Food Sec. (2016) 8:635–642
DOI 10.1007/s12571-016-0570-1

REVIEW

Links between energy access and food security in sub Saharan Africa: an exploratory review

Phosiso Sola[1,2] · **Caroline Ochieng**[3] · **Jummai Yila**[4] · **Miyuki Iiyama**[2]

Received: 9 April 2015 / Accepted: 23 March 2016 / Published online: 26 April 2016

Abstract Three quarters of the population in Sub Saharan Africa lacks access to modern energy, and relies instead on biomass fuels for cooking and heating. The environment and health implications of the use of biomass fuel has been widely documented in the literature, and has raised the topic of energy access in various policy and development arenas. Still, the impact of energy access on food security at the household level has not been explored in detail; consequently the two sectoral policies remain unaligned. Our aims for this review were to document how lack of access to energy can impact on food security through influence on dietary choices and cooking practices; and how reallocation of household resources from food to energy procurement causes a switch to biomass energy forms of lower grade. We searched the literature for published peer-reviewed articles available through major online publication databases, initially identifying 132 articles but finally reviewing a set of 19 that met our criteria. While most studies suggested that fuelwood scarcity can affect food security through three hypothesised pathways, very few of them provided empirical data to support this argument. Overall, the review found coping measures for woodfuel scarcity to be highly contextual and influenced by geography, household economy and labour availability. Due to the limited number of studies with detailed data, it was not possible to perform a comparative analysis that could support or refute a hypothesis that lack of access to energy can impact on food security. More rigorous studies on this topic are needed which could provide evidence for policy action.

Keywords Energy access · Fuelwood · Food security · Nutrition · Sub-Saharan Africa

Introduction and aims

According to the International Energy Agency (IEA), 2.5 billion people worldwide lack access to clean energy for cooking and heating (IEA 2014), and instead rely on biomass fuels for their household energy needs for cooking and heating. The situation is worse in sub-Saharan Africa (SSA) where more than three quarters of the people remain dependent on biomass fuels, such as firewood, charcoal, dung and agricultural residues as their primary sources of household energy (IEA 2014; WHO and UNDP 2009). Achieving food security, economic development and poverty reduction remain elusive goals without energy access,[1] which has been termed "the missing Millennium Development Goal" (Rehfuess et al. 2006;

✉ Caroline Ochieng
caroline.ochieng@sei-international.org

Phosiso Sola
p.sola@cgiar.org

Jummai Yila
j.yila@cgiar.org

Miyuki Iiyama
m.iiyama@cgiar.org

[1] Centre for International Forestry Research (CIFOR), C/O World Agroforestry Centre, United Nations Avenue, Gigiri, P.O. Box 30677, Nairobi 00100, Kenya

[2] World Agroforestry Centre (ICRAF), United Nations Avenue, Gigiri, P.O. Box 30677, Nairobi 00100, Kenya

[3] Stockholm Environment Institute (SEI), Linnegatan 87D, Box 24218, 10451 Stockholm, Sweden

[4] Africa Forest Forum (AFF), C/O World Agroforestry Centre, United Nations Avenue, Gigiri, P.O. Box 30677, Nairobi 00100, Kenya

[1] According to The International Energy Agency, energy access is about providing modern energy services to everyone around the world. These services are defined as household access to electricity and clean cooking facilities (e.g. fuels and stoves that do not cause air pollution in houses). Populations that do not have access to modern energy services thus lack access to energy, or are energy poor http://www.iea.org/topics/energypoverty/

Brew-Hammond 2012). The high dependence on biomass for fuel has a number of consequences that are now well documented; public health impacts, reduced livelihood opportunities especially for women and girls who bear the responsibility of biomass gathering, environmental impacts such as deforestation and forest degradation, and contribution to global climate change (Lim et al. 2012; GACC 2012; Kissinger et al. 2012; Shindell et al. 2012). The health and climate impacts have especially gained high attention in recent years. According to the WHO, use of biomass fuels is the leading environmental risk factor for ill health, responsible for 4.3 million deaths annually (WHO 2014). In SSA, the disease burden from household air pollution (which is linked to pneumonia, Chronic Obstructive Pulmonary Disease, cardiovascular disease and several other outcomes) is only exceeded by malnutrition (Lim et al. 2012). The climate impacts of biomass fuel use occur through deforestation, but also emission of black carbon, a short lived climate pollutant (UNEP and WMO 2011; Shindell et al. 2012). Addressing the energy access challenge therefore promises a major win-win development.

