CHAPTER 9

GRASSROOTS INNOVATIONS IMPROVE WOODFUEL IN SUB-SAHARAN AFRICA

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Woodfuel (charcoal and firewood) is the most common form of biomass energy used for cooking and heating in Sub-Saharan Africa and is preferred for its affordability, accessibility, and convenience. More than 90% of the population in the region relies on either firewood or charcoal.[1] Charcoal is used mostly in urban centres and firewood in rural areas. Households that lack woodfuel access, for instance, are forced to abandon food stuffs that are nutritious but cooking-energy-intensive and switch to others that are less nutritious but cook more quickly.[2] Others reduce the number of meals or amount of food consumed per day, and a large proportion of income is spent on cooking energy at the expense of purchasing food.[3] At the Kalobeyei Refugee Camp located in northwestern Kenya, an arid land characterized by water scarcity, 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.[4]

International debates—including discussions around the Sustainable Development Goals—have pointed to the need to move to 'clean and renewable energies'. In regions such as Sub-Saharan Africa, where woodfuel is the main source of cooking and heating energy, this creates a complex and contradictory landscape for both local authorities and donors. The recommendation to move away from woodfuel is mainly the result of negative implications for the environment and human health that are associated with unsustainable production and inefficient utilization. Instead of hoping that woodfuel will be abandoned, it is more practical for governments and donors to invest in making it sustainable.[5] Solutions exist that have the potential to make woodfuel systems sustainable through interventions at all stages of the value chain, including sustainable wood production, efficient wood-to-charcoal conversion technologies (kilns), and efficient utilization.[6]

The negative impacts of woodfuel systems are associated with unsustainable and inefficient production and consumption. For example, cutting down trees without replanting others results in deforestation and land degradation. The carbonization of wood into charcoal using

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inefficient kilns results in air pollution, wood wastage, and land degradation. In this way, unsustainable woodfuel use contributes to climate change. Firewood too has implications for the environment. For instance, collecting deadwood from natural forests interferes with soil nutrient recycling and removes seedbed material, consequently affecting seedling regeneration.[7]

Collecting firewood from the forest is life-threatening, hard work for women and children and limits their ability to take part in productive activities and schooling, respectively. Burning biomass fuel, especially in poorly ventilated kitchens using inefficient cook stoves, has been linked to health problems from illnesses associated with smoke in the kitchen. Globally, over 4 million deaths occur annually from illnesses related to the smoke generated by indoor combustion, which mainly affects women and children.[8]

Decades of attempts by non-governmental organizations and governments to shift usage from open fire to more efficient or less smoky stoves, or away from biomass to other fuels such as liquefied petroleum gas (LPG) or solar photovoltaic systems, have been less than successful, especially because the technologies fail to respond to users' social-cultural practices and needs.[9] Small-scale studies across the global south indicate that the choice of fuel and stove type are complicated decisions that cooks and households make in the context of constraints that include an underestimation of the value of traditional stoves and a mismatch between users' goals and those of stove innovators, among other complex factors.[10]

Instead of documenting why woodfuel innovations have failed, this chapter presents examples of how grassroots communities are applying simple innovations to improve their production and use of woodfuel in ways that address their practical needs.

Instead of documenting why woodfuel innovations have failed, this chapter presents examples of how grassroots communities are applying simple innovations to improve their production and use of woodfuel in ways that address their practical needs. These innovations include (1) sourcing firewood from trees on farms, (2) processing organic residues into fuel briquettes, and (3) using biochar-producing cooking systems. The first and second innovations address energy production issues, and the third addresses energy consumption issues of the local energy value chain described in this Global Innovations Index (GII) 2018 report. For impact and replicability, research and development (R&D) analysts need to apply processes that involve all stakeholders, such as the transdisciplinary methods of generating knowledge and implementation of the understanding gained in the R&D processes.

The chapter shows how transdisciplinary methods work and describes examples of grassroots innovations using biomass energy. In many of the affected communities, women are responsible for sourcing fuel that is used to cook food and, in some instances, to provide heat. The majority of those involved in the grassroots innovations in woodfuel are women in rural areas, low-income urban neighbourhoods, or refugee camps in search of affordable cooking fuel that also meets their needs. Briquettes are produced mainly in low-income urban neighbourhoods and some rural areas where biomass is available. In addition to women, youth—both girls and boys—are also involved and the briquette activities are focused on generating income.

Transdisciplinary R&D

Transdisciplinary research methods are relatively new and still developing as an approach. For the purposes of understanding grassroots needs and innovations in sourcing cooking fuel as well as innovations in kitchens using biomass fuel in Sub-Saharan Africa, a team consisting of biophysical scientists, social scientists, gender specialists, engineers, economists, science facilitation and communications experts, and grassroots researchers has been built. The grassroots researchers are perhaps the most important participants because they help the entire team understand what kinds of changes in social practice are attractive and useful to local communities.

What is at stake is more than just the cooking preferences of local communities. Rather, grassroots researchers are considering the question: What does our community need to adopt from the larger research world and what role can women play in ushering in a new era in energy use? Transdisciplinary research teams differ from interdisciplinary teams and participatory action research teams in several ways: the grassroots researchers are not just research subjects—they should also be considered as part of the team since they share their insights about how their community might choose to change their approaches to energy use. Most importantly, the team using transdisciplinary methods to investigate grassroots biomass innovations integrates several attributes specific to the cultural context of both the researchers and the problem at hand.[11] Furthermore, the team applies natural science methods, such as the quality characterization of cooking fuels in laboratories, and measures emissions through participatory cooking tests performed by women as cooks. In summary, the team works along the innovation process cycle, which includes understanding the context, identifying and developing interventions and technologies, engaging in their implementation, assessing impacts, and communicating lessons.

Enhancing the impact of grassroots innovations in woodfuel through R&D

Understanding community members' needs, aspirations, fears, and solutions to the challenges they face as well as the potential for innovation is critical to achieving sustainable development. The transdisciplinary team's approach targets working with communities on scalable, tailor-made local innovations. It is important, however, to link local innovations to external science and technology because neither grassroots innovations nor science and technology alone can effectively address social, economic, and environmental challenges. Work on biomass energy addresses some of the bottlenecks faced by local communities, including resource scarcity that inhibits the scalability and diffusion of local innovations. These bottlenecks, identified by research on grassroots innovations,[12] can reduce otherwise effective interventions. Furthermore, innovation and community involvement are integrated to encourage participation and technology uptake as well as to tap community creativity, a need identified by the same authors. Research is also carried out in order to generate facts and enhance understanding of the role of local innovations in developing solutions, making a case for their inclusion in development and research agendas.

The grassroots innovations on making woodfuel sustainable include several elements, discussed below.

Sourcing firewood from trees on farms

Multipurpose trees on farms, such as those grown for timber or fruit, need to be pruned as part of the farm management practice that encourages rapid biomass and trunk growth.[13] Farmers practicing agriculture with trees, commonly referred to as 'agroforestry', know that. In the Kibugu village in Embu County, Kenya, the *Grevillea robusta* tree is grown primarily on farm boundaries for timber and is pruned biennially (every two years) during the dry season, mainly in the month of January. Pruning is carried out by young boys in families or by hired youths. The firewood is then carried to the homestead by girls or women, where it is first spread under the sun and then stored under shade for about three months to dry. In this way the firewood dries well and burns more efficiently and with less smoke. Before use, the firewood is removed from the shade and put in a rafter/drying rack in the kitchen close to the roof for further drying. About 40% of the households in this village depend exclusively on firewood from trees on the farm; about 16 trees provide firewood that lasts a household for roughly five months when used in an open fire.[14] Sourcing firewood from trees on the farm reduces women's workload in collecting firewood from forests. Some farmers produce more firewood than they need and sell the surplus for income.

In Malawi, firewood from *Albizzia lebbeck* (18 kilojoules per gram, or kJ/g) and *Senna spectabilis* (18 kJ/g), the two agroforestry tree species being promoted there, have a calorific value slightly higher than the locally sourced firewood (17 kJ/g).[15] The calorific value of firewood sourced from multipurpose trees being promoted in Malawi show that quality firewood can also be sourced from farms in the form of prunings resulting from management of the trees. The innovation here is that the different tree species being grown on farms in different parts of the region can produce quality firewood. Their fuel properties need to be identified and this information disseminated to farmers, who are then able to make informed decisions. The other link with R&D includes the integration of this sustainable source of firewood with efficient cooking systems for optimal benefits. Sourcing firewood from trees on farms depends on the level of adoption of agroforestry as influenced by size of land and crops being grown.

Resource recovery and reuse for energy through briquetting technology

Briquetting technology involves compacting or compressing dry biomass into a solid unit using manual or electric machines or moulding it using bare hands. The resulting briquettes are used like firewood or charcoal.[16] Community groups gather organic residues such as charcoal dust, sawdust, maize cobs, coconut husks, rice husks, or sugarcane bagasse, which they grind and compact. Sometimes, when primary materials lack binding capacity, an additional binder is necessary. Commonly used binders include soil, biodegradable paper, molasses, and starch such as that made from cassava or maize.

Using the charcoal dust–and-soil briquettes to cook a traditional meal of green maize mixed with dry beans for a Kenyan standard household of five people costs 88% and 93% less than cooking the same meal with charcoal and kerosene, respectively.

The briquettes are made either from carbonized materials (that are burned under conditions with a low supply of oxygen into a high carbon content substance carried out mainly using kilns—a process referred to as 'carbonization') or non-carbonized materials. Carbonized briquettes are preferred for cooking because their black colour resembles the colour of charcoal. They also produce less smoke and burn for longer periods than non-carbonized briquettes. Non-carbonized types produce fine particulate matter (PM2.5), burn for shorter periods than carbonized ones, and are popular for industrial use. PM2.5 is one of the key elements of concern about health from burning biomass energy.[17] In Kibera, an informal settlement (slum) in Nairobi, a briquette made from charcoal dust (80%) and bound with soil (20%) produces three times and nine times fewer emissions of carbon monoxide and PM2.5 and burns for one and a half times longer than conventional wood charcoal.[18] This briquette produces PM2.5 of 0.03 milligrams per cubic metre (mg/m3) compared to 123.3 mg/m3 from burning a briquette made from non-carbonized sawdust (74%) bound with gum arabica (26%).[19]

Communities save about 30% and 70% of income spent on cooking energy if they purchase the briquettes or produce them for home use, respectively. The technology creates job opportunities, especially for youth and women. For example, a study carried out in Nairobi and its environs among eight community-based groups showed that 68 female and 101 male members, 78% of whom (45 female and 89 male) were youth below 35 years of age, were involved.[20] Each group earned a monthly income between US$7 and US$1,771 during the dry seasons and between US$7 and US$2,240 during the wet seasons. The range of the income earned is huge because the amount of sales is influenced by the level of awareness about the benefits of briquette within the neighbouring community as well as accessibility to the production site, which are also points of sale.

In northwestern Kenya, after a training conducted in November 2017, a briquetting innovation is being applied by women at the Kalobeyei Refugee Camp and host communities using charcoal dust made from the invasive *Prosopis juliflora* tree and other available organic wastes.[21] In Accra, Ghana, briquette technology is being scaled up by linking research on quality characterization, mapping sources of raw materials, and identifying market opportunities to development initiatives. This involves working with the private sector and with women's groups that use firewood in smoking fish.[22] Using the charcoal dust–and-soil briquettes to cook a traditional meal of green maize mixed with dry beans for a Kenyan standard household of five people costs 88% and 93% less than cooking the same meal with charcoal and kerosene, respectively.[23] Briquette processing practices and types produced vary from one locality to another depending on the raw materials available, the capital available to purchase machines, and local preference. The adoption of these community-based processing practices is high in low-income areas where communities face the challenges of accessing affordable cooking and heating energy and low employment opportunities.

The briquettes have climate change mitigation benefits because they reduce demand for trees that would otherwise be cut down for charcoal or firewood; they also consume organic waste, which otherwise poses disposal challenges in cities. Briquettes—especially those made from carbonized biomass—burn cleaner than firewood in terms of the fine particulate matter, which is a critical cause of respiratory illnesses associated with smoke in the kitchen.[24] Areas that can be improved—such as carbonizing raw materials before making briquettes, applying appropriate mixing ratios of raw materials and binding agent, and drying raw materials and the resultant product, among others—have been identified. Capacity building support materials have been developed and trainings carried out in response to local context. Briquettes serve as a complementary fuel to charcoal and firewood, hence reducing demand for the latter two fuel types, with potential for reducing the negative impacts of unsustainable woodfuel. Completely replacing charcoal and firewood with briquettes is unlikely because the availability of raw materials may not be adequate to produce enough fuel to meet the demands of cooking and heating that charcoal and firewood currently meet.

Improved biomass cooking systems

Cooking culture is an important factor in the debate on how best to address sustainable development, including ways to mitigate the effects of climate change. For instance, the chemical and physical properties of fuel, the ventilation needed, the stove type, and how the process is managed all have implications for the amount of fuel used, the burning period of the fuel, and the amount of ash and emissions produced. These effects of the cooking processes have implications for daily life such as health, income, and nutrition, among others. The transdisciplinary R&D team is investigating how to improve cooking systems by working with communities to understand why they resist change and why they prefer to maintain their traditional practices, such as using open fire in cooking and heating. The team is also identifying the improvement the communities aspire to make in their cooking systems. This effort has involved working with cooks in families, mainly women, in participatory cooking tests that compare different fuels and stoves. Men and other members of the households are involved in trainings.

Studies in the participatory cooking processes have shown that the three-stone open fire is better than most improved stoves because it is easy to light and the firewood does not need to be chopped into small pieces. It heats the living space better than most improved stoves, allowing families to socialize, especially in the evenings. It is also preferred for cooking foods that require long cooking times and allows for easy roasting of food such as green maize and sweet potatoes.[25]

The communities have also revealed that the three-stone open fire has some characteristics that the communities find unappealing, such as difficulty in controlling the heat emitted, high consumption of fuel, and the production of a lot of smoke, although some improved stoves produce more smoke than an open fire.[26] Some cooks make slight modifications to the three-stone open fire, such as reducing the number of open spaces between the stones into which firewood is fed from three to one, hence reducing fuel consumption. Another popular and inexpensive change is to reduce the height of the stones. Just how much impact these changes make in terms of energy use, efficiency, and emissions needs to be studied well. In Malawi, after women produced and used briquettes, they developed a stove suitable for this type of fuel and named it the 'Briquette Mbaula'.[27] The energy efficiency and emission characteristics of this new stove relative to the existing types were studied through cooking tests in an ordinary kitchen, and data analysis of the results is on-going.

To improve cooking systems that meet users' needs and preferences, the transdisciplinary team has also been working with farmers on the use of the Top Lit natural Updraft (TLUD) biochar- producing gasifier stove locally produced in Kenya.[28] When using the stoves, cooks found that the gasifier stoves save fuel, cook faster, and reduce emissions. Cooks' observations were confirmed by measuring emissions during participatory cooking tests in the home. These studies show that the gasifier uses 40% less fuel and reduces emissions of carbon monoxide and PM2.5 by 45% and 90%, respectively, compared to the three-stone open fire.[29] One benefit inspiring the community is that the gasifier burns with a low amount of oxygen, which is easily controlled by using a door on one side of the stove. This process results in 20% of the initial fuel turning into charcoal; this charcoal can be used to cook another meal and can also be used as biochar to improve the soil.[30]

The burning process of the gasifier stove differs from the Briquette Mbaula stove developed by women in Malawi in that the gasifier stove turns fuel into charcoal as a by-product, while the Briquette Mbaula burns the fuel into ashes. The community in Kenya using the gasifier stove has recommended some improvements to the gasifier that would allow for cooking food that takes longer. For instance, they found that firewood burned in the gasifier turns into charcoal in about 50 minutes. The charcoal is then harvested and stored for another day's use. The fuel turns into charcoal in the gasifier stove before food that takes longer (three hours), such as maize and beans, has fully cooked. This necessitates refilling the stove with fresh fuel and relighting it. Such challenges are being addressed together with the community while working with post-graduate students and the Kenya Industrial Research Institute, which produces the gasifier stoves. The gasifier stove is being added into the stove mix and is especially useful for cooking food that gets ready quickly. A total replacement of three-stone open fire has not been achieved because it cooks diverse amounts and types of food.

Improving woodfuel for sustainable development

To advance woodfuel into a sustainable and efficient household energy sector, a systems approach that integrates all the stages of the value chain—including the production of wood, marketing and trade, consumption practices, and policy framework—is critical. The transdisciplinary team's work on woodfuel involves addressing different stages of the value chain in an integrated approach. For example, it seeks to combine the use of prunings from on-farm trees with the use of improved cooking systems.

Work led by the World Agroforestry Centre (ICRAF) in Tanzania found that on-farm firewood supply ranged from 0.5 to 8 metric tonnes per hectare for a variety of tree species. When the utilization of the firewood was compared between three-stone open fire and improved cook stoves, the latter consumed 67% less firewood and reduced gas emissions (PM10) by 60%.[31] Those collecting firewood from forests spent 50% less time because less firewood was consumed in improved stoves. Linking sustainable sources of charcoal dust for briquette production is being made by carbonizing tree branches such as those from the invasive *Prosopis juniflora* and organic wastes such as crop residues in a drum kiln. Using the invasive wood species in arid lands contributes to controlling bush encroachment, which is otherwise a menace in arid lands, while the use of organic waste contributes to cleaning neighbourhoods.

Conclusions, lessons, and impact

This chapter has presented some of the results of a transdisciplinary team approach to cooking fuel. The list below presents some lessons that can be learned and some conclusions about how this approach can increase the impact of the resulting innovative interventions.

- Grassroots innovations have a chance to address global challenges, and the potential of these innovations can be tapped through a transdisciplinary approach that brings together researchers and the community in a way that enables co-learning and co-innovation. The process of involving grassroots communities in co-innovations enhances women's involvement in the development of innovations that address their needs and aspirations as the main users.
- Making woodfuel sustainable through grassroots innovations will have more impact if different stages of the value chain are addressed in an integrated approach. For instance, a combination of sourcing firewood from trees on farms and using improved stoves to reduce consumption will have greater impact than either of these interventions alone.
- Grassroots innovations face challenges in producing quality products that can be addressed through capacity development. Potential consumers are also not aware of the quality and accessibility of the products that can be addressed through awareness campaigns.
- Governments and donors should invest in R&D that scales up grassroots innovations and local communities. Especially women, as the main users of woodfuel, should be involved so that technology development addresses their needs and aspirations.
- While replicating and improving grassroots innovations, it is important to consider their suitability with respect to the local context, including policy, needs, preferences, and potential. Incorporating specific local conditions into large-scale policy changes is always difficult, particularly when an in-depth, comparative understanding of specific conditions is constrained by a lack of adequate research. Comprehensive studies of biomass energy use in India, where far more research has been done, have yielded similar conclusions.[32] A second challenge is bridging the gap between woodfuel users and researchers. Although woodfuel is used by people of many classes, poor women are less able to buy new devices or change to fuels that require purchase.

Notes

1 IEA, 2006, p. 46.
2 Caniato et al., 2017.
3 Sola et al., 2016.
4 Njenga et al., 2018.
5 Mendum and Njenga, 2018.
6 FAO, 2017.
7 Kilian, 1998.
8 Lim and Vos, 2012.
9 Hollada et al., 2017.
10 Khandelwal et al, 2017.
11 Njenga et al., 2017.
12 Seyfang and Smith, 2007.
13 Rocheleau et al., 1988, p. 99.
14 Njenga et al., 2017.
15 Njenga et al., 2017.
16 Njenga et al., 2013.
17 Lim and Vos, 2012.
18 Njenga et al., 2013.
19 Njenga et al., 2013.
20 Njenga et al., 2013.
21 Nienga et al. 2018.
22 Gebrezgabher et al., forthcoming.

23 Njenga et al., 2013.

24 Lim and Vos, 2012.

25 Njenga et al., 2016.

26 Njenga et al., 2016.

27 Njenga et al., 2017.

28 Sundberg et al., 2017.

29 Njenga et al., 2016.

30 Njenga et al., 2017; Sundberg et al., 2017.

31 Sererya et al., 2017.

32 Khandalwal et al., 2017.

References

Caniato, M., D. Carliez, and A. Thulstrup. 2107. 'Challenges and Opportunities of New Energy Schemes for Food Security in Humanitarian Contexts: A Selective Review'. *Sustainable Energy Technologies and Assessments* 22: 208–19.

FAO (Food and Agriculture Organization of the United Nations). 2017. *The Charcoal Transition: Greening the Charcoal Value Chain to Mitigate Climate Change and Improve Local Livelihoods,* by J. van Dam. Rome: FAO.

Gebrezgabher, S., S. Amewu, and M. Njenga. Forthcoming. 'Adoption and Economic Impact of Briquette as Cooking Fuel: The Case of Women Fish Smokers in Ghana'. In Gender and Resource Recovery and Reuse for Energy. Working Paper. International Water Management Institute (IWMI), Colombo, Sri Lanka.

Hollada, J., K. N. Williams, C. H. Miele, D. Danz, S. A. Harvey, and W. Checkley. 2017. 'Perceptions of Improved Biomass and Liquefied Petroleum Gas Stoves in Puno, Peru: Implications for Promoting Sustained and Exclusive Adoption of Clean Cooking Technologies'. *Int. J. Environ. Res. Public Health* 14: 182–96.

IEA (International Energy Agency). 2006. *World Energy Outlook 2006.* Paris: IEA/OECD.

Khandelwal, M., M. Hill, P. Greenwough, J. Anthoney, M. Quill, M. Linderman, and H. S. Udaykumar. 2017. 'Why Have Improved Cookstove Initiatives in India Failed?' *World Development* 92: 13–27.

Kilian, W. 1998. 'Forest Site Degradation: Temporary Deviation from the Natural Site Potential'. *Ecol. Eng.* 10: 5–18.

Lim, S. S. and T. Vos. 2012. 'A Comparative Risk Assessment of Burden of Disease and Injury Attributable to 67 Risk Factors and Risk Factor Clusters in 21 Regions, 1990–2010: A Systematic Analysis for the Global Burden of Disease Study 2010'. *Lancet:* 380: 2224–60.

Mendum, R and M. Njenga. 2018. 'Integrating Woodfuels into Agriculture and Food Security Agendas and Research in Sub-Saharan Africa (SSA)'. *FACETS* 3: 1–11.

Njenga, M., O. Baloi, M. Iiyama, Y. Terada, and R. Mendum. 2018. 'Resource Recovery for Briquettes and Women's Empowerment in Humanitarian Conditions in Kenya'. A presentation at the Workshop on Sustainable Rural Bioenergy Solutions in Africa, 19 January 2018, Nairobi. Available at http://www.irena.org/events/2018/Jan/Workshop-on-Sustainable-Rural-Biofuel-Strategy-in-Africa .

Njenga, M., C. Chasweka, J. Njoroma, and S. Mng'omba. 2017. 'Sustainable Tree-Based Energy Production and Cooking Systems'. A component of the Empowering Forest Dependent Communities through Commercialization of Small-Scale Forestry Project, supported by EU and DFID. Project report. World Agropforestry Centre (ICRAF), Nairobi, Kenya.

Njenga, M., M. Iiyama, R. Jamndass, H. Helander, L. Larsson, J. de Leeuw, H. Neufeldt, K. Röing de Nowina, and C. Sundberg. 2016. 'Gasifier as a Cleaner Cooking System in Rural Kenya'. *Journal of Cleaner Production* 121: 208–17.

Njenga, M., Y. Mahmoud, R. Mendum, M. Iiyama, R. Jamnadass, K. Roing de Nowina, and C. Sundberg. 2017. 'Quality of Charcoal Produced Using Micro Gasification and How the New Cook Stove Works in Rural Kenya'. *Environmental Research Letters* 12 (9). Available at http://iopscience.iop.org/article/10.1088/1748-9326/aa7499.

Njenga, M., C. Sundberg, and R. Mendum. 2017. 'Sustainable Woodfuel Systems in Sub-Saharan Africa: Application of a Transdisciplinary R&D Approach'. A presentation at the International Transdisciplinarity Conference 2017, Transdisciplinary Research and Education Intercultural Endeavours, Leuphana University of Lüneburg and td-net Network for Transdisciplinary Research. Abstracts booklet, p. 72. Available at https://www.leuphana.de/fileadmin/user_upload/PERSONALPAGES/_uvwxyz/vilsmaier_ulli/files/ITD17_booklet_26.9.17.pdf.

Njenga. M., A. Yonemitsu, N. Karanja, M. Iiyama, J. Kithinji, M. Dubbeling, C. Sundberg, and R. Jamnadass. 2013. 'Implications of Charcoal Briquette Produced by Local Communities on Livelihoods and Environment in Nairobi, Kenya'. *International Journal of Renewable Energy Development* 2 (1): 19–29.

Rocheleau, D., F. Weber, and A. Field-Juma. 1988. *Agroforestry in Dryland Africa.* Nairobi, Kenya: International Council for Research in Agroforestry (ICRAF).

Sererya, O. G., A. Kimaro, L. Lusambo, G. Uckert, J. Hafner, S. Sieber, F. Graef, and T. Rosenstoc. 2017. Resilience and Livelihood Benefits of Climate Smart Agroforestry Practices in Semiarid Tanzania. Poster presented at the Tropentag 2017: Future Agriculture: Social-Ecological Transitions and Bio-Cultural Shifts, 20–22 September, 2017, University of Bonn and the Center for Development Research, Bonn, Germany. Available at http://www.tropentag.de/2017/abstracts/posters/960.pdf.

Seyfang, G. and A. Smith. 2007. 'Grassroots Innovations for Sustainable Development: Towards a New Research and Policy Agenda'. *Environmental Politics* 16 (4): 584–603.

Sola, P., C. Ochieng, J. Yila, and M. Iiyama. 2016. 'Links between Energy Access and Food Security in Sub Saharan Africa: An Exploratory Review'. *Food Security* 8 (3): 635–42.

Sundberg., C., J. K. Gitau, M. Njenga, and J. Mutune. 2017. 'Introducing Biochar-Producing Gasifier Cookstoves in a Rural Community'. A presentation at the Rural Transformation and Urbanization Agricultural Research for Development Agri4D Conference 2017, Swedish University of Agricultural Sciences, SLU, 20–21 September 2017, Uppsala, Sweden. Abstracts available at https://www.siani.se/wp-content/uploads/2017/10/agri4d_abstract_170915_final.pdf.