treatments between men and women, they measure aspects of the business environment that matter for all entrepreneurs engaged in WTE businesses, regardless of gender. The investment climate indicators measure the business environment for WTE businesses in the context of access to resources such as land, access to finance and access to infrastructural services such as electricity, water and transportation which are relevant to the productivity and growth of the enterprises.

6.2 Methodology

In 2016, a company-level survey of 32 formal WTE businesses engaged in the production and sale of recovered energy products such as biogas and briquettes was conducted in Kenya. A structured survey questionnaire was used to interview all the respondents. During the interview, representatives of the enterprises, mainly those who were decision-makers or founders of the business, were asked to identify the major constraints to their business activity. In addition to company owners' perceptions of the various investment climate indicators, owners of the WTE enterprises were asked to provide objective data related to the different indicators. This study presents findings from the survey conducted in Kenya focusing on *policy and infrastructure* and *finance* aspects of the investment climate. The study also provides lessons learned on constraints faced by men and women in WTE enterprise development.

6.3 Results and Discussion

6.3.1 General characteristics of WTE enterprise owners

Women are involved as owners, workers and managers in the WTE sector. In our survey, 42% of the 32 WTE enterprises were owned by women. The types of enterprises in our sample included briquette and biogas enterprises. Table 6.1 presents the characteristics of the owners by the type of enterprise they owned. More than two-thirds of the briquette enterprises in our survey were owned by women while only 13% of the biogas plants in our sample were owned likewise. This indicated that women generally preferred to engage in briquette production and sales. Entrepreneurs operating in the reuse sector did not differ much in their personal traits such as age and years of experience in reuse activities. The average age of the owners of the sampled briquette enterprises was 41 years with eight years of experience in WTE activities while the average age of the owners of the biogas plants was 44 years with five years of experience in reuse activities. These enterprises predominantly hired seasonal workers and women's share of the labor force was on average 55% for the briquette enterprises and 18% for the biogas plants indicating that the briquette enterprises hired more female labor than the biogas plants.

Although the education level was low in the WTE sector, as most of the owners had not progressed beyond the high school education level, owners of biogas plants had a higher education level than the owners of briquette enterprises. None of the owners of the briquette enterprises had higher education levels beyond a high school, while more than one-third of the owners of biogas plants had achieved either vocational or graduate degree level. The briquette sector is preferred by female entrepreneurs with low level of education. The low level of formal education was one of the factors limiting the development of women as entrepreneurs and contributed to their lack of access to resources as described in subsequent sections. For instance, the low level of education limited the capacity of women to develop bankable business models and thus hindered the participation of women in accessing finance such as bank loans.

TABLE 6.1. GENERAL CHARACTERISTICS OF WTE ENTERPRISES.

	WTE enterprise type	
	Briquette	Biogas
Gender of owner (%) (1=female, 0= male)	64	13
Age of owner	41	44
Percentage of female workers (%)	55	18
Education level of founders (%):		
Up to primary	27	26
High school	72	29
Vocational	0	22
Graduate degree	0	23

6.3.2 WTE enterprises' perceptions of policy and infrastructure factors

Representatives of WTE enterprises were asked to identify the major constraints to their business activities and rate a set of potential bottlenecks related to policy and infrastructure factors. Policy and infrastructure were among the key factors that affected investment in WTE enterprises. In order to assess the policy and infrastructure environment within which WTE enterprises operated, a number of indicators were used. These indicators included entry and exit factors (such a the time it takes to get registration, licensing, certification, renewal and closure) and the costs related to entry and exit. Furthermore, other factors related to regulations (such as customs and tax) and infrastructural services including electricity, water, transport, construction permits and product certification were used as indicators to assess the policy and infrastructure environment.

Figure 6.1 provides a summary of the differences in identified constraints by gender of the owners, showing the percentage of male and female entrepreneurs perceiving each investment climate indicator as a major or severe constraint to company growth. The survey results showed that such perceptions varied across male- and female-owned enterprises. A larger share of female-owned enterprises perceived access to land, water and business licensing and permits to be a major or severe constraint. The male-owned enterprises also identified these factors as major constraints, however the share of male-owned enterprises was lower. For example, while access to land (100%) and business licensing (88%) was considered as a severe constraint by the female-owned WTE enterprises, 64% of male-owned enterprises considered the same as a

severe constraint. About three-quarters of female-owned enterprises reported tax administration and tax rates as severe constraints but these percentages were only 36% for tax rates and 45% for tax administration among male-owned enterprises. Both male- and female-owned enterprises complained about environmental regulations and product certification, however the share of male-owned enterprises in this context was higher than that of the female-owned enterprises. Lack of an educated workforce was perceived as a major constraint by a quarter of female-owned enterprises but none of the male-owned enterprises considered it to be a major constraint.

In our survey, female owners of enterprises judged most constraints as more severe than their male counterparts, and the gender gap for several constraints was large. The biggest differences were for business licenses, access to land, tax administration, tax rates and the availability of an educated workforce where there was 25 or more percentage points' difference. There were also constraints deemed as more severe by male rather than female entrepreneurs such as environmental regulations, product certification, transport and customs and trade where there was a 10 or more percentage points' difference among male and female owners.

Figure 6.2 shows the top five constraints by gender of the entrepreneur, illustrating reform priorities of the WTE sector. The bars show the percentage of male and female entrepreneurs who believed that the constraint was major or very severe. Access to land and water stood out as the two most severe constraints for both genders. Access to land was a constraint on enterprise expansion, especially in urban and peri-urban areas where most of the businesses were located. Business licensing, tax rate and tax administration were more important constraints for women while transport and environmental regulations were identified as major constraints by men.

FIGURE 6.1. PERCENT OF WTE ENTERPRISES REPORTING POLICY AND INFRASTRUCTURE FACTORS AS MAJOR OR SEVERE CONSTRAINTS BY GENDER.

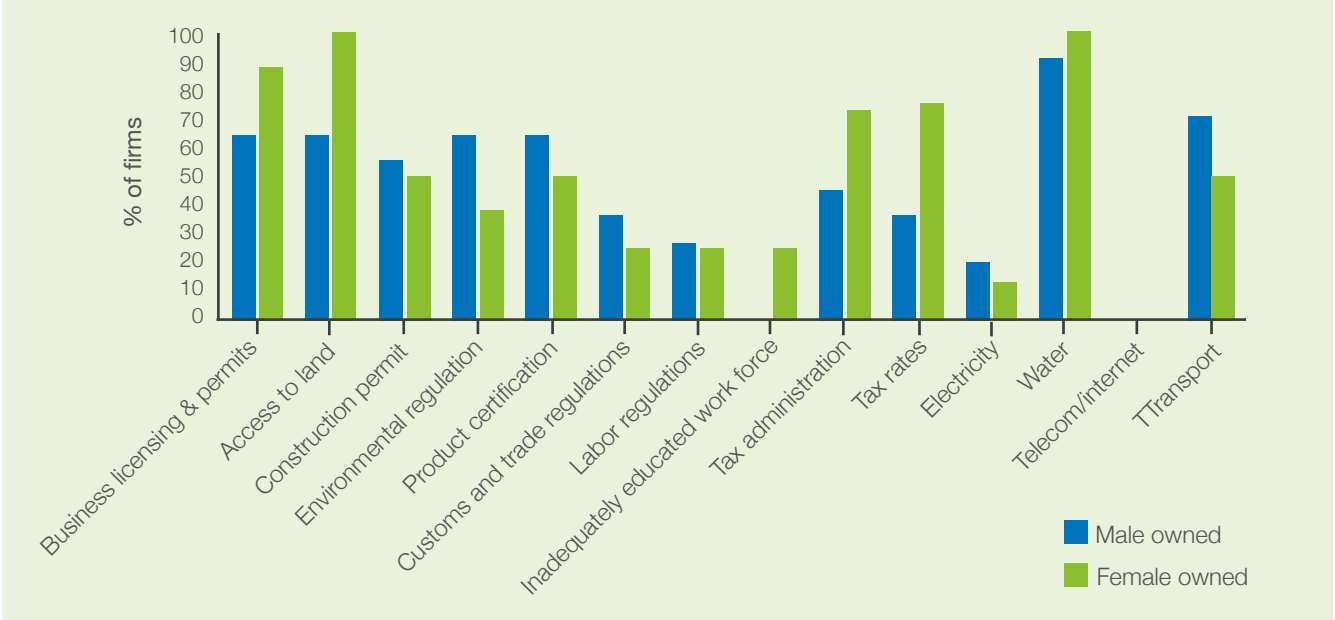
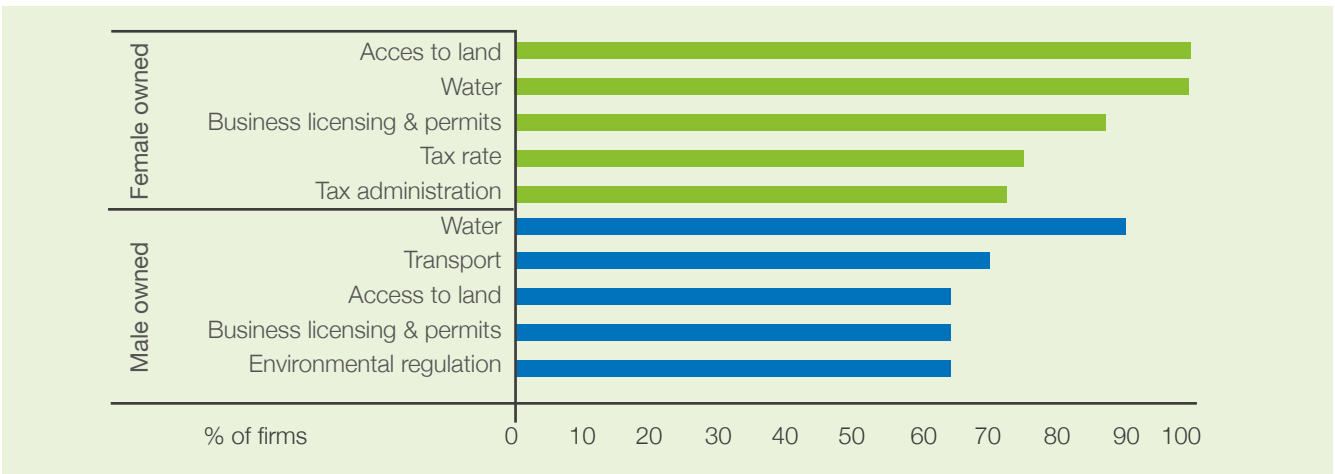


FIGURE 6.2. TOP RANKED CONSTRAINTS BY GENDER OF OWNER.



Business licensing and registration procedures are among the important indicators used to measure the challenges faced in establishing and running businesses (World Bank 2004). From the perceptions' study, business licensing and permits were rated as one of the top five constraints by both men and women (Figures 6.1 and 6.2). To get a better understanding of how this factor affected male and female entrepreneurs, data were collected on cost and time spent in obtaining and renewing business licenses and permits. This included time spent in the process such as staff time used in dealing with processing and renewal of the licenses and permits.

Starting a WTE business in Kenya is a lengthy process. The average number of days required to start a new WTE business is 45 days. Both men and women faced on average the same number of procedures to obtain a business license (Table 6.2). However, it cost on average 20% less for women to obtain a license in terms of time and money compared to men. Moreover, women, on average, spent less management time on dealing with licenses and permits than their male counterparts. Women were less likely to meet and negotiate bribes with government officials. It is also possible that government officials were supportive of female entrepreneurs as Kenya's Ministry of Trade and Industry has established a gender unit which supports female entrepreneurs. The number of days required to renew a license was similar for both genders.

6.3.3 *Access to finance and its disproportionate effect on women and men*

Access to finance at the company level is important for productivity and growth (Afram and Del Pero 2012). The availability of external financing to bridge the gap between internally generated resources and the financing needs of companies is an essential part of a sound investment climate (Iarossi 2009; Iarossi et al. 2009). In this section we first examine enterprise owners' perceptions of the cost and availability of external finance followed by objective measures of the availability and cost of external financing.

TABLE 6.2. TIME AND MONEY SPENT BY MEN AND WOMEN ON BUSINESS LICENSES AND PERMITS.

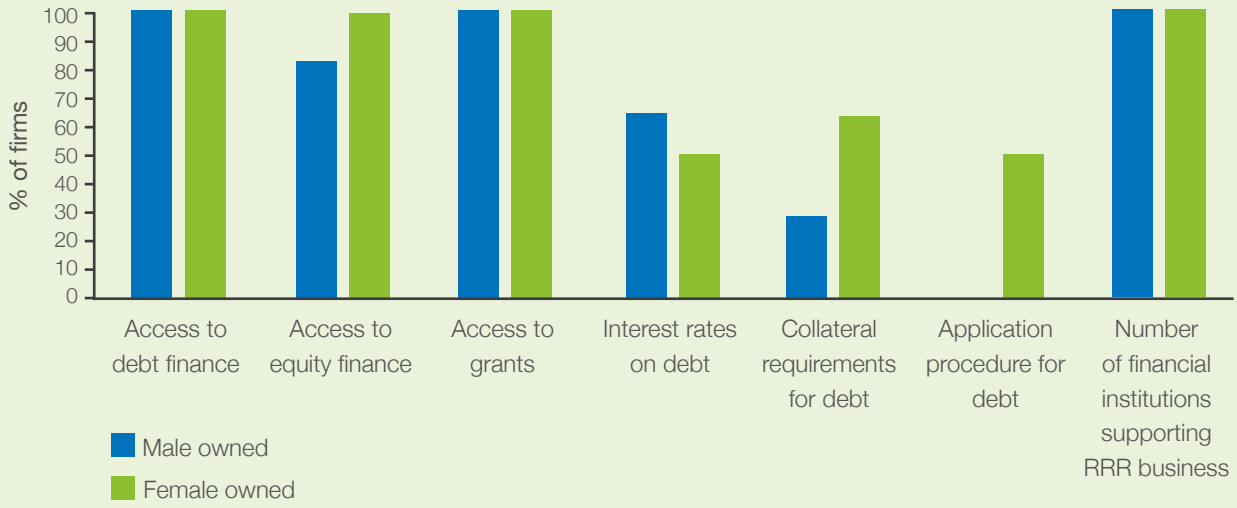
	WTE enterprises	
	Male-owned	Female-owned
Duration to obtain license (days)	47	38
Number of procedures to obtain license	13	13
Cost of license and permit (KES)	23,700	18,833
Management time spent dealing with license (%)	10	4
Number of days to renew license	11	10
Cost to renew license (KES)	5,750	5,083

WTE entrepreneurs tended to agree on the level of severity of many constraints related to access to finance (Figure 6.3). Access to different sources of finance (debt, equity and grants) and number of financial institutions supporting WTE businesses were rated as the most severe constraints by both male and female entrepreneurs. Collateral requirements on applications for loans were reported as severe constraints by more women than men. While both male- and female-owned enterprises identified collateral requirement as a major constraint, the share of female-owned enterprises rating this factor was higher. This could be associated with the patriarchal family system where most assets such as land and houses that are required as security in acquiring loans are owned and controlled by men. In addition, application procedures for loans were perceived as a major constraint by half of the female-owned enterprises but none of the male-owned enterprises concurred. This can be attributed to the fact that all of the women owning the WTE enterprises had only primary or high school education while more than one-third of the men had higher education. Low level of education and application procedures requiring document completion were an intimidating combination for women, who may have asked for assistance in filling out the documents, resulting in possible loss of confidentiality. Thus, women's low levels of education coupled with lack of landownership for collateral were major constraints in getting access to bank loans for them.

6.3.4 *Gender-differentiated sources of finance for initial investment and working capital*

Perceptions of WTE enterprise owners are informative indicators of problems in accessing finance, however, they do not provide sufficient and objective data to understand the underlying problems in accessing financing opportunities. Thus, in addition to eliciting perceptions about access to finance, owners were asked about how they financed initial investment and working capital. Both men and women relied largely on internal funds to finance the bulk of their initial investment (Table 6.3). On average male- and female-owned enterprises financed respectively 67% and 79% of their initial investment through the owners' contributions. Male-owned enterprises financed more than a quarter of their initial investment with funding from international donors and governments, however, this percentage was only 5% for female-owned enterprises. Borrowing from informal sources such as non-banking institutions and other sources including family and friends was noted among women. This could be associated with the low level of knowledge that may affect women's awareness or access to information on financial support opportunities. It is possible that women were interested in small-sized enterprises for ease of management

FIGURE 6.3. PERCENTAGE OF COMPANIES REPORTING FINANCE FACTORS AS MAJOR OR SEVERE OBSTACLES.



and ease in consolidating initial investment from friends and family members. This may require a low amount of initial investment compared to sourcing from donors and governments and illustrates women's participatory strength in reliable social networks for financial support whose repayment modes could be less stressful, less risky and more informal.

TABLE 6.3. SOURCE OF FINANCING FOR INITIAL INVESTMENT BY GENDER.

	Male-owned	Female-owned
Owners' contributions	67	79
Borrowed from bank	0	0
Borrowed from non-banking institutions	0	4
Funding from international donors	28	5
Government grants	5	0
Other	0	12

There was little difference between male- and female-owned enterprises in the sources of finance for working capital (Table 6.4). Both relied on retained earnings to finance the bulk of their working capital needs. However, women were more likely than men to rely on other informal sources of finance for working capital needs. This indicated that women were able to inject additional funds for working capital needs in addition to retained earnings. Having ample working capital not only helps to meet business obligations, it is vital for business growth.

WTE enterprises financed 70 to 85% of new investments and more than 85% of their working capital needs with the owners' contributions or retained earnings. This was considerably higher than in other sectors such as the manufacturing sector in Kenya where manufacturing firms finance on average 51% of working capital and 59% of new investments with retained earnings (Iarossi 2009). The formal sources of financial support for business such as banks and donor support were less utilized by entrepreneurs involved in WTE businesses in Kenya. This could be associated with the informal nature of the WTE enterprises as well as the low level of education of the owners of the WTE enterprises, especially the female business owners.

TABLE 6.4. Source of financing for working capital by gender.

	Male-owned	Female-owned
Retained earnings	100	86
Borrowed from banks	0	0
Borrowed from non-banking institutions	0	0
International donors	0	0
Government grants	0	0
Other	0	14

6.3.5 Loan application procedures and impacts on women's WTE enterprises

Measuring loan application and rejection rates provided important information about barriers to accessing finance. WTE enterprises made little use of loans from banks to finance their investments or their day-to-day working capital needs and instead they usually resorted to internal funds. The proportion of WTE enterprises applying for a loan was low. Only 8% of male-owned and none of the female-

owned enterprises had applied for a loan in the previous year (2015). In order to understand why the enterprises did not apply for loans, we present the reasons reported by the owners of the enterprises that did not apply for a loan in Table 6.5. About half of the female-owned enterprises and a third of the male-owned enterprises indicated that they had no need for a bank loan demonstrating that these enterprises were not investing beyond what their internal sources allowed, showing a lack of growth in the sector. Furthermore, a higher proportion (87%) of the female-owned enterprises indicated that they did not believe the loan would have been approved as the reason for non-application. This illustrates a lack of trust among women on how much the loaning bodies believed in their ability to run businesses that generate enough income to pay back the loans. Given that fixed assets are used as collateral in most developing countries, it is not surprising that the collateral requirement was also an obstacle to accessing finance for both male- and female-owned enterprises. A high interest rate was cited by about 10% of the male-owned enterprises as the reason for non-application while none of the female-owned enterprises cited interest rates as a reason for non-application.

TABLE 6.5. Reasons for not applying for a loan offered by male and female entrepreneurs

	Male-owned (%)	Female-owned (%)
Applied for a loan	8	0
Reason for not applying:		
No need for a loan	30	50
Complex application procedure	0	0
High interest rate	10	0
High collateral requirement	10	13
Did not think it would be approved	50	87

6.4 Lessons for Action on the Investment Climate for Women's Empowerment

Assessing the gender dimension of the investment climate is important when considering strategies to improve the business environment and promote women's engagement and productivity in the WTE sector. The rate and nature of women's participation and growth in the WTE sector are affected by many factors including regulatory and legal conditions, physical infrastructure, access to resources, availability of capital and human resources. This study assessed gender-differentiated impacts of factors that influenced the establishment and running of WTE enterprises and concluded and recommended that:

- The educational level of the owners of WTE enterprises was lower for women than men. Furthermore female-owned enterprises rated *access to land, water, business licensing and permits* and *access to finances* as major constraints to the establishment and growth of their enterprises;
- WTE enterprises made little use of loans from banks to finance their investments or their day-to-day working capital needs. Both female and male entrepreneurs relied predominantly on their own internal funds and retained earnings to finance initial investments and working capital needs which might limit growth in their businesses;
- The low level of education among women had various adverse implications on the growth of their enterprises. Female entrepreneurs in the WTE sector were intimidated by the application procedures for requesting loans or grants from financial institutions or donors. Furthermore, female entrepreneurs doubted if the institutions processing loans would give their applications favorable consideration and as a result they ended up not submitting applications. Owners of the WTE enterprises were more risk averse and preferred to borrow money from informal sources such as friends and relatives, which, although providing benefits in terms of low risks, provided women with limited funds for investment; hence their businesses could stagnate as informal and small-scale;
- Another limitation to borrowing loans could be associated with the patriarchal family model where the male has more ownership of land and other assets which are important security in borrowing funds. It is likely that banks doubt if women with low education and limited resources will be able to run businesses that will generate enough money to repay the loans;
- Access to different forms of finances are key reform priorities that need to be put in place to address the gender disparities in accessing resources for businesses. Such interventions may involve regulations and opportunities that reduce the need for high literacy levels, hence making the conditions favorable for less educated women. One good example could be the use of mobile phone lending systems such as Mpesa which is highly successful in the country. In this way women can borrow money using the phones and make repayments in small instalments which increases their confidence in borrowing without the fear that they will be turned down or lose property if they fail to repay. This system of borrowing also keeps the confidentiality that women entrepreneurs may wish to preserve with respect to their financial situations. Further, microfinance institutions and financial cooperatives

that integrate business development training could be used as alternatives to commercial banks to finance WTE businesses; and

- Access to water and land for female enterprises was another limiting factor to growth of the businesses. This could be enhanced by reserving space for women, especially where processes are characterized by irregularities such as corruption. Moreover, gender disaggregation of land records to establish the baseline is important in implementation of policies and regulatory practices to help improve women's access to land.

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Acknowledgments

This research was carried out with funding by the European Union (EU) and technical support from the International Fund for Agricultural Development (IFAD) and as part of the CGIAR Research Program on Water, Land and Ecosystems (WLE), supported by Funders contributing to the CGIAR Trust Fund (https://www.cgiar.org/funders/).

Source: Ndaro M.

CHAPTER 7

Gender and Improvement of Cooking Systems with Biochar-producing Gasifier Stoves

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7.1 Introduction

7.1.1 Gendered challenges in access to and use of biomass cooking energy

Firewood is a limited resource in high demand with about 90% of the households in rural Kenya using it for cooking and heating space (MoE 2002). Most people in sub-Saharan Africa (SSA) have limited access to less-polluting fuels (Rao and Pachauri 2017), hence they continue to rely on biomass, which is unsustainably harvested, undermining the environmental health of landscapes, especially in arid regions. Women spend much time on firewood collection which deprives them of opportunities to engage in other developmental activities. Women and children at a global level spend three to seven hours per day near the cookstove (WHO 2005) and hence inhale much smoke, an amount equivalent to 40 cigarettes per day (WHO 2006) which damages their respiratory systems. This is exacerbated by the use of inefficient cooking appliances which is a serious issue as globally 2.6 billion people, most of whom reside in rural areas of either SSA or developing areas of Asia, lack clean cooking facilities (IEA 2013). Peoples' eating and cooking habits are changed by lack of access to sufficient and appropriate cooking fuel. This is mostly evident by reduced numbers of meals per day, switching to less energy-intensive foods, undercooking of food and exchanging part of the food supply for fuel (FAO 2013). This in turn affects the quality, quantity and nutritional value of the food consumed (Sola et al. 2016). Despite the intervention in the 1950s to promote improved stoves which burn biomass more efficiently, use less fuel and have lower smoke emissions than traditional cookstoves, their uptake has remained low (Karekezi et al. 2004). This is mainly due to their relatively high prices and lack of consideration of sociocultural, technical aspects of cooking systems (Hollada et al. 2017). Lotter et al. (2015) envisioned a continuing challenge with the adoption of improved cooking technologies especially if they do not reduce the cost of cooking while improving the customary cooking characteristics. It has also been assumed that poor, uneducated women refuse the improved stoves out of ignorance.

This study framed the research assumption differently by looking at the home cooks who use biomass as experts on managing households and food security within their homes regardless of their educational background. Women's life choices are heavily influenced by their traditional and reproductive gender roles with many of them deeply embedded in long chains of knowledge generation gained

outside of formal educational systems. The failure of cooks in SSA but also South Asia and Latin America to abandon open fires for improved cookstoves or other fuel types (electricity, LPG [liquid petroleum gas] or solar) has frustrated development experts for decades. This is probably attributable to improved stoves failing to align with the priorities of the local users which they use to make decisions to adopt externally-initiated interventions, hence influencing the uptake of such interventions (Sesan 2014). Expert-driven efforts to develop people, especially women, without involving them at the problem-scoping stage and generation of the alternatives to solve the problem are among the reasons for the failure of improved cookstove initiatives in India as the interventions developed did not meet their needs and preferences (Khandelwal et al. 2017). As a result, there is a need to involve women, as the cooks and end-users, in cooking system research and development to ensure that their needs, aspirations and fears of losing the benefits of using open fires are integrated during stove development.

This case study is based on the farm-level production and use of biochar in Kenya, run by the Biochar-Energy project working on efficient energy and biochar-producing cooking systems. This partnership project operated by the World Agroforestry Centre (ICRAF), International Institute of Tropical Agriculture (IITA), Royal Institute of Technology (KTH), Stockholm, Swedish University of Agricultural Sciences (SLU) and Lund University and supported by the Swedish Research Council. The project was developed to address the challenges faced in accessing biomass fuel including farm residues, and the adoption of improved cooking systems for efficient use of this type of cooking fuel. It also aimed at increasing crop yields through soil amendment via the aforesaid biochar produced. Enhancement of environmental benefits through reduced pressure on tree resources as sources of cooking energy and efficient use of farm residues would be realized as well. The project began in 2013 and lasts until 2018, split into two phases of three-year periods. The project sites encompass Kwale a coastal area, Siaya a semi-arid area and Embu a highland area. The case study presents experiences mainly with households in Kwale where the data analysis on adoption has been completed. The first phase of the project (2013-2015) was implemented in Embu; it had a baseline of 50 households and worked with 20 households on a Top Lit UpDraft (TLUD) galvanized iron sheet gasifier stove produced by local artisans in Nairobi. Women joined participatory cooking tests to measure energy-use efficiency and emissions from the gasifier compared to a three-stone open fire (Njenga et al. 2016). The second phase (2016-2018) involves working with 150 households in the three sites who were issued with an improved version of the Top Lit UpDraft (TLUD) gasifier with the brand name Gastov sourced from a different producer, the Kenya Industrial Research Institute (KIRDI). The second version was sourced from a difference producer in response to the constraints highlighted by women after using the former version. This case study aimed at gathering the gendered findings on participation in technology development, uptake and impacts from the lessons learned by women using the stove. This helped to highlight some of the factors to be considered in the development of energy-efficient technologies for enhanced uptake.

7.1.2 *Household biochar-producing cooking system*

The gasifier cookstove is a recent innovation which has started to gain attention as a cooking stove in the developing world (Torres-Rojas et al. 2011). In the gasifier stove, biomass fuel produces its own energy-rich gases which mix with oxygen and combustion takes place to produce heat used for cooking. The burning process takes place under controlled oxygen delivery at temperatures between 700°C and 1,000°C (Torres-Rojas et al. 2011) turning the fuel into charcoal which is either harvested or left to continue burning to produce heat for cooking. The charcoal can be used for further cooking purposes (Njenga et al. 2016) or as a soil amendment where it is referred to as biochar (Jeffrey et al. 2013). The gasifier has the following components as shown in Figure 7.1.

Figure 7.1. The Gastov

Source: Gitau J./ICRAF.

(a) An insulated casing with a 5.5 x 4.5 cm air entrance door that can be regulated at half or full height at the bottom; **(b)** a 19-cm-high fuel canister in the middle; **(c)** a charcoal cover (snuffer) used to cool the charcoal by cutting off oxygen; **(d)** a 6-cm high gas combustion chamber on top as the main burner, fitted with a skirting; **(e)** casing (skirting) to hold the pot in position and protect flames from wind; and **(f)** a canister holder.

7.2 Research Design

In Kwale, the 50 households interviewed in the baseline survey agreed to use the gasifier. Before being issued with the gasifier, 22 women and 31 men were trained in October 2016 on gasifier use. Even though some of the trained male family heads were not the stove users, they were the decision-makers in some households and hence training male and female members would help to promote uptake of the stove. The trained men were advised to transfer their skills to cooks in their households. Follow-up visits were conducted every three weeks. Details on the study area and household selection are described in Gitau et al. (forthcoming). After two to three months of gasifier use, the stove users were interviewed using semi-structured questionnaires to ascertain their experiences in using the gasifier and perceived benefits and constraints of using it; they were also asked about fuel types and the amount of firewood used before and after introduction of the gasifier, sources of firewood for the households, the main fuel collectors in the households, time spent in firewood collection, costs for households that bought firewood and the amount of charcoal produced from the gasifier. Focus group discussions were held with cooks, mainly women, on areas for further improvement of the new version of the gasifier stove (the Gastov) and feedback was shared with KIRDI, the stove manufacturer.

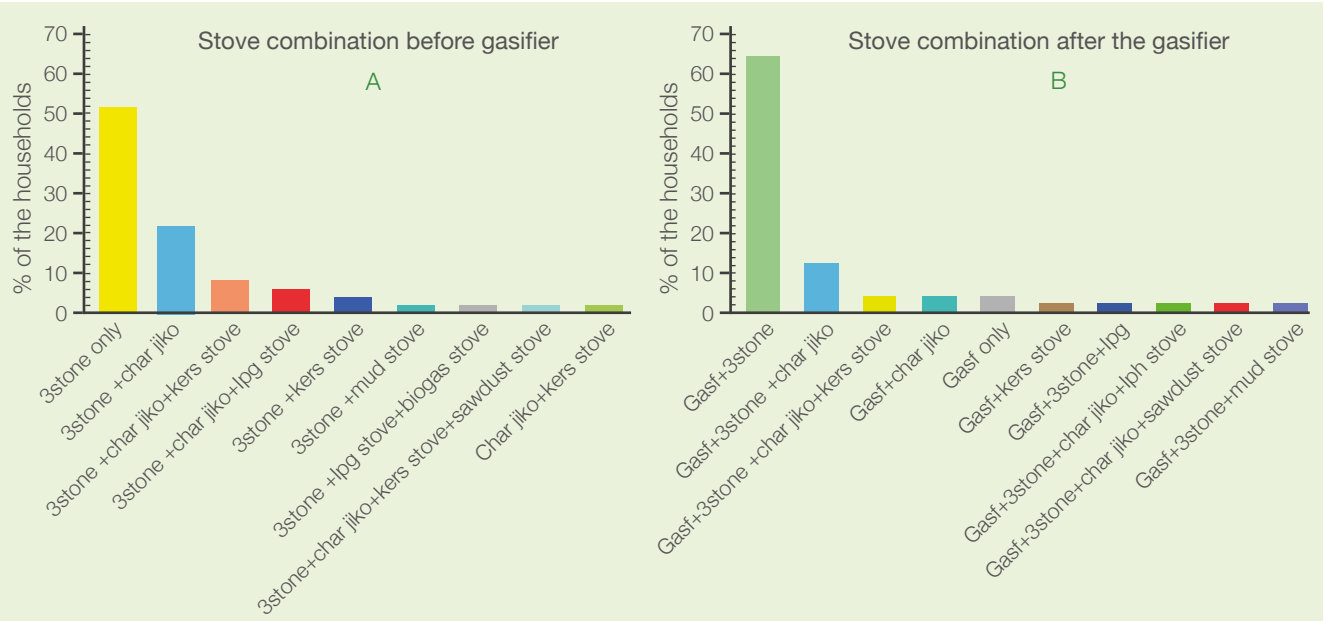
7.3 Results and Discussion

7.3.1 Stoves used by the households before and after introduction of the gasifier

The household size at Kwale ranged from one to eleven people with a mean of five members; 48 of the households were headed by men and two by women. Out of the fifty households, 52% of the female spouses had not completed any level of education while 34, 6, 6 and 2% had primary, secondary, tertiary and university education, respectively. A comparison of the adoption of the galvanized iron sheet gasifier stove and the improved version of the Gastov gasifier later in the study revealed that the former was being used by 35% and the latter by 96% of households at varied frequencies in Embu and Kwale respectively. Probably this is because the latter had been considerably improved to respond to cooks' needs.

To effectively meet their household needs, women stacked various stoves they had before and after the gasifier was introduced (Figure 7.2a, b). Stacking is the use of more than one stove to fulfil household energy needs (Ruiz-Mercado and Masera 2015; Ado and Darazo 2016). The gasifier was reported to be easier to use in terms of cleaning and maintenance, heat adjustment and handling; moreover it was noted that kitchens and cooking pots were cleaner, there was less exposure to flames and cooking pots were kept firmly in position. However, the gasifier did not perform well in heating kitchen space and required more time for fuel preparation (Gitau et al. forthcoming). Use of gasifiers reduced concentrations of carbon monoxide (CO) and fine particulate matter (PM2.5) by 40% and 90% respectively compared to three-stone open fires (Njenga et al. 2016). Two to three months after gasifier introduction, 30 households were using it for five days and nine times in a week on average for brief cooking chores while 18 households used it for four days and nine times a week both for brief and longer cooking chores. Therefore, with the uptake of the cleaner gasifier, indoor air pollutants were likely to have been moderated.

FIGURE 7.2. STOVE STACKING BEFORE (A) AND AFTER (B) GASIFIER



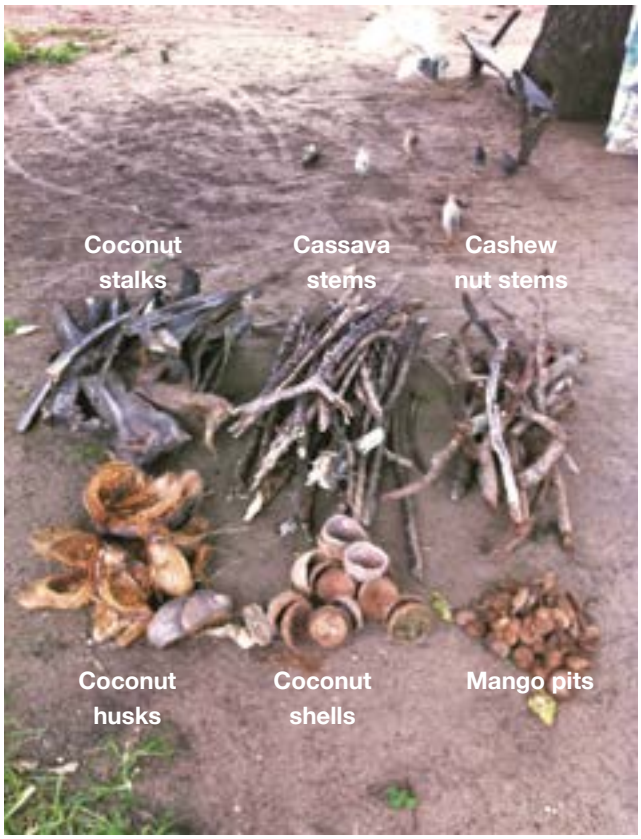
Note: Gasf = gasifier, char = charcoal, kers = kerosene.

7.3.2 *Use of the gasifier, fuel sources and preparation*

Firewood was used with the gasifier by 98% of the households and 96% of them used firewood together with crop residues. (Figure 7.3). Firewood was sourced on farm, from natural forest, from dealers (purchased), or from community land, friends' farms and private plantations. Pruning from trees on farm was the main and exclusive source of firewood for 98% and 41% of the households respectively. Even for the households that did not buy firewood, sourcing the fuel cost the collectors in terms of time and physical effort spent. Women were the main firewood collectors for 94% of the households. They spent one hour on average on a round trip to collect firewood within their farms from one to fifteen times per month. Twenty-six percent of the households bought firewood from once to ten times per month at KES 50 (USD 0.5) per headload of firewood on average. On average these households were buying eight headloads costing KES 400 (USD 4.00) before the gasifier was introduced but this diminished to five headloads for KES 250 (USD 2.50) on average per month after gasifier introduction (Gitau et al. forthcoming). With uptake of the gasifier, there is potential to save 38% of the money that would have been otherwise spent on firewood each month.

Before introduction of the gasifier, 42% of the households used charcoal for cooking and 71% of them purchased it, income that would be saved from using gasifier stove. The gasifier was used by 96% of the farmers and 85% of them stored the charcoal produced and collected 0.5 to 13 kg (5.13 kg on average) though some had produced more and used it for cooking and ironing clothes. Producing charcoal using the gasifier hence contributes to saving money otherwise spent on purchasing charcoal. It is an innovation that reduces expenses on cooking energy, thereby addressing nutritional opportunity costs associated with the high costs of cooking fuel.

FIGURE 7.3. Fuels used with the gasifier.



Source: Gitau J./ICRAF.

Women prepare pruned firewood and carry it to the homestead either when fresh or dry. They carry firewood loads on average weighing 35 kg on their heads (Figure 7.4a, b) along rocky routes from the collection points to their homesteads, risking injuries. Residues are also gathered and dried after crop harvesting and used as fuel to complement the available firewood, hence making the households more energy secure. However, use of these residues as fuel also competes with other residue uses such as nutrient recycling (leaving the residues on the land to decompose and improve soil fertility).

FIGURE 7.4. A WOMAN TRANSPORTING FIREWOOD **(A)**, A WOMAN BEING ASSISTED WITH HER HEADLOAD OF FIREWOOD **(B)**, A WOMAN PREPARING FIREWOOD **(C)**

Source: Gitau J./ICRAF. **A**

Source: Gitau J./ICRAF. **B**

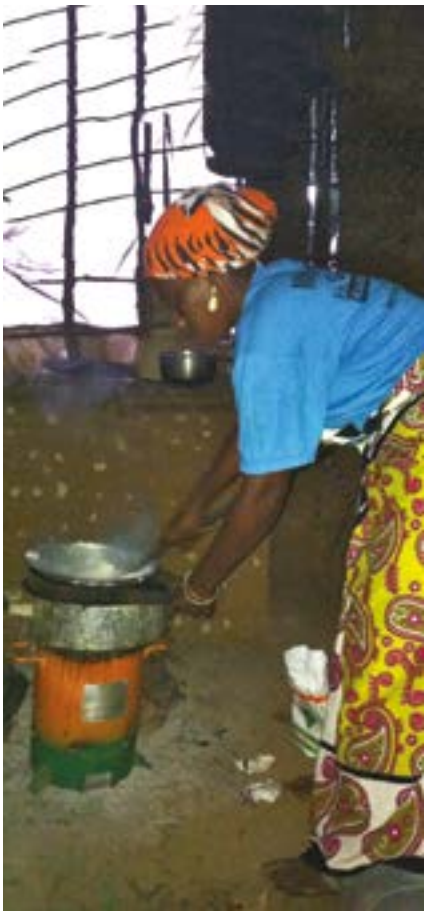
Source: Gitau J./ICRAF. **C**

Women chop the wood into smaller pieces of about 19 cm in length and varying diameters of below 5 cm to fit in the fuel canister (Figure 7.4c). This increases their workload; for instance in the first cycle of this project, women reported this task as tiring and time consuming (Njenga et al. 2016) while with the Gastov 42% had challenges with fuel preparation (Gitau et al. forthcoming). The firewood is arranged in the canister and lit with a match from above using light dry organic residues as tinder. When the fuel is burning well, the canister is returned into the outer casing of the gasifier and the combustion chamber is fixed back and cooking starts (Figure 7.5a). When the flame extinguishes this indicates that the charring process is complete and the charcoal is harvested by pulling the canister out of the outer casing, placing it on the ground and covering it with charcoal to cut off oxygen and facilitate cooling. After cooling, the charcoal is stored in a bag in a dry place (Figure 7.5b).

In Kwale, farmers applied the biochar in their plots to grow maize (Figure 7.5c). This resulted in more than double the average maize yields compared to plots where biochar was not applied (Sundberg et al. forthcoming). This can reduce the need to buy food and the excess produce can be sold to generate income. Due to its nutrient-holding capacity, biochar application on soils is likely to reduce the need to buy fertilizer and manure as the nutrients are available to the crops for a longer period.

After two to three months, 96% of the households were using the gasifier although at varying frequencies. Women were the main household cooks (45 of the gasifier users were women and only three were men). Two of the men cooked because they had separated from their spouses and the other's wife was in hospital, but he normally assisted her with cooking when she was at home. All the households liked the gasifier because it saved fuel, was less smoky and produced charcoal as a by-product (Gitau et al. forthcoming); however, some experienced challenges with fuel preparation, reloading of fuel, lighting and timing (when to collect charcoal). The challenges differed from one household to another; for instance, during a follow-up visit, an elderly lady reported that she liked using the gasifier but found it difficult to collect the charcoal and continued to use the heat from the charcoal till it burned into ashes. In some households the daughters, especially in school or college, preferred the stove compared to their mothers which could be attributed to education and age. The older women found lighting the stove and preparing fuel hard and time consuming while it was easy for their daughters. Thus the younger women found the gasifier more appealing than

FIGURE 7.5. A WOMAN COOKING WITH A GASIFIER **(A)**, CHARCOAL PRODUCED FROM A GASIFIER **(B)**, BIOCHAR BEING APPLIED FOR CROP PRODUCTION **(C)**.



Source: Gitau J./ICRAF. **A**

Source: Njenga M/ICRAF. **B**

Source: Njenga M/ICRAF. **C**

cooking on an open fire because it was more hygienic. To overcome some of these challenges, monitoring and capacity enhancement were carried out by a young male research assistant in every household every three weeks for about three months when the adoption study was carried out.

7.3.3. Implications of gasifier cooking system use for women

Reduced women's workload and risks in sourcing firewood from forests: The TLUD galvanized stove reduced fuel consumption by 40% (Njenga et al. 2016) and studies on the improved version TLUD Gastov are underway. Uptake of the gasifier means reduced need to collect firewood (hence less physical wear and tear), more time to engage in other activities and cost savings on firewood. For instance, using improved cook stoves in Chamwino and Kongwa districts in Tanzania resulted in 67% less firewood use and halved fuel collection time (Sererya et al. 2017). When searching for firewood, women are prone to accidents and encounters with dangerous wildlife. Some women (as in Kereita in Kiambu County) carry loads of firewood (67 kg) over hilly and rough terrain once a week to avoid making another trip over the same period. This makes them vulnerable to accidents, for example 'Margret' broke her arm on such a trip which stopped her from both collecting firewood and waged farm labor, yet she still needed to put food on the table for her household (Njenga et al. 2017). Some of the household income was used for treatment of her injuries which would have otherwise been used to address other household financial needs.

Reduced indoor air pollution: The galvanized gasifier reduced concentrations of CO and PM2.5 by 40% and 90% respectively compared to three-stone open fires (Njenga et al. 2016). CO in the kitchen causes headaches, dizziness and in high concentrations can result in unconsciousness or even death. Uptake of the gasifier can help to reduce smoke-related health problems which mostly affect women.

Potential for business creation: Young women can make money by providing services of preparing firewood by cutting it into small pieces in households with gasifiers. Men do this with saws while women use machetes (Figure 7.4c). There are women in the village who sell firewood and if they cut it into small pieces they may get better prices from households that are using a gasifier stove. Moreover, if women produce more charcoal than they need for cooking or for use as biochar in soil amendment they can sell the surplus. For instance, students from Chalmers University in Sweden testing grey water filters in Kisumu bought biochar from the farmers in this project at Siaya. Biochar can purify water as it absorbs hydrocarbons and other organic and inorganic substances (Hale et al. 2012; Mohan et al. 2012).

Environmental management: The gasifier has lower emissions and produces charcoal as a by-product. When used on farms, it remains in the soil for longer periods than biomass would if burned or left to decompose. Biochar production and use remove carbon from the atmosphere so it is considered to have carbon-negative properties (Bracmort 2010). Gasifier uptake is promising and this implies that women will contribute to carbon sequestration through the production and use of biochar (via reduced emissions from cooking and reduced need to fell trees for firewood). Harvesting of biomass (fuel) is an unsustainable activity which leads to deforestation and climate change issues (The World Bank 2011). The gasifier uses less fuel than three-stone open fires (Njenga et al. 2016), thus reducing pressure on forest resources. Harvesting deadwood may affect soil quality and consequently seedling regeneration (Kilian 1998) because if these residues are left to decompose, they enhance the soil fertility of the forest.

7.3.4 Women's contribution to the development of efficient cooking systems through co-learning

After 20 households in Embu had used the galvanized gasifier for five months, the project received feedback on their experiences and constraints (such as it being too hot and being unstable). This necessitated identification of an improved model from the market which could overcome functional challenges to avoid low uptake in the second phase of the project, which scaled up to 50 households in each of the three study sites. To participate in the cooking test agreed to help and this yielded scientific data on fuel use and emissions. For the improved model just like in the former version, the households perceived benefits (less fuel, less smoke and production of charcoal) and constraints (difficulties in lighting, reloading and need for firewood preparation into small pieces) and the however the problem of the wall of the stove getting too hot and instability of the stove were overcome in the improved version. The aforementioned constraints still persist and this would inhibit uptake of Gastov gasifier stoves by women who are the main users. This was addressed through work by female students in sustainable development and sustainable technology who applied design ethnography by observing cooking processes and later holding focus group discussions with the cooks; the results were later discussed with engineers at KIRDI (Saraswati 2018; Sujjesy 2018). Following the feedback from the women, the new Gastov was redesigned to have a dual purpose – using firewood and charcoal as well as control of the fuel required based on the type of meal being cooked. This exemplifies the

importance of involving women from the scoping stage of stove development research for enhanced uptake.

7.3.5 *Limitations affecting women's access to the gasifier*

The gasifier is produced by KIRDI and is not locally available. A unit costs KES 5,500 (USD 55) which is too expensive for most women who have limited sources of income, some working as casual laborers earning less than USD 3.00 per day, part of which they use to feed their families and meet other financial needs. Saving money to buy the gasifier is not easy for them. However, this can be solved through training of local artisans, mostly women being the main stove users, to jointly work with men to construct the unit at the local level, with quality control being exercised, especially on the type of metal used for frame distribution as it needs to withstand high temperatures. The government, through county development budgets, could support such activities for reduced input costs to make them affordable. Women could form groups and make small incremental credit contributions towards purchasing the gasifier stove. Education, skills and awareness also need to be pursued among men and women for increased demand and this is being addressed through training events and follow-up meetings.

7.4 Conclusions and Recommendations to Enhance Gender Equality through Uptake of the Gasifier

Gender implications on improvement of cooking systems: The public dialogue on the use of firewood and charcoal for home cooking and heating focuses on two main issues discussed in the introduction: the negative impact of smoky kitchens on respiratory health of women and children; and the unsustainable harvesting of biomass that undermines environmental health. In light of the seriousness of these two issues, there tends to be an assumption that given any reasonable alternative, biomass users could choose other options which is mostly not the case. Researchers framed the problem in this study differently by perceiving the home cooks as the experts on managing households and food security in the specific contexts in which they live hence making the adoption decisions that were observed more comprehensible.

In decision-making to use innovations such as the gasifier, women balance a wide range of factors such as: capacity to cut firewood into small pieces, availability of soft firewood species, relative availability of employment opportunities compared to cost savings produced by using less fuel, their interest in business opportunities afforded by cutting firewood into small pieces and the capacity of local households to pay for such services, and the market to sell charcoal or vegetables produced from improved soils and so forth.

This study points to the need for more nuanced consultation with biomass users as they make complex choices about home energy use. Younger women with perhaps fewer family responsibilities, less investment in open fire cooking and potentially more interest in business generation, may be more willing to shift their own use and that of their households in the direction of stoves like the gasifier. Even they, however, will probably maintain open-fire access for cooking of particular meals or in cases where heating is necessary. Homes with very young children and the elderly are more likely to need heating during rainy seasons in geographies located at elevation. The encouraging results of this study are that some women are willing and able to capitalize on gasifier technology. Further study is needed about the social context of home energy use perhaps with specific attention to the kinds of support that would help younger women develop the enterprises around providing services for cutting firewood into small pieces, charcoal, stove repair or stove production businesses. In addition, support for agroforestry initiatives that produce firewood and charcoal with fewer environmental impacts would possibly help to increase stove adoption rates. All of these innovations may lead to social changes as women benefit from cash generated by energy-related businesses and in turn can afford to spend money on other household or personal goals. In cases where a woman's participation in stove/energy provisioning allows access to cash income for the first time, one might expect changes in relationships between men and women, older and younger generations and those with greater and lesser ambitions. It is even possible to imagine that in households where members engage in biomass energy businesses, increased cash flow might be directed towards purchase of other energy sources such as electricity for lighting. In short, this study demonstrates that even incomplete shifts in cooking technology use could have positive impacts on women and communities even if the primary public health goals are not immediately met.

Benefits of gasifier use:

- Women liked the gasifier because it used less fuel, produced less smoke and produced charcoal as a by-product. Uptake of the gasifier reduces exposure to indoor air pollutants and associated health problems and women and children below school-going age will benefit more as they spend more time in the kitchen cooking. However, the burning process of the gasifier is not entirely clean, hence it should always be used in a well-ventilated environment;
- Households can be more energy secure through uptake of the gasifier which uses firewood and residues and produces charcoal for another cooking session. This can lead to freeing up of some of the time which

would have been used in firewood collection which in turn can be used by women in other productive activities;
- The gasifier contributes to saving time used by women on fuel collection and money to buy fuel, reduces the need to carry heavy loads of firewood and increases farm yields through use of biochar for soil amendment; and
- Young women were more willing to use the gasifier compared to their older counterparts but also stacked among the various stoves they had to meet their needs effectively.

Potential business opportunities:
- There is potential business opportunity for women who can offer services for cutting firewood into small pieces to be used with the gasifier; and
- Women can raise income through sale of the charcoal produced by the gasifier.

How to overcome fuel preparation challenges:
- Fuel preparation challenges can be addressed by cutting the firewood when it is fresh and soft, and then drying it.

Recommendations for enhanced uptake:
- Local artisans, mostly women, need to be trained on how to construct the gasifier to mitigate purchase cost. This can lead to increased uptake and diffusion of the technology. Women in groups can also save money together, hence they can pool resources and purchase for each other in a rotational manner; and
- Young women who are more interested in the stove should be targeted as trainers to train their fellow women rather than male research assistants as they have better understanding of the cooking needs of women.

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Acknowledgments

This chapter is based on research carried out in Kenya supported by The Swedish Research Council, project number 348-2913-182. The authors appreciate the active participation of householders, the Kenya Industrial Research Institute (KIRDI) and all members of the research team.

Source: Njenga M./ICRAF.

CHAPTER 8

Women in Energy: Perspectives on Engaging Women Across the Energy Value Chain: The Case of wPOWER

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8.1 Introduction

Globally, 1.2 billion people lack access to electricity (IEA 2016). Over 2.7 billion people, representing approximately 38% of the global population, rely on traditional biomass for cooking, mainly by burning wood, charcoal, crop waste and animal dung in open fires and on inefficient cookstoves (IEA 2016). This population remains concentrated in sub-Saharan Africa (SSA) and India, with estimates showing that the two regions account for over 850 million of those without access to electricity. Research has since confirmed that indoor air pollution, as a result of inefficient use of solid fuels, accounts for the premature deaths of 4.3 million people annually (Lim and Vos 2012). Most of these victims are women and children (Lim and Vos 2012), with current statistics indicating that approximately 800,000 children under the age of five die each year due to household air pollution (WHO 2016). Culturally, and more so in rural areas, women are the primary users of these inefficient cooking methods that increase their exposure and the risk of multiple detrimental health impacts. On the other hand, degradation of natural resources due to unsustainable harvesting and inefficient energy use means that women spend more hours (at least five hours a day) collecting fuel for cooking (GACC n.d.). Most women and girls have limited access to education and opportunities for empowerment due to time-consuming chores such as foraging for firewood, cooking and taking care of the household (Coltrane 2000).

8.1.1 Background information

Women's labor within this energy dependence on open fires and inefficient cookstoves is often invisible. Evidence shows that women are predominantly concentrated in certain energy subsectors, particularly those that are less capital intensive at the initial phase and consequently less profitable. This promotes a sense of 'survival entrepreneurship', i.e. being engaged in bottom-of-the-ladder, survival activities (Deshpande and Sharma 2013). They are also known to employ business models that are 'closer' to the final

customer such as charcoal retailing (Delahunty-Pike 2012). Generally, there is a lack of recognition of the economic value of women's work despite the fact that their participation benefits consumers and communities directly and is heavily oriented towards end of energy chain activities (Shankar 2015). At the decision-making level, in contrast, men dominate the sector (EIGE 2015).

Given the realities discussed above, i.e. (1) increased global carbon emissions; (2) inefficient cooking methods; (3) devastating health, environmental and economic outcomes; and 4) the vulnerability of women in the entire equation, there was a consensus that sustaining low-carbon emissions requires putting in place a set of conditions needed to create an 'enabling environment' (UN/DESA 2013) and increase women's participation across the energy access value chain. Consequently, women's knowledge, empowerment and collective action are now considered central to building more environmentally sustainable pathways for environmental management; adaptation to climate change; and securing access to sustainable energy (UN Women, UNDP and UNEP 2015). In addition, adoption of clean energy technologies with the active participation of women as entrepreneurs and consumers is critical in reducing the numbers of premature deaths of women and children, decreasing unsustainable biomass energy use and alleviation of limited life opportunities for women in rural and urban households (ACCESS 2014; WHO 2016).

8.1.2 Partnership on Women's Entrepreneurship in Renewables (wPOWER)

The genesis of the Partnership on Women's Entrepreneurship in Renewables (wPOWER) and its efforts was underpinned by needs to unite support for women's participation and promote the pivotal role they can play in clean energy entrepreneurship. To respond to this need, wPOWER was launched by the Department of State (United States) at the Annual United Nations Framework Convention on Climate Change Conference of the Parties (COP 19) at Warsaw, Poland in January 2013. The partnership, housed in Nairobi, Kenya, has grown into what is now a coalition of over 30 partners across the energy supply chain, including representatives from technology, implementation, research, advocacy and donor agencies (Figure 8.1).

FIGURE 8.1. wPOWER PARTNERS.

8.1.3 wPOWER organizational structure

In line with its mandate, the senior leadership of wPOWER constitutes women, with most of the team members comprising women as well, which reflects the values and mission of the organization. Figure 8.2 shows wPOWER's organizational structure.

8.1.4 wPOWER's vision

wPOWER's goal is to support over 8,000 women entrepreneurs and leaders by 2018 to enhance access to renewable energy and the adoption of energy-efficient technologies at the household level in local communities. wPOWER has already achieved more than half of this goal, empowering over 5,500 clean energy entrepreneurs working in underserved rural areas in Africa and India who are now catalysts for both urban and rural development. Table 8.1 summarizes the number of clean energy entrepreneurs trained by wPOWER and its partners.

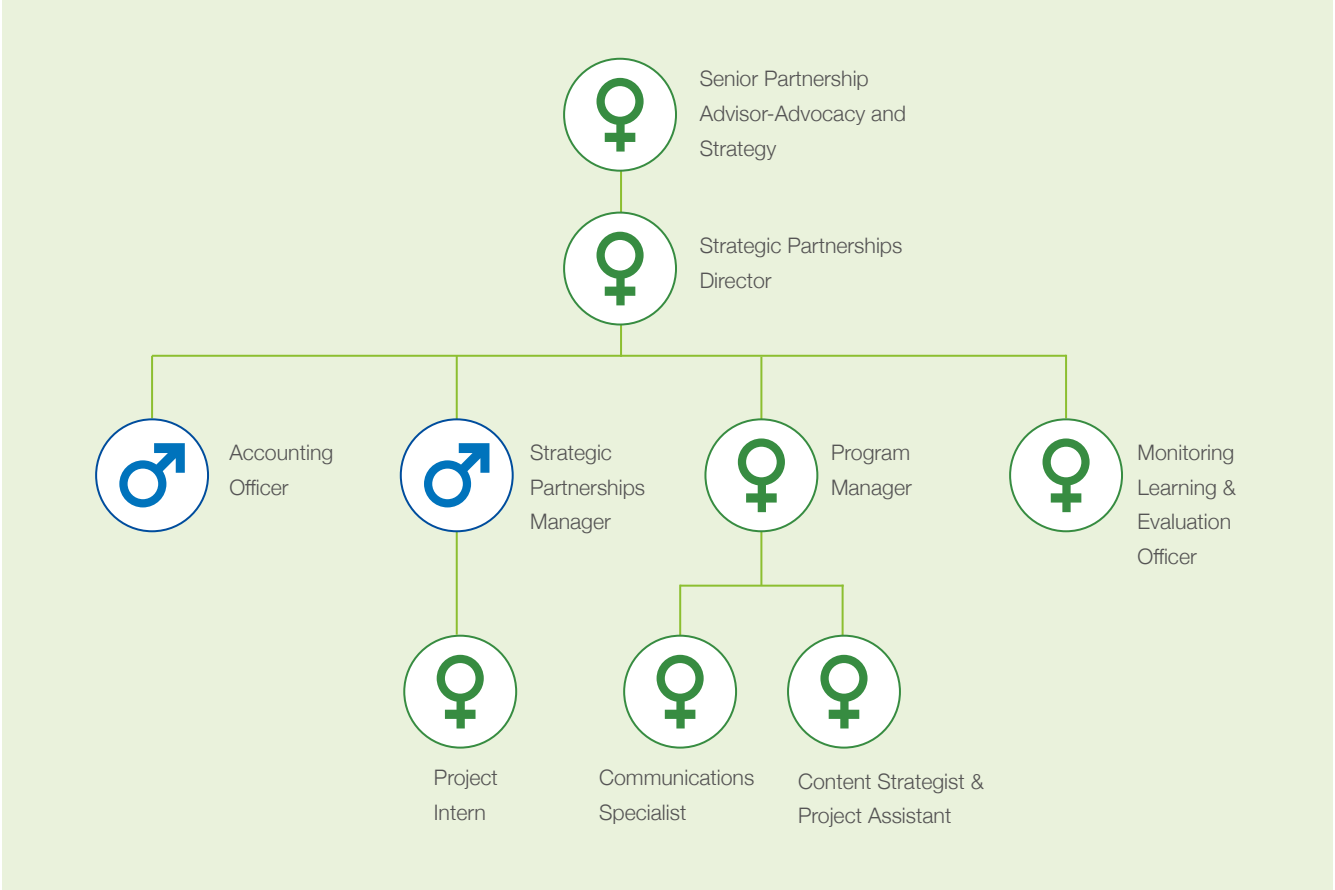
8.1.5 wPOWER strategies to integrate women in the renewable energy value chain

The burden of energy poverty is often disproportionately onerous for women and yet they are rarely involved and often marginalized in the energy value chain (WHO 2016). When they are included, they tend to be concentrated at the low-value end of the chain. Delahunty-Pike (2012) who studied gender roles played across the charcoal value chain confirmed that small-scale selling/retailing of charcoal is done almost entirely by women. The goal of the partnership is to catalyze the rate of energy adoption at the household level by integrating the primary users of energy across the entire value chain and by focusing on women in clean energy entrepreneurship.

TABLE 8.1. TOTAL NUMBER OF PEOPLE TRAINED AS CLEAN ENERGY ENTREPRENEURS BY wPOWER AND ITS PARTNERS.

wPOWER and its partners conducting the training	Total number of people trained (as of September 2017)
wPOWER Hub	380
Solar Sister	2,174
Care International	1,055
Swayam Shikshan Prayog (SSP)	1,087
Greenbelt Movement Kenya	164
Energy 4 Impact	434
Global Alliance for Clean Cookstoves (GACC)	755
Total	**6,049**

FIGURE 8.2. wPOWER ORGANIZATIONAL STRUCTURE.



"To achieve human dignity and shared prosperity, we must address how a majority of the world's poor, particularly women, cook." Wanjira Mathai, Senior Partnership Advisor, Advocacy and Strategy, at wPOWER

Although wPOWER is not directly involved in the decision on which products partners should stock, the hub lobbies for solar technologies, improved (charcoal and firewood) production and use, ethanol cookstoves and fuel briquettes among other household clean energy solutions. wPOWER carries out its work by employing three pillars in a multifaceted approach to enhance women's integration in the renewable energy value chain. These pillars are: (1) building evidence, (2) sharing best practices and (3) advocacy. In addition to these pillars the organization uses community training as a strategy to build women's networks. Descriptions of the goals and expected outcomes of each of the strategies used by wPOWER are provided below.

8.1.5.1 Building evidence

To achieve its vision, wPOWER initially engages in evidence building. This involves gathering of information and data that support the important role that women must play in advancing the adoption of clean energy technologies. All recommendations and/or actions plans by wPOWER stem from evidence-based data. By using such data and implementing researched best practices, the organization is able to diagnose the most effective options to reduce greenhouse gas emissions, improve livelihoods, while simultaneously empowering women to be entrepreneurs.

Evidence building is carried out through reviews of existing literature, evaluation reports, case studies, compiling baseline surveys to assess needs, gaps and best practices in clean energy technologies. wPOWER's online site contains an exhaustive repository of resources collated from partners, practitioners, researchers and academic institutions. In addition, wPOWER also develops its own resources based on primary data from outcome surveys to be able to add new knowledge and seal off information gaps that exist in the quest to support the role of women in clean energy.

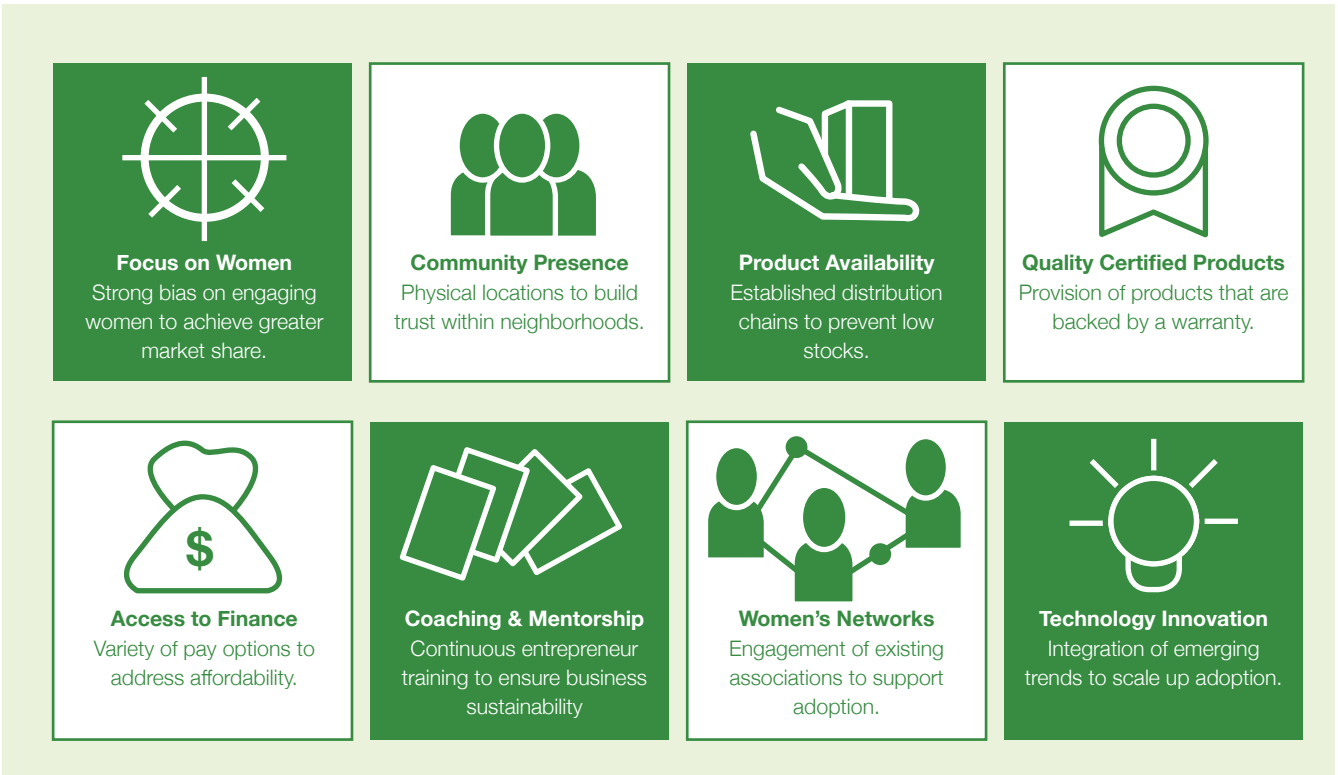
"Prioritizing women's leadership in clean energy entrepreneurship is investing in our future." Wanjira Mathai

8.1.5.2 Sharing best practices and experiences

To ensure partners and other players in the sector can replicate and scale up for more effective approaches to clean energy entrepreneurship. wPOWER aim to spur effective implementation through providing access to practical tools to wPOWER partners. This in turn helps to accelerate the participation of women in the value chain.

In this light, wPOWER has created eight main principles for best practices for effective approaches to clean energy entrepreneurship (Figure 8.3). These are: focus on women, community presence, product availability, quality-certified products, access to finance, coaching and mentorship, women's networks and technology innovations. These success principles are key for organizations in the business of accelerating energy access to ensure success in the sector.

FIGURE 8.3. wPOWER BEST PRACTICE PRINCIPLES THAT UNDERSCORE SUCCESS IN THE CLEAN ENERGY ENTREPRENEURSHIP.



8.1.5.3 Advocacy

wPOWER, through its partnership programmes, plays a collaborative role in bringing policy-makers, manufacturers, distributers, suppliers and the end-user to forums that are focused on empowering and developing capacity for women to be clean energy entrepreneurs (Table 8.1). The organization, in collaboration with its partners, advocates for women's leadership in clean energy entrepreneurship and across the energy value chain. To be precise, a key qualification for partnership is a demonstration of common interest in the overall goals of developing women entrepreneurs in clean energy to address energy poverty and climate change. There is also a need to demonstrate evidence of the organization's effort in engaging women across their energy value chains. To ensure sustainability, the advocacy is based on multiple factors (Box 8.1) on both the supply side (policy and legislative environment, availability of raw materials, access to storage and distribution networks) to the demand side (access to fuel, availability of technology to use the fuel, traditional practices and price).

BOX 8.1. SPECIFIC ELEMENTS OF THE ADVOCACY STRATEGY.

wPOWER considers the building blocks to successful implementation of the initiative to be:

1. Awareness
Women entrepreneurs must be aware of the opportunities across the value chain. End-users must be aware that there are alternatives to their current solutions.

2. Accessibility
Entrepreneurship opportunities must be accessible with few barriers to entry. Products must be easily accessible within the communities where the women live.

3. Affordability
Entrepreneurs must have access to affordable financing to access the opportunities. Products must be affordable at a price end-users can bear.

4. Advocacy
Strong advocacy around the issue is warranted. Robust policies are needed to promote engagement across the value chain.

5. Association
Influence and potential in women's networks and community groups must be tapped effectively across the value chain.

6. Acceptability
Cultural barriers must be taken into consideration when approaching women in entrepreneurship and adoption of clean energy technologies.

Capturing this opportunity, wPOWER worked to promote a 'modern' wood energy value chain in Kenya in the first phase of its operation (October 2013 to September 2016). The importance of wood energy for communities in SSA and South Asia as a way to cook food, boil water and produce and sell charcoal as a source of income, is well documented (World Bank Group 2009; wPOWER 2017). In the present scenario, most of the households still continue to use woodfuel in the form of firewood and charcoal for cooking and space heating; charcoal is mainly used in urban areas in charcoal stoves and firewood in rural areas is mainly used for open fires.

While woodfuel use at the household level has been associated with deforestation and land degradation (primarily through illegal and unsustainable charcoal production), poor health and contribution to climate change, research shows that it will continue to be a significant energy source in the developing world, particularly in SSA, for the foreseeable future (World Coal Association 2012). Due to the slow adoption rate of modern sources of energy such as ethanol-based cookstoves, efforts are being directed to make woodfuel a sustainable source of energy in SSA. Promoting this modern wood energy value chain can alleviate health problems associated with traditional use of wood energy on inefficient and polluting cookstoves.

This points to a direct link on the role of women as effective catalysts for the adoption and use of clean energy technologies at household and community levels. With this in mind, wPOWER focused on training events to build women's capacity in entrepreneurship, financial and technical skills.

8.2 Methodology

8.2.1 Capacity-development trainings on renewable energy by wPOWER

wPOWER has spearheaded several activities including a Training of Trainers (ToT) course on Sustainable Clean Energy Entrepreneurship and community training at the local level. The ToT course included modules on empowering and developing transformative leaders, sustainable clean energy entrepreneurship, environmental stewardship and developing and delivering content. This level-one ToT course was held at the Wangari Maathai Institute for Peace and Environmental Studies (WMI), University of Nairobi in July 2014 with 27 participants (18 women and nine men) from wPOWER partner organizations (Green Belt Movement, Swayam Shiksha Prayog, CARE International, Solar Sister and Women for Women International) across Kenya, Rwanda, Uganda, Tanzania, Nigeria and India (see Figures 8.4A, B).

This course allowed trainees to launch themselves as entrepreneurs and trainers in clean energy technologies such as briquettes, solar lighting and clean cookstoves.

FIGURE 8.4A AND **4B** TRAINING SESSION IN ACTION AT THE WMI.

Source: wPOWER. **A**

Source: wPOWER. **B**

Upon completion of level-one TOT training, community training in different regions was carried out. In Kenya specifically, the first phase of local community training conducted by the graduates of the level-one ToT covered seven regions, namely: Othaya, Maragua, Kahuro, Kibera, Munyaka, Homa Bay and Machakos areas (Figure 8.5). A total of 353 trainers (320 women and 33 men) were trained at the local level in their respective regions. Development of baseline data and a monitoring and evaluation (M&E) exercise were undertaken, which resulted in easier tracking and mapping of the impacts and outcomes of the initiative.

8.2.2 Survey on outcomes of the trainings

As a way to evaluate impact and progress, a qualitative survey was conducted. The respondents of the survey were drawn from the total number of trainees in the level-two TOT's (353 participants) across the aforesaid seven regions in Kenya. Using an M&E questionnaire as a guide, the research assistants conducted face-to-face interviews with the respondents. The participants responded to queries on major themes to determine (1) if they had started a business after the training; (2) their opinion on how the training had impacted on the way they are conducting business/lives; (3) statistics on the number and type of clean energy products sold; (4) challenges they were facing as entrepreneurs; (5) gender variation of their customers; (6) approximation on amount of money saved after adopting clean energy products; (7) income generated from clean energy entrepreneurship, among others.

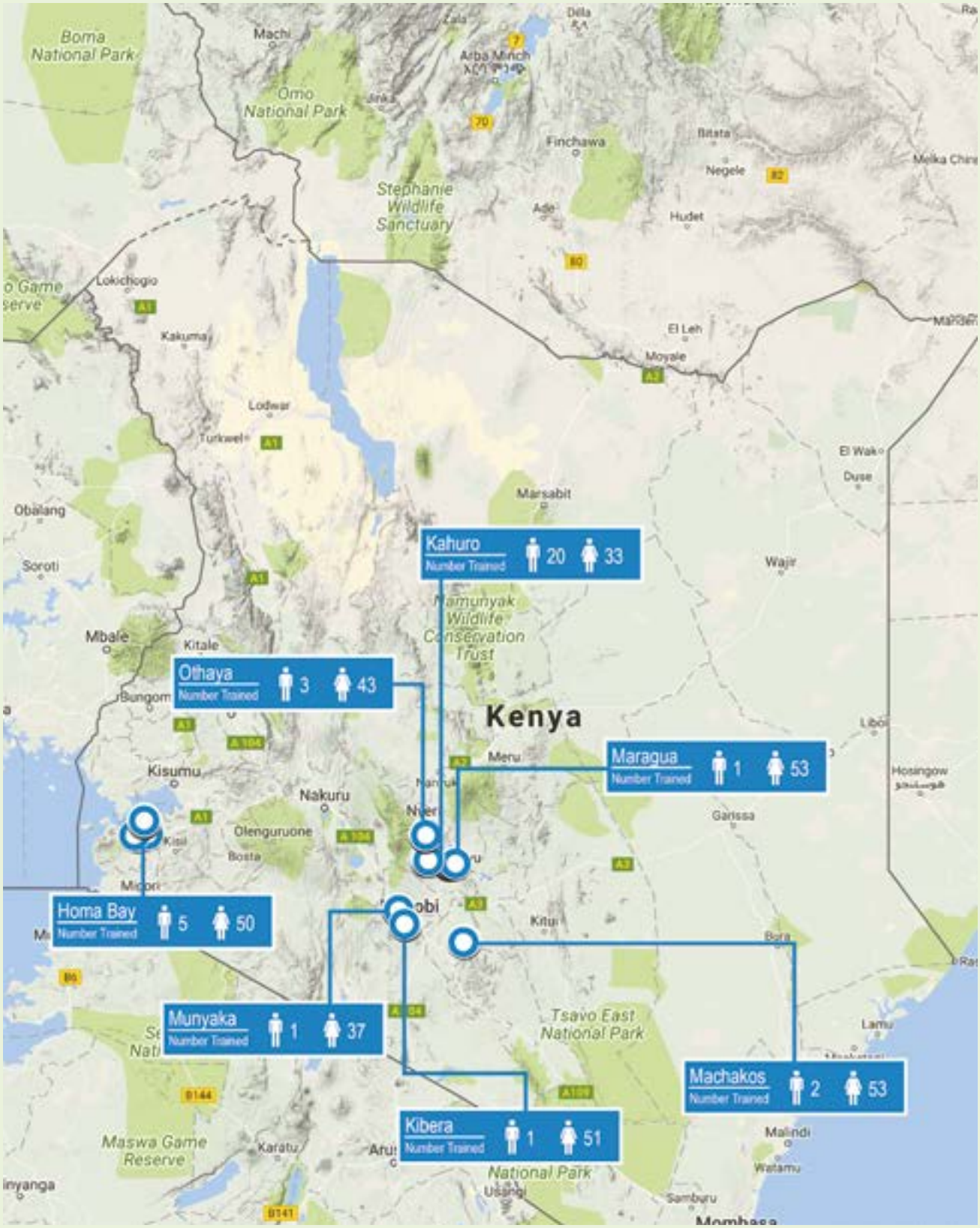
8.3 Impacts of the Trainings on Renewable Energy by wPOWER

A total of 306 participants responded to the survey, indicating an 88% response rate with 8% and 92% being men and women respondents respectively. Approximately 54% of the respondents had completed primary school and 34% had completed secondary school education. Comparisons between clean energy entrepreneurship and level of education showed that trainees who had higher educational levels were more likely to engage in entrepreneurship. After the training, a total of 23 respondents were engaged in clean energy entrepreneurship.

Results also indicated that a major impact was an increase in the average monthly income among the 23 entrepreneurs who started business after the community training. On average, each of the entrepreneurs generated an income of approximately USD 32.00 per month through the sale of clean cookstoves and solar lamps. The impact also included near elimination of monthly lighting expenses from kerosene and electricity bills for over 100 households, and a decline in cooking fuel-related expenses by almost half from an average of USD 17.20 to 8.80.

Looking specifically at the Kaewa area program location, Machakos County, the design of the local community training program was tailored to the region and took into consideration the challenges in the adoption of alternative energy there. These were documented (see Table 8.2). These challenges

FIGURE 8.5. DISTRIBUTION OF MEN AND WOMEN WHO PARTICIPATED IN THE COMMUNITY TRAINING CONDUCTED BY THE LEVEL-ONE TOT GRADUATES IN KENYA.



Source: wPOWER.

TABLE 8.2. CHALLENGES FACED BY THE COMMUNITY MEMBERS IN THE ADOPTION OF ALTERNATIVE ENERGY OPTIONS

Biogas	%	Solar	%	Others	%
Lack of raw materials	4.9	Lack of knowledge and skills	5.7	Unavailability	4.1
Lack of knowledge and skills	23.8	High installation cost	54.9	Lack of knowledge and skills	13.1
High installation costs	18.0	No response	39.3	High installation cost	24.6
No response	53.3			No response	58.2

emphasized the need for training, and providing connections with suppliers, to name but a few. The training was attended by 55 participants (53 women and two men), drawn from various registered women's groups from Machakos County.

The wPOWER training led to increased awareness on the need to protect the environment with over 95% of the respondents claiming commitment to do this. It was indicated that the uptake and adoption of improved biomass cooking devices and solar lighting equipment may have increased as more of the entrepreneurs were able to convince customers on the importance of using clean energy not only as a cheaper option but also as protection against respiratory diseases associated with smoke inhalation. Some of the products commonly used were JikokoaR, Jiko Kenya, the Kenya Ceramic Jiko (KCJ) and the Safi™ ethanol-based cookstoves at the household level. The lighting devices used included dlight™ (A1, S2, s20), EnvirofitR duo torch and solar lanterns. Although lack of funds was considered as a major challenge contributing to the low percentage of trainees becoming entrepreneurs (8%), the adoption of clean energy sources and products for those who remained as end-users was encouraging. The adoption of these products resulted in the following impacts:

- ***Reduction in cost of cooking:*** The cost of cooking fuel compared before and after the use of new cooking devices showed a reduction of about 10%. This meant that the adoption of clean cooking and lighting devices also contributed to improved livelihoods through cost reduction.
- ***Light for studying:*** Children were able to study well with solar energy providing adequate light as cited by 7% of the participants and a reduced monthly energy cost amongst 3% of the participants.
- ***Briquette making:*** 38% of the participants practiced briquette making after the training for their household use. Those not continuing to do so attributed reasons to lack of time, lack of raw materials and appropriate market.
- ***Decreased charcoal use:*** 70% of the respondents disengaged from charcoal production after the training, with 63% engaging in briquette making for the first time and 73% continuing to engage in tree planting.
- ***Training and mentorship:*** While 20% of the people trained were already aware of climate change, 7% of those trained instilled this knowledge in other people, promoting environmental awareness and tree planting.

These results therefore confirmed that engaging women in clean energy entrepreneurship had a direct impact on community adoption of clean energy practices. Based on these impacts, wPOWER continues to make progress in improving livelihoods, creating efficient production and use of cleaner energy, promoting a sustainable environment and empowering the role of women in the clean energy chain.

8.4 Conclusions and Recommendations

The inclusion and mainstreaming of women in the energy sector is as much a decision-making choice, as it is a process of influencing the existing perceptions and fighting prejudices. The myopic developmental approach that focuses on investments primarily in the area of cooking stoves and lighting initiatives for women as opposed to recognizing the critical role that women play across the entire clean energy value chain, needs to change. Results from this study have shown that women are a critical force for the sustainable management of natural resources and increasing clean energy access. This means that the involvement of women in clean energy initiatives has the potential to not only improve livelihoods but to increase access to clean energy solutions. Financial constraints were indicated as a key reason for the low number of women engaging in entrepreneurship post-training. wPOWER acknowledged this gap and the results formed a basis for the strategic engagements in the next project phase to ensure access to affordable financial support to see more women become entrepreneurs. As for energy sector institutions, there needs to be a shift from a general call for better women's integration to a gender-inclusive strategy at the core part of every human resource strategy. This strategy, in turn must be complemented with targets and periodic monitoring. Broad systemic approaches are needed to change and challenge the status quo, which is why this enabling ecosystem created by the unique partnership network of organizations hosted by wPOWER is so critical. wPOWER is committed to working with like-minded partners to achieve our shared goal – one of a world free of energy poverty and where women's leadership and entrepreneurship are the norm.

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Acknowledgments

The authors gratefully acknowledge research support from Davina Ngei (content strategist, wPOWER), initial editing by Maureen Onyango and the funding support by The U.S Department of State.

Source: ICRAF.

CHAPTER 9

Gender as Key in Community Participation

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9.1 Introduction

The notion of community participation is longstanding in the development field and aims to bring marginalized voices into development processes to ensure more equitable development (Cornwall 2003). While today it is deemed critical that projects and programs involve local communities – to the point of it being mandatory – the extent of this participation (Table 9.1) and who participates are contentious topics. For instance, while in many instances when community participation is purported as the foundation of a project, in actuality it involves selective participation, whereby wealthier, more educated, more visible and more vocal individuals (Botes and van Rensburg 2000) are able to be involved in the development process. Engaging with only certain groups and community representatives is a pitfall that many projects fail to overcome, as other important groups are overlooked during the development process.

It is critical to consider community participation in the gender-energy realm. For instance, while both women and men use energy sources every day at home, they do not always do so equally; women and men have different energy needs as well as dissimilar access to this energy. This disparity is compounded by the fact that most energy programs and

TABLE 9.1. Typology of participation.

Form/level of participation	Characteristics
Nominal participation Passive participation	Membership in the group Being informed of decisions *ex post facto*; or attending meetings and listening in decision-making, without speaking
Consultative participation	Being asked an opinion in specific matters without guarantee of influencing decisions
Activity-specific participation	Being asked to (or volunteer to) undertake specific tasks
Active participation	Expressing opinions, whether or not solicited, or taking initiatives of other sorts
Interactive (empowering) participation	Having voice and influence in the group's decision

Source: Agarwal (2001).

projects are gender-blind, meaning they fail to account for these unique gendered variations in energy use and access stemming from deeply embedded cultural (gender) norms. Here, there tends to be selective participation whereby, for example, cookstove implementation projects are mainly used by women yet men and community representatives (also commonly male) are the ones consulted. While energy interventions that take gender into account have the potential to be more effective, efficient and sustainable (Clancy and Stockbridge 2017), it is clear that interventions typically consider women and men as a single, heterogeneous unit, whereby they are designated as 'people' or 'community members'.

Issues of this failed gendered differentiation come to light particularly when women's interests are not considered during the design and implementation of projects. In such instances, the projects often fail as they do not sufficiently or accurately address women's unique energy needs and access abilities. As women are frequently the primary users of household energy sources, such as to cook with, taking their viewpoints into account is important for the success of any projects as discussed in the case studies presented in this document.

9.2 Gender and Community Participation as Depicted in the Case Studies

Clean cookstove projects over the past several decades have aimed to reduce the amount of organic material used in cooking for various reasons (i.e. to reduce deforestation, to improve user health conditions) and reduce indoor air pollution. However, arguably millions of dollars have been lost due to the high failure rate of these clean cookstove projects. This failure rate is directly related to project managers overlooking what the users (i.e. women in sub-Saharan Africa) actually want, including the specific barriers they wish to address by switching their household energy type and use. The authors of the case study on gasifier cookstoves illustrate how women's needs and preferences in cooking systems can be successfully integrated in projects by involving them as researchers in the participatory cooking tests as opposed to having them as study subjects.

The authors in the case study on briquettes in Uganda by Green Heat discuss how, while there is potential for both women and men to be involved in the briquette supply chain, often women face unique difficulties including 1) lack of time to participate in sales training events due to household burdens, 2) religious hindrances that impact women's ability to interact with men outside the family, 3) household budget control where men divert women's briquette enterprise running capital to other uses and 4) cultural barriers. Cultural barriers are important to note as they directly relate to societal gender relations and norms. For example, and as noted in this case study, due to cultural norms men feel insecure or undermined if their wives earn more money than they do, which in turn impacts not only their spouses' success and capability in the briquette industry but also the industry itself as a large talent pool (i.e. women) becomes unreachable and underutilized. On the other hand, gender roles shape men and women's skills in unique ways. For instance, women make up 91% of the people involved in sales through kiosks due to their intimate experience with household cooking fuel (i.e. men generally do not cook), a positive skill that the business is relying on.

Recognizing these cultural barriers, Green Heat has, by way of community participation, tried to include the husbands of female sales agents in the sales training process. For example, the husbands were invited to basic finance training events, which subsequently reduced "incidents of extravagance or spending business capital outside business needs". It is important to note that this involvement of men was not the ultimate solution to increasing women's control of their earned income. In many traditional communities, men make the household financial decisions. This factor arose in the case study, whereby the female sales agents contended their husbands were using their earned sales income for other purposes, thus hindering the growth of their briquette businesses. Green Heat has continued to work with the husbands by explaining the business model and its importance in order to ensure that their spouses' businesses can sustainably grow.

Growth of women-led waste-to-energy businesses is being inhibited by their low participation in sourcing funds from formal external sources; they prefer to borrow from family members and friends, which could be associated with limitations in skills or the complexity of acquisition procedures. On the one hand, the authors of the case study on investment climate for waste-to-energy enterprises in Kenya show that women's access to financial resources from banks or donors is affected by their low education as well as the intimidating application procedures. On the other hand, applying for licenses is faster for women as they spend less time negotiating to give bribes. Other factors that affect adoption may not be considered while working with women, as their groups are assumed to be homogeneous. The case study on the potential uptake of briquettes by women fish smokers in Ghana who are currently using firewood illustrates that large-scale firewood users who are older than their small-scale trader counterparts are not likely to adopt briquettes as they obtain a discount for firewood compared to small-scale traders who purchase on a daily basis and spend more money.

Overall, this document suggests that there is room for potential concerning community participation. For instance, while community participation has not yet been implemented in this sector, it is clear that briquette projects will likely follow suit *vis-à-vis* other energy efficiency projects (i.e. cookstove projects) and fail if they do not consider the specific, unique needs of, for example, the women fish

smokers. For example, whereas practitioners might believe that these women will adopt briquette technology if it renders health benefits, in reality the women indicated that costs (and in particular, discounts) are their main concerns. To fully understand what is important to these women (i.e. health versus costs) and therefore to most efficiently drive the clean briquette business in this industry, stakeholders should endeavor to bring in these women and discuss *how* they could best benefit from *which* types of cleaner and more cost-efficient energy sources like briquettes. Moreover, involving these women could further illuminate the extent to which they are willing to adopt this technology and the conditions they have for such adoption. Such involvement goes beyond the nominal type of participation discussed by Agarwal (see Table 9.1) and extends to interactive, empowering forms of participation, meaning these women are able to actively influence and choose to what extent they adopt new technologies.

9.3 Lessons on Gender Considerations in Community Participation in Development

In general, this chapter lends credence to the importance of community participation in development processes. It also points to the necessity of considering gender norms that might inhibit such participation or the success of certain projects. The crux of effective project implementation, then, lies in the ability to bring in the points of view of all potential stakeholders rather than only a select group.

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CHAPTER 10

Challenges and Solutions for Gender Mainstreaming and Gender Integration in Research and Development

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10.1 Introduction

There is an increasingly wider consensus that gender inequalities worldwide in agriculture and natural resource management are critical barriers to establishing robust food and nutrition security and poverty reduction. While there is commitment for inclusion at the policy level, implementation in both research projects and grassroots conditions remains complex. Even the definitions of equality vary substantially between cultures, nations and individuals. The purpose of this document has been to concretely demonstrate that the expansion and improvement of energy access in sub-Saharan Africa can provide a vehicle for expanding the economic, cultural and personal opportunities for women and girls. At the same time, by providing men and women with the chance to improve a central component of their lives – the production and use of energy products – the case studies described here show that expanding energy access and sustainability creates circumstances in which women's contributions benefit all community members rather than becoming a zero-sum game in which women and girls benefit at the expense of men.

Gender mainstreaming is a term commonly used in the development community to discuss the process of bringing the concerns and experiences of women and men into development policies and programs for action aimed at achieving gender equality; as such the needs of women and men can be valued and favored equally (UN Women 2014). The term is perhaps unfortunate in that it implies that women and concern for gender have been excluded from the mainstream of social life. At the same time, it does indicate that while women and other marginal groups may in fact have developed subcultures around their limited arenas of responsibility, the well-being of home and family, for example, they have been precluded from participation in wider realms of engagement. In the case of home energy use, we see an area where men and women sometimes play highly restricted and codified roles. In some countries for example, women do all of the cooking in the home while men cook in restaurants where they are paid. As a result, as these case studies demonstrate, sharing technological innovations for home cooking, for example making briquettes from recycled waste or providing improved cooking devices, brings development professionals and researchers into social

contexts where traditional norms and gender expectations may be deeply entrenched. Using a new fuel or new cooking devices may require changes that touch on social practices that reach back beyond human memory. It is thus important to understand that the normative practices in some places and communities, the 'mainstream' if you will, may resist equality and an end to what from the global perspective may look like or be, discrimination.

Gender integration in development projects requires thoughtful planning, staffing and resourcing. It involves developing an understanding of the gender-based constraints and opportunities that could limit or facilitate a project's desired changes, i.e. how will anticipated activities and their outcomes affect women and men differently, and how will the different roles and status of women and men affect the work to be undertaken. However, the real challenge is that one has to decide how much social change one thinks is possible or desired by the existing clients, being careful not to negatively disrupt their social conditions. In the development context one hears reference to gender-responsive projects in contrast to gender-transformative approaches. Although this is a contested arena, it is arguably the case that both individuals and communities may be more or less receptive to even a conversation about the roles that men and women may currently occupy, much less what kinds of social change may be acceptable. Gender-related differences in participation in agricultural production, natural resource management, household decision-making, marketing and food consumption need to be understood in the context of underlying sociocultural norms. Men and women's experiences, expectations, needs and knowledge can be strongly influenced by these norms. In turn, their capacity to take advantage of income opportunities, new technologies or services will be impacted. Initiatives that fail to recognize the inherent differences and social inequalities that exist between men and women, and which are often complexly intertwined with clan mores, ethnicity, age and other modes of social differentiation, risk reinforcing such inequalities, and the sustainability of any development outcomes (FAO 2013; GEF 2017; IFAD 2012; CGIAR 2011).

Further, 'men' and 'women' are not consistent categories and one of the benefits of gender integration is that unnecessarily constraining norms can be replaced with a desire to utilize each person for her/his talents and interests. As described in the case studies on briquette enterprises by Sanivation in Kenya and Green Heat in Uganda in this document, sales skills by women in cooking energy, a domain they well understand, are being applied for enhanced demand and profits. It is necessary to tailor approaches and methods to the needs, priorities and interests of different social groups including women and men of different ages and socioeconomic, ethnic or religious backgrounds.

Most importantly, gender mainstreaming should, at its core, facilitate critical awareness of traditional gender roles that impede the equitable achievement of benefits for both men and women. In a recent study that builds on a sample of 700,000 people across the world, Fisher and Naidoo (2016) concluded that households headed by males have on average 13% more asset wealth than their female counterparts, and on average own an astonishing 303% more land. One general mechanism underlying the patterns that have been observed is that in many areas in developing countries, women lack the rights, knowledge or capital to secure their land and asset inheritance after being widowed, and such events can have a long-term impact on livelihood opportunities (Cooper and Bird 2012; McPeak and Doss 2006). As such, gender inequality in these regions is entrenched in the cultural, political and market systems that operate at household, community and national levels (Deere and Leon 2003; Vijaya et al. 2014).

10.2 The Challenges of Gender Integration

Many critics refer to how gender mainstreaming has been operationalized to serve the purpose of international development agendas not necessarily concerned with equality issues (Mukhopadhyay 2014). Others refer to how the loose adoption and adaptation of gender mainstreaming concepts have led to pervasive popularizations of notions such as women being less corrupt than men, images of women as being more environmentally conscious or inherently peaceful, generating myths that only serve to obscure the complexity of men and women's lives and the interaction of gender issues with class or age (Cornwall et al. 2007).

Feminists and advocates for gender equality have observed a growing divide between gender debates and feminist theory, and the way gender mainstreaming is put into practice on the ground (Cornwall et al. 2007). Beneficial collaborative approaches for example, involve men and boys in discussions around women's empowerment and gender equality, or involve tools that reach within the household dynamics bringing to light gender inequalities in the day-to-day activities of the household and the family, and foster discussions around how these inequalities contribute to their disadvantaged situation.

Efforts that meaningfully address gender inequalities among smallholder farmers and community-based organizations recognize that targeting and involving women only, does not automatically lead to more or equitable benefits. Even less does it guarantee the sustainability of potential benefits and changes. Gender analysis needs to look beyond disparities between men and women, as these are the symptoms of a more fundamental problem that is rooted on traditional norms and attitudes about what it means to be a woman or a man in a given community.

In cases where a high level of conflict exists between individuals or subgroups, one of a development professional's challenges is determining an achievable goal as opposed to striving for ideal conditions that may fuel backlash.

10.3 Considerations for Moving Forward

The different case studies presented in this document focus on energy innovations and the ways in which women's participation can enhance community well-being. The cases portray examples of ways in which different organizations, both public and private, have tried to engage women across the energy value chain. Some initiatives have enabled increased participation of women in income-generating opportunities, such as the selling and marketing of briquettes. Others have increased women's access to training and information, either to be able to participate in energy-associated businesses or to better demand and decide what kind of energy sources are most suited for them and their needs. Some initiatives also strengthened collective action through their work with women's networks and community groups.

All these initiatives have the potential to increase women's bargaining power, both in the community and within their households, that could provide them with more active participation in decision-making over their lives and those of their households. This is, however, not a straightforward process and it is influenced by the same gender relations and their entrenched power distribution that constrained women's access to those opportunities in the first place. Women may have access to more income but assumptions (norms) regarding their role in the household might limit their ability to retain control over that income. Similarly, time burdens and domestic responsibilities may limit how far women can travel to work and the type of work they can undertake (Gammage et al. 2016).

Gender relations however are not static because they involve a constant process of negotiation and renegotiation that can render positive transformations. In this context, increased bargaining power is key, but it also requires acknowledgment of the negative effects of traditional gender norms by both men and women, engaging men in the discussions about gender, fostering intrahousehold collaboration and engaging in dialogue with community leaders, government and private sectors involved in the energy value chain.

10.4 Examples of Challenges Faced by Researchers in the Eastern and Southern Africa (ESAf) Region *vis-à-vis* Gender Integration and Solutions to Address Them

10.4.1 Gender integration challenges faced by researchers

To identify some practical challenges that researchers face in integrating gender in their work, an online survey via e-mail was carried out on August, 3 2018 among ICRAF researchers working in the ESAf region. The survey was mailshot to 39 people who were asked to identify two priority challenges, ranked by severity, that they faced in integrating gender into their research in development work and possible solutions to address each of them. Responses were received from five male and five female researchers. Analysis of the responses indicated that culture and mindset were most important (Figure 10.1). These findings tend to support the argument presented earlier that researchers and practitioners desiring innovative and inclusive solutions to agricultural and natural resource challenges need to understand the local social cultural norms that define differences and inequalities between men and women. Culture, for example, defines women and men's participation in meetings where women are passive and find it hard to express themselves in the presence of men. Likewise, young people's participation is browbeaten by the presence of older people. From a cultural perspective, women believe that their views do not hold the same weight as those of men. In fact, some women prefer to air their views through men which negatively affects their contribution to research and development (R&D). In order to conform to cultural beliefs and tendencies they prefer to give responses that are biased, hence it is difficult to divine the truth about issues. If women's views and needs are not effectively communicated and interpreted this hinders their effective empowerment and development of appropriate technology. The need for proper understanding of women's needs and perceptions is critical in the development of appropriate cooking systems as discussed in the case on the gasifier cooking system in Kenya.

The cultural expectation that women should give birth at a certain age, take care of families and carry out family maintenance roles inhibits their full participation in gaining formal education. A study in rural areas of Chongwe District in Zambia revealed disparities between boys' and girls' education caused by high drop-out rates among girls at both primary and secondary schools (Mwanza 2015). Girls, for example, failed to continue with their education due to domestic chores, early marriages or becoming pregnant. The resulting low formal education among women was the second most critical challenge affecting gender integration. This cultural expectation on women's contribution to bearing children at a specific age, for example, adversely affects women's advancement in higher education among the staff of the Green Heat briquette-producing company. Most final decisions regarding resources such as land management rest with men and this is also linked to culture. Knowledge and skills on improvement of resources, such as those concerned with cooking energy, are held by women but decisions on changes such as the installation of a biodigester or planting of trees on farms are made by men. The men's power in decision-making even includes disposal of women's earned income, a factor that inhibits women's development and leads low growth of to waste in energy enterprises as funds are diverted to other uses by the husbands.

Limited knowledge about gender and the inherent misconception that gender is designed to favor or support women only among the beneficiaries and researchers was among the top three challenges affecting gender integration in R&D among the interviewed scientists. This is linked to ineffective interaction between communities and researchers and ineffective data collection on gender issues as scientists may not have the necessary skills to carry out gender-related work. The lower number of female researchers compared to men was another limitation. Due to the lower representation of women in teams of researchers, the views of women participants may be stifled and not entirely captured as women are more liberal in disclosing information to other women.

Disproportionate numbers of women participants at training events was another challenge to gender integration identified by the researchers. This was associated with ineffective skills' transfer to women, especially in activities mainly carried out by women, and a possible cause for low adoption of technologies. Low attendance rates by women at training events could be due to the triple burden roles they play in reproductive work (e.g. domestic chores and care giving to children and adults), productive work (salaried or informal work) and other community-related work.

10.4.2 Possible solutions to addressing barriers in gender integration

Awareness-raising: The researchers proposed points of action to enhance gender interaction including: raising awareness about the importance of recognizing every individual perspective and recognizing and respecting holistic participation in order to overcome cultural barriers and achieve sustainable development (Table 10.1). In this way men will be supportive of the initiatives directed at women and youth empowerment as opposed to feeling alienated. Cultural barriers could also be overcome through the use of compatible and appropriate research tools and approaches in data collection, training events and communication. As recommended by Mwanza (2015), there is a need to address negative attitudes and cultural beliefs that hinder the education of female children in order to encourage the full participation of girls in schools.

Capacity development: Low education of women and low involvement of women in leadership at the community level could be addressed through deliberate policies that promote education for all with effective reinforcement systems and training on leadership skills. Increasing women's formal education levels at the community level will enhance their capacity resulting in active participation in development, leadership

FIGURE 10.1. PRIORITY CHALLENGES FACED IN GENDER INTEGRATION IN R&D IN THE ESAF REGION.

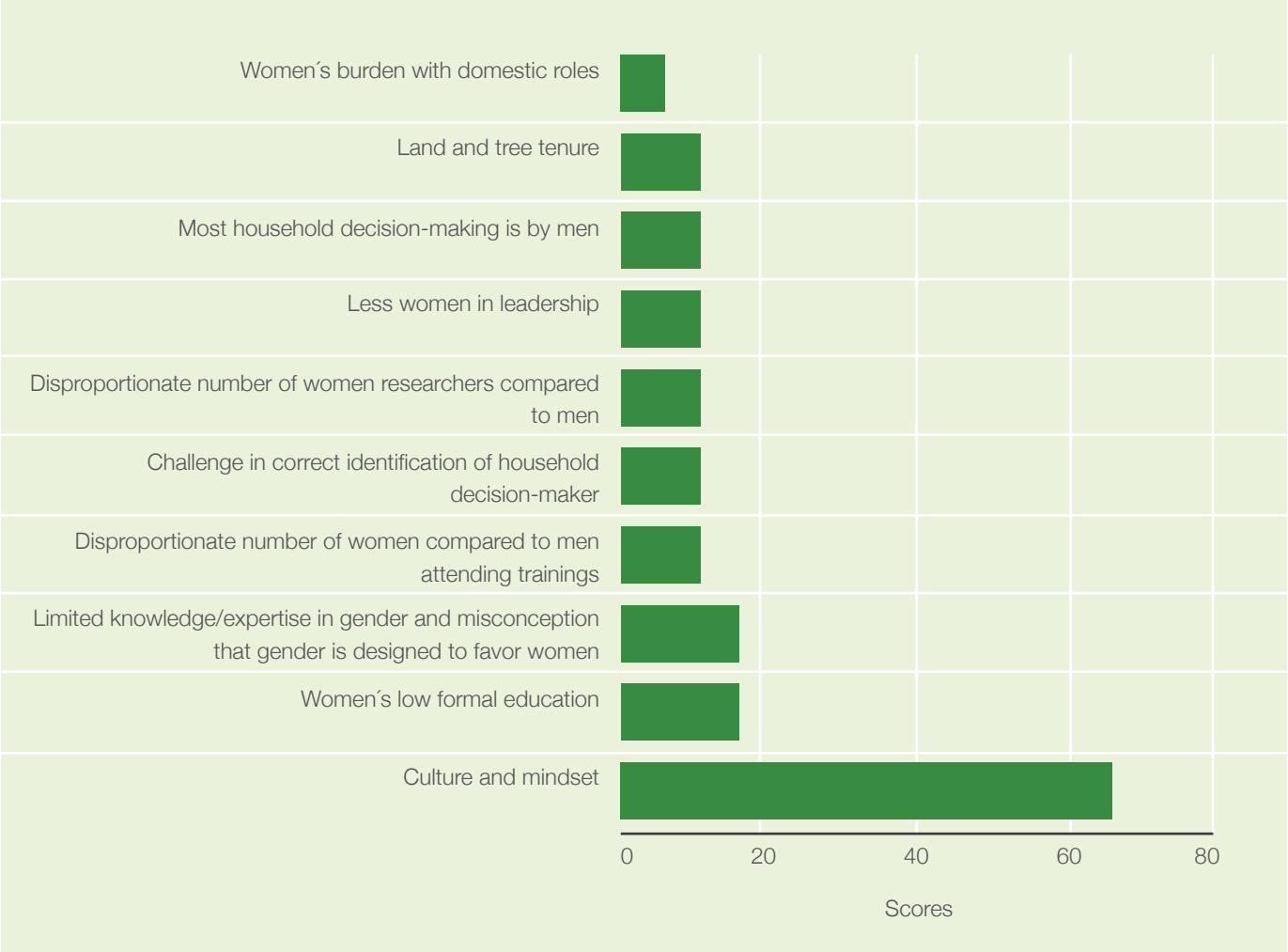

TABLE 10.1. PROPOSED SOLUTIONS TO ADDRESS THE CHALLENGES IN GENDER INTEGRATION IN R&D.

Challenges in gender integration in R&D	Solutions to address barriers in effective gender integration in R&D
Culture and mindset	• General awareness raising on the importance of gender integration and women's involvement to overcome cultural barriers; • Capacity development for women, e.g. in decision-making to overcome cultural barriers; • Use of appropriate gender-responsive tools and approaches in data collection, training events and communication; • Exposure for women through exchange visits; • Effectively addressing cultural practices that adversely affect women; and • Church and local leaders to play a role in promoting women's involvement in development including addressing cultural barriers unfriendly to women.
Women's low formal education	• General policies on education with effective reinforcement systems; and • Increased opportunities for formal education for women.
Limited knowledge/expertise in gender and misconception that gender is designed to favor women	• Capacity development among scientists on gender integration especially in the design of gender-responsive projects and research methods such as collection of gender-disaggregated data; and • Raising awareness on the role of gender integration in development among community members.
Disproportionate number of women compared to men attending training events	• Deliberate efforts and incentives as well as support mechanisms that encourage women's participation in training events.
Challenges in correct identification of household decision-makers	• Raising awareness on the role of gender integration in R&D among community members.
Disproportionate numbers of women researchers compared to men	• Capacity development and training of more women scientists and their placement in strategic institutions.
Fewer women in leadership positions	• Capacity development among women on leadership.
Most household decision-making is by men	• Women's empowerment on income generation in activities they are already involved in. Sensitization of men and women on issues around gender equality within the household.
Land and tree tenure	• There is a need for community sensitization on the need for women's involvement in decision-making; and • Changes in policy for recognition of women's rights on land and tree resources.
Women's burden with domestic roles	• Systematic assistance for women and girls who already have children to ensure that parenthood does not preclude participation in education and other activities; and • Raising awareness on the effects of numerous children in a family compared to resource endowment and increased access to family planning information and methods.

and entrepreneurship. Capacity development for scientists, especially in the design of gender-responsive projects and collection of gender-disaggregated data, was proposed as a way to enhance their skills in gender integration. The low number of women scientists could be addressed through special programs to encourage women to pursue science-oriented careers and put in place mechanisms and incentives that encourage their appointment in R&D institutions upon completion of their studies. The outcome of the capacity development for women in energy-based entrepreneurship as presented in the case study by wPOWER showed positive results where women took leadership in businesses as well as awareness raising at the grassroots level on environmental management.

Active participation of women: Awareness raising about the role of gender in development and capacity development was suggested as a way to improve women's active participation such as speaking at meetings and taking leadership roles. There is also a need for women's awareness raising and education on programs that are friendly to their way of carrying out business. For example, the case study about the investment environment in waste-to-energy businesses in Kenya found that women were intimidated by the application procedures for sourcing funds from banks or donors. The recommendations included educating women about mobile money through systems such as Mpesa where they can borrow money through their phones for their business. Mpesa is a mobile phone-based money transfer, financing and microfinancing service launched and operational in Kenya since 2007.

Improved decision-making capacity for women: Men's involvement in initiatives that are designed to improve women's decision-making would result in men's support of the process which then avoids alienating them. Awareness raising among men and women including local and church leaders on gender and cultural issues that undermine women's decision-making power is also important. In the case study on briquettes by Green Heat in Uganda, management involved the husbands of the women sales agents in training events so that they could address the problem of the men diverting income from the briquette business. This approach agrees with the proposals made in this chapter that involvement of men and boys in discussions around women's empowerment and gender equality is promising for transformative change. It is widely documented in previous gender-related studies that commercialization can change gender roles within the farm household, often resulting in a lower share of the income being controlled by women (Chiputwa and Qaim 2016). Chiputwa and Qaim (2016) suggest that loss of female control can be prevented and even reversed when measures to promote gender equity are integrated into market-linkage initiatives.

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Source: Njenga M./ICRAF.

CHAPTER 11

Take-home Messages on Gender and Resource Recovery and Reuse (RRR) for Energy

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The case studies presented in this document demonstrate that innovations that recover energy from organic waste have multiple impacts that benefit some of the world's most disenfranchised people. Requiring little investment capital for either producers or consumers, these methods produce inexpensive fuels that fit existing cooking practices. Women and young people can be involved more easily in the production process because the technologies involved are uncomplicated and input materials can be cheaply accessed.

In addition to providing affordable fuels, the case studies address additional benefits to communities when waste materials are put to good use. These include:

- Reusing waste materials from urban markets and highly populated neighborhoods, with limited sanitation services, can help to keep streets and public spaces clean while providing raw materials for briquette production.
- In extreme cases such as refugee camps in arid locations, human waste that would otherwise be a threat to groundwater and human well-being can be directed towards fuel production.
- Providing the indoor urine-diverting dry toilets (UDDTs) for recovery of human excrement can prevent refugees, especially women and children, from having to go outside at night to use pit latrines and supply faecal sludge for briquette production.
- RRR for energy contributes to provisioning cheap, accessible cooking and heating energy that burns cleaner than firewood and charcoal.
- Fuels that burn cleaner such as biogass reduce soot on cooking pots, an improvement that encourages men to participate in cooking.
- Bioslurry from biogas production increased yields in coffee cherries and bioslurry can also be used as feed for pigs and poultry.
- Burning biomass in gasifier stoves produces biomass gas for cooking and in addition produces charcoal as a by-product which can be used as biochar to improve soil quality in home gardens or be used again as fuel for cooking.

- The RRR-to-energy innovations reduce pressure on trees that would otherwise be cut down for charcoal or firewood.

The solutions described in this document can be adapted to various conditions and constraints. They are adaptable to low income urban informal settlements, isolated subsistence rural villages and refugee camps located in extremely arid regions where other means of energy sourcing are so difficult that many families suffer severe energy poverty. Because of this flexibility, local cooks who are generally women, often burdened with family responsibilities and lacking access to cash income, can be more easily integrated into the production and efficient use of energy. Low levels of education and lack of capital or landownership need not preclude participation.

As a business opportunity, the household cooking fuel domain is also attractive for women as traders and consumers: it does not require high literacy levels, it is not capital-intensive and women already have in-depth cooking experiences. Women's traditional knowledge can in this way become a modern business asset. Unlike conventional energy production and use, the profit margin of these varied and small- to medium-scale ventures is limited. The organic waste to energy described can thus grow into healthy local businesses, but they are unlikely to result in larger regional or export goods or to become attractive to international investors. For this reason, investments in these RRR activities for cooking energy solutions will be transformative for local women and/or youth, as the potential benefits stay in the communities and regions they serve. Existing mobile money systems such as Mpesa in Kenya, can provide a means for energy entrepreneurs to save their profits and reinvest in their businesses. Low cost widely used methods are more effective for female energy producers even when they use waste materials for their production. Bank loans and other more formal means can be intimidating and women fear negative experiences.

The positive impacts that RRR-to-energy strategies can offer disadvantaged women and their families address the major challenge of energy poverty and the disproportionate impact poverty has on women. Nonetheless, a few major limitations remain even in this positive environment:

- The cultural expectation that women should give birth at a certain age, take care of families and carry out family maintenance roles inhibits their full participation in gaining formal education and working full-time. Deliberate policies that promote education for all with effective reinforcement systems and training on leadership skills would help to address these issues.

- As interventions are devised to spread RRR-to-energy, researchers and practitioners must be aware that social change is a tough call for many people. What may look and feel like progress for one group of people, may deeply upset others. Taking the time to understand the existing cultural expectations in a given community is key to success.

- Men's involvement in initiatives that are designed to improve women's decision-making would result in men's support of the process which then avoids alienating them. Particularly in circumstances where everyone is poor, it is critical that everyone disenfranchised group an improvement even if women are the most disenfranchised group.

ANNEX 1

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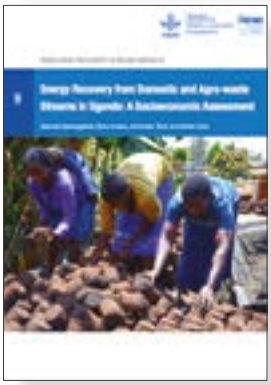
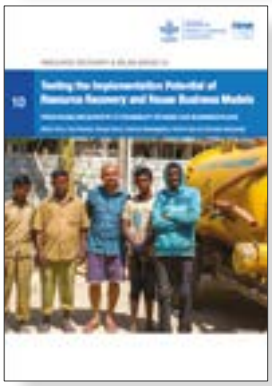
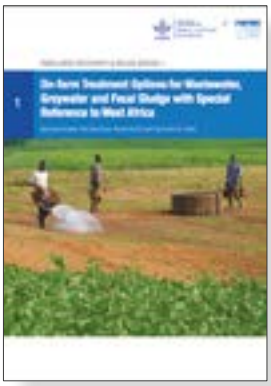
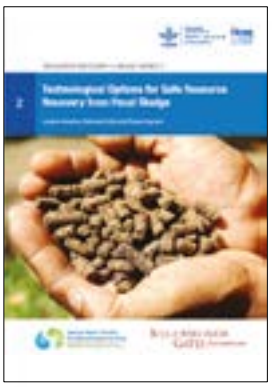




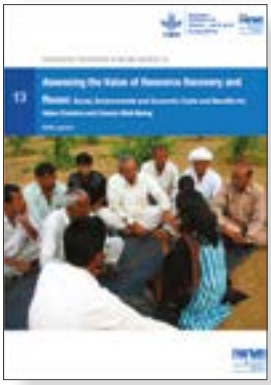


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CGIAR Research Program on Water, Land and Ecosystems

The CGIAR Research Program on Water, Land and Ecosystems (WLE) is a global research-for-development program connecting partners to deliver sustainable agriculture solutions that enhance our natural resources – and the lives of people that rely on them. WLE brings together 11 CGIAR centers, the Food and Agriculture Organization of the United Nations (FAO), the RUAF Foundation, and national, regional and international partners to deliver solutions that change agriculture from a driver of environmental degradation to part of the solution. WLE is led by the International Water Management Institute (IWMI) and partners as part of CGIAR, a global research partnership for a food-secure future.

Resource Recovery and Reuse (RRR) is a subprogram of WLE dedicated to applied research on the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams. This subprogram aims to create impact through different lines of action research, including (i) developing and testing scalable RRR business models, (ii) assessing and mitigating risks from RRR for public health and the environment, (iii) supporting public and private entities with innovative approaches for the safe reuse of wastewater and organic waste, and (iv) improving rural-urban linkages and resource allocations while minimizing the negative urban footprint on the peri-urban environment. This sub-program works closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU), and many national and international partners across the globe. The RRR series of documents presents summaries and reviews of the subprogram's research and resulting application guidelines, targeting development experts and others in the research for development continuum.

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ISSN 2478-0510 (Print)
e-ISSN 2478-0529 (Online)
ISBN 978-92-9090-877-7

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