An important dimension of energy access that is not well documented, although hypothesised, is its impact on household food security and nutrition. The Word Food Summit of 1996 defined food security as a situation whereby "*all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*". Because food has to be cooked for it to be palatable and safe, food security cannot be guaranteed if there is no access to energy for cooking it (Bogdanski 2012). While any effort to address the energy access challenge is positive and likely to have broad benefits, certain comparative sectoral advantages are lost if some key sectors are not engaged in energy access debates and processes. The framing of the energy access issue and its sector impacts has important implications, more so because sometimes the sector-specific interests might conflict, and not all energy access interventions achieve the intended win-win outcomes (Simon et al. 2012). More importantly, engagement of the food security sector in energy debates could lead to new ideas for jointly addressing energy access and nutrition goals. A prerequisite to this engagement is concrete evidence showing that indeed, provision of energy can alleviate food insecurity especially for sub-Saharan Africa, where a quarter of the population is undernourished (FAO 2015).

In this review, we aimed to synthesise the existing evidence on the impact of energy access on food security and highlight the pathways through which these impacts occur, as reported in literature. The review was motivated by the current knowledge gap on the interaction between these two major development concerns, which are never tackled jointly by development policies and programmes. To our knowledge, this is the first attempt to synthesise the existing knowledge on this topic. We focused the review in sub-Saharan Africa, which has the worst indicators for both energy access and food security, with future projections indicating a worsening situation owing to increasing population growth (IEA 2014; FAO 2015).

Methodology

Conceptual framework

The study is based on a review of literature that was guided by a conceptual framework on potential pathways through which lack of energy access can impact on food security (Fig. 1). The literature search and synthesis of its findings was guided by this framework, which categorises the link between energy access and food security into three thematic areas, based on the following hypotheses:

> *Energy access influences dietary choices and cooking practices*

Fuelwood scarcity can potentially affect cooking practices and dietary choices. It can result in reduced cooking times, skipping meals and a switch to foods that are less fuel demanding. Few of the principal food crops in developing countries are palatable or even fully digestible unless cooked. Furthermore, foods such as beans that are highly nutritious are more fuel demanding; therefore protein intake can be lowered when alternative faster-cooking foods are chosen, leading to poorer nutritional balance. Unavailability of fuel for cooking can therefore influence the type, the quantity and the quality of the foods consumed and their ability to be digested, and could be a cause of malnutrition.

> *Poor access to cooking fuel leads to reallocation of household resources from food production and preparation to fuel procurement.*

Fuelwood scarcity may force household members to spend less time in productive and income generating activities, including agriculture and food production. The meagre income may be spent on purchasing fuelwood rather than on food purchase.

> *Lack of access to energy leads to switches to inferior energy forms, thereby reducing agricultural productivity*

Agricultural by-products such as crop residues and dung have an important role in increasing land productivity and crop yields. Households could switch to these "inferior" forms of energy when fuelwood becomes scarce.

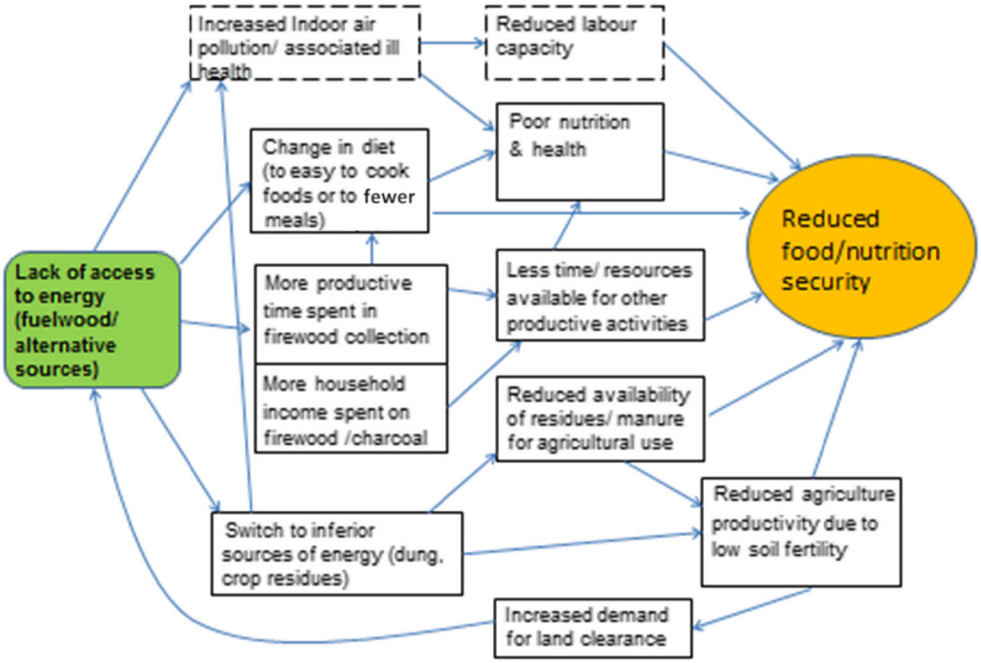

Fig. 1 Possible links between energy access and food security investigated in the study. The dashed lines boxes were not within the scope of this review. Source: Authors

Literature search and data extraction

The literature search was conducted online from the following bibliographic databases: Scopus, Google Scholar, openDOAR and Web of Science. This was coupled with a search for grey literature on stakeholder websites such as FAO and WHO; and hand searches of the references of included studies. The following broad search terms and their synonyms were used to identify articles that were relevant to the study aim: i) energy and food security in sub Saharan Africa, ii) energy and nutrition in SSA, iii) fuelwood or woodfuel scarcity and nutrition in sub Saharan Africa and iv) fuelwood or woodfuel scarcity and diets in sub Saharan Africa. Original research articles as well as review articles were included in this review.

The search generated 131 relevant articles that were preselected after screening titles and abstracts. These articles were subjected to further screening based on the following eligibility criteria; i) articles that covered both energy AND food security/nutrition; ii) articles that focused on a biomass based energy type (charcoal, fuelwood, crop residues, dung); iii) articles with SSA as the geographic focus. This second stage of screening resulted in 19 articles that were eligible for a full review and data extraction.

The final set of articles were grouped into the three thematic areas as encapsulated by the hypothesised relationship between energy access and food security (Fig. 1). Data extraction for included studies under each theme was conducted by one author using standardized forms, and checked by the other three authors during synthesis. Key findings and characteristics of studies were reported in summary tables. Due to the very limited number of studies with detailed data, and high heterogeneity among the studies, it was not possible to carry out a comparative analysis of the identified literature. Instead, we performed a descriptive analysis guided by the three themes, and present the findings in a narrative form.

Results

General findings

The 19 studies discussed some links between energy and food security, but very few of them provided the data that could support or refute the three stated hypotheses. Some articles that had gone through the screening had to be eliminated at the review stage because they gave suggestions of the linkage without backing it up with literature. These included a number of articles published in the 1980s that have been cited by many authors in support of the link between energy access and food security, for instance Adams et al. (1980), cited in FAO (1990). Furthermore, a number of studies cited by various authors as supporting the link between energy access and food security did not meet our criteria, based on title and abstract screening; and did not have sufficient content to support the relationship. Finally, some earlier studies could not be tracked as they were unavailable online; and due to funding limitations we could not employ alternative means to trace them Table 1.

Hypothesis 1. Influence of energy access on dietary choices and nutrition

The influence of fuelwood scarcity on nutrition has been alluded to for several decades. Surprisingly, empirical studies to

Table 1 Nineteen articles linked to the three research hypotheses

Author (date)	Study location	Energy Type (s)	Hypotheses		
			1	2	3
FAO (2013)	Global	wood fuel, biofuel, electricity, mechanical power, LPG		X	
Brouwer et al. (1996)	Malawi	Biomass fuels	X	X	X
Makayoto et al. (2012)	Kenya	Electricity, biomass, petroleum		X	
Chikaire et al. (2011)	Nigeria	woodfuel, kerosene, electricity	X	X	X
Bogdanski (2012)	Developing countries	fuelwood, charcoal and animal dung	X	X	X
FAO (1990)	Sub Saharan Africa	firewood and charcoal	X	X	X
Köhlin et al. (2011)	Global	All		X	
Melgar-Quinonez et al. (2006)	Developing countries	All		X	
Atanassov (2010)	Mozambique	All			X
Hiemstra-van der Horst and Hovorka (2008)	Botswana	All	X		
Maconachiea et al. (2009)	Nigeria	All			X
Madubansi and Shackleton (2006)	South Africa	electricity, fuelwood, kerosene,		X	X
Soussan et al. (1992)	Global	All			X
Dewees (1989)	Global	Woodfuel	X	X	x
Brouwer et al. (1997)	Malawi	fuelwood, crop residues,	X	X	X
Damte et al. (2011)	Ethiopia	fuelwood, crop residues, dung, charcoal			X
Mekonnen (1999)	Ethiopia	fuelwood, crop residues, dung, charcoal			X
Palmer and Macgregor (2009).	Namibia	fuelwood, crop residues, dung, charcoal			X
Makungwa et al. (2013)	Developing countries	Fuelwood	X	X	X

substantiate the arguments supporting the link between them were very limited. Only six articles in the review addressed this link in detail; of which two were original research articles by the same author (i.e. Brouwer et al. 1996; Brouwer et al. 1997), and four were reviews (FAO 1990; Chikaire et al. 2011; FAO 2013; Makungwa et al. 2013).

FAO (2013) reports that lack of access to sufficient and appropriate cooking fuel may force people to change their eating and cooking habits by reducing the number of meals, switching to foods that require less cooking time, undercooking their food and bartering part of the food ration for fuel. Through these practices, the quantity, quality and nutritional value of the food consumed would be affected. However, the authors provide no empirical evidence or literature citations to support these statements. The earlier review for the FAO (1990) cites several articles that mention the link between energy access and food security. On the links to nutrition, the review tackles amongst other questions the influence of fuel availability on frequency of food preparation and appropriateness of foods prepared for special groups such as infants. They found various studies that have suggested the link, including those of Adams et al. 1980; Kamweti 1980; Casey 1981 and Cecelski 1984. The author notes that even though this link is often cited, it is probable that the relationship is not as direct as is assumed, and other variables such as availability of time for food preparation play an equal or greater role (FAO 1990, citing Cecelski 1984).

Brouwer (Brouwer et al. 1996) presented one of the few studies that entailed a detailed investigation into the link between fuelwood availability and nutrition. The study was carried out in four villages in Malawi, characterized by both nutritional insecurity and fuelwood scarcity. The author observed that due to increased collection time for fuel, time for food processing and preparation decreased, as did the time for rest. He reported that the impact of fuelwood availability on nutrition occured through strategies that households use to cope with the scarcity, including time allocation. This is supported by findings from his later study (Brouwer et al. 1997) indicating that fuelwood scarcity results in *changes in fuel collection location, times and patterns rather than food itself.*

In the same setting, Brouwer (Brouwer et al. 1996) also found that economising on fuel as a coping strategy for fuelwood scarcity led to a switch to lower grade fuels, such as twigs. He observed that because twigs require frequent tending of fires, they are not a suitable fuel for foods that require long cooking time such as dry beans and cereals; hence these foods are dropped from the diet. This contradicts the hypothesis investigated by Fleuret (FAO 1990); that fuelwood shortage leads to substitution of foods requiring less cooking to customary food items with prolonged cooking times.

Hypothesis 2. Influence of energy access on household resources

It has been hypothesised that *one important consequence of energy scarcity is that precious cash resources are used to purchase fuel*, *thereby reducing the households' ability to accumulate financial resources* (Chikaire et al. 2011). Similar to household income, household time would need to be reallocated to fuel procurement. These reallocations lead to less income being available for purchase of food, farm investments and less time investment in food production, procurement, preparation and/or cooking.

A number of studies and reports in this review referred to linkages between the time women spent on collecting wood and the amount of time they devoted to productive activities (FAO 2013). However, only two articles (Madubansi and Shackleton 2006; Brouwer et al. 1997) had primary data to back up these assertions. The authors warn against drawing conclusions on a simple relationship between physical scarcity of fuelwood and household resource allocation; but instead urge researchers to consider the wider context that incorporates socio-ecological aspects as well. These include household composition in terms of size, gender, labour availability, land tenure and cultural values.

From their historical study on the impacts of an electrification program in South Africa, Madubansi and Shackleton (2006) found that energy access determined the changing patterns of energy use for lighting and powering entertainment and communication appliances (i.e. from dry-cell batteries to electricity) but not energy for cooking. For thermal needs, fuelwood remained the most widespread fuel, and the amount used per month had not changed over years despite the evidence of increased physical fuelwood scarcities around the local environment. They did, however, observe a slight increase in the percentage of households purchasing fuelwood, from 27 % in 1991 to 31 % in 2002. They attributed the increase in purchase to increase in the amount of time required for fuelwood collection, due to increasing fuelwood scarcity.

Brouwer et al. (1997) found mixed results on the influence of fuel scarcity on household resources. With increasing distance to woodlands, households initially collected further away, spending more time on collection. But when distance to woodlands increased further, households especially with smaller family sizes saved on fuelwood collection time by switching to lower quality wood found closer to the villages (Brouwer et al. 1997). The authors noted that "*the amount of fuelwood collected and*, *hence*, *consumed*, *is not only determined by fuelwood availability*, *but more by labour availability*".

This view was supported by other articles in the review (Dewees 1989; FAO 1990; Köhlin et al. 2011). The authors argue that distance to collection place and collection times are not reliable indicators of fuelwood shortages as is so often postulated in the literature. Rather, the actual household resource allocation responses to fuelwood shortages depend on individual decisions at the household level that are in turn dependent on the available labour, household entitlements, access to woodlands as well as cultural practices that are context specific. In the case of Malawi (Brouwer et al. 1997), households that tended to increase collection distance in times of fuelwood scarcity were larger in size, and had more female adults. On the contrary, smaller sized households did not increase travel distance when fuel became scarce; instead they tended to use more twigs. Dewees (1989) observed that household decisions to allocate resources to fuel collection depend on labour availability for all competing farming activities as a whole rather than physical fuel scarcity alone. The author cites the case of Zimbabwe, where an earlier study had reported that labour allocation to fuelwood collection increased during the dry season simply because households were freed from agricultural labour (Dewees 1989: citing Du Toit et al. 1984). Where agricultural labour demand was very high such as in Machakos and Kisii Districts in Kenya, farmers tended to plant trees on farm to reduce labour spent on woodfuel collection.

Overall, this literature shows that when faced with similar physical shortages of fuelwood, households less endowed with labour and household entitlements are more likely to reallocate time and resources from productive activities to fuel procurement; and are also more likely to switch to inferior fuels. Thus, they are more likely to face food security challenges that can be attributed to energy access challenges. Relatively well-off households on the other hand have better coping measures, such as purchase of fuelwood. We did not, however, find studies which showed the extent to which the purchase of fuelwood would impact on household food expenditure, and how this would influence food security.

Hypothesis 3. Influence of use of lower grade fuels on agricultural productivity

According to the energy ladder model, charcoal is ranked highest amongst biomass forms of energy in terms of efficiency and cleanliness at the end-user point (Hosier and Dowd 1988). Firewood is second place; and at the lowest level of the ladder are agricultural residues and dung (thus the term inferior fuels). If people switch from charcoal to fuelwood, or fuelwood to dung, they would be moving down the energy ladder; using less efficient and less preferred fuel forms.

Four studies described how lack of energy access leads to a switch to lower end energy forms such as cow dung and agricultural residues. According to Brouwer et al. (1997), the switch was caused by increase in distance to fuel collection points as fuelwood becomes scarce. On the contrary, Palmer and Macgregor (2009) found very little evidence for substitution between fuelwood and dung; rather the use of cow dung as fuel was a predominant feature in livestock rearing

communities. However, the livestock rearing regions also generally experienced acute fuelwood scarcity, hence it was possible that reliance on dung was an adaptive response to fuelwood scarcity. Dewees (1989) suggested that households would switch to twigs and sticks when there was physical scarcity of fuelwood, but also observed that "*there is only limited evidence which suggests that if woodfuels were more available, the use of animal dung for fuel will decline*" (p. 1165). In a more recent study in Ethiopia, Damte et al. (2011) found that crop residues and dung both served as alternatives to fuelwood; but also as complementary sources. This therefore suggests that fuelwood scarcity could lead to increased use of crop residues and dung. However, an earlier study by Mekonnen (1999) found that fuel wood and dung were only complementary, since households in Northern Ethiopia did not reduce their use of dung even when forest biomass was available.

The results are therefore mixed, with some authors suggesting that fuelwood scarcity would lead to use of dung as fuel (Dewees 1989; Brouwer et al. 1997; and Palmer and Macgregor 2009), while others (Mekonnen 1999) found other reasons that motivated the use of dung as fuel. The energy ladder model has been disproved in several settings. In Mexico for instance, Masera et al. (2000) found that households "*follow a multiple fuel or 'fuel stacking' strategy by which new cooking technologies and fuels are added, but even the most traditional systems are rarely abandoned*".

Application of manure and crop residues in soil fertility management is not a universal practice. However, where this is not the norm and they are used as fuel instead, some authors have suggested that this could deny farmers a vital source of soil nutrients and contribute to reduced crop yields. Three articles in this review explored this relationship (Arnold and Jongma 1977; FAO 1990; Ejigie 2007). Arnold and Jongma (1977) suggest that "*diversion of dung from use in agriculture is equivalent to burning food in order to cook food*", and estimate that each ton of cow dung used as fuel accounts for 50 kg of food grain lost as a result of reduced soil fertility. Ejigie (2007) supports these findings. Citing an anonymous study in Ethiopia, he reports that Ethiopia's grain production is lowered by 550,000 t annually due to diversion of dung from field application to cooking. While FAO (1990) suggested this hypothesis, they did not find any evidence for it. Other reviews, however, contradict these arguments. For instance McIntire et al. (1992) and Arnold et al. (2006) argue that burning dung and crop residues does not divert them from agricultural uses.

Discussion and conclusion

The link between energy access and food security has been alluded to for many years, but rarely supported with scientific evidence. This review aimed to identify and synthesise the existing literature on the topic, focusing on the key relationships that have been hypothesised. The review is very timely given the increased global attention being paid to both energy access and to food security. If energy access impacts on food security, efforts can be synergised to respond to the two development challenges.

In this review, we found 19 articles that tackled the issue of both energy access and food security. However very few of them had the empirical evidence to support or refute the linkage. Consequently, it is not possible to draw conclusions on whether or not energy access impacts on food security. Our finding should, however, not be construed as "evidence of absence" of an association between energy access and food security; but rather it should be a pointer to an urgent need for more research on this topic.

Despite the lack of evidence on the direct effect of lack of energy access on food security, the literature on coping measures for fuelwood scarcity identified in this review and other literature do point to a relationship that is location specific and socio-ecologically contextual. We approached the analysis from three hypotheses as laid out in our conceptual framework; in practice, however, the impact is multi-directional. For instance, reduction in time spent on food related activities as shown in this review would impact on a number of activities from food production to food purchase (going to markets), to processing and cooking. Similarly, use of residues and twigs for fuel not only makes them less available for soil fertility, but also prevents women from doing multiple chores as fires made from them require frequent tending (Brouwer et al. 1997), thereby limiting labour availability. The pathway for nutritional effects is also complex. For instance if less fuel is available, there can be reduced boiling of water for drinking and other hygiene purposes (Chikaire et al. 2011), which would impact negatively on health and nutrition.

More research is needed to generate clear evidence on whether or not energy access impacts on food security, and the pathways through which those impacts occur. The need for this evidence was raised decades ago in the FAO supported review in 1990 (FAO 1990). Despite their call for in-depth studies to test the hypothesis that energy access impacts on food security, no comprehensive studies have been undertaken to date. Paying closer attention to the interphase of energy access and food security can offer the means and opportunity for tackling these two global challenges.

Because of limitations of time and resources, we could not conduct a full systematic review. Furthermore, our review was also focused on one region – sub-Saharan Africa. Our search strategy was however comprehensive, including a hand search for all citations in recently published articles on the topic (e.g. Makungwa et al. 2013). It is therefore unlikely that relevant articles in sub-Saharan Africa were excluded from this review.

The limited literature we found further demonstrates that a full systematic review on this topic would be premature. Instead, more primary research is needed before a full synthesis of the evidence can be conducted.

Acknowledgments This review was made possible through funding support by the Swedish International Agriculture Network Initiative (SIANI) towards an Expert Group on Synergies and Linkages between Energy Access and Food Security. We would also like to acknowledge the support of the following institutions: The Stockholm Environment Institute (SEI), Centre for International Forestry Research (CIFOR), International Centres for Research in Agroforestry (ICRAF), Africa Forest Forum (AFF), CG programmes on Forest Trees and Agroforestry (FTA), the Agriculture for Nutrition and Health programmes and the Japanese Government. The authors contributed their personal time towards this review.

References

Adams, R., Stepick, C., Ulinski, C., & Williamson, D. (1980). *The impact of decreased fuelwood availability on nutritional status*. Report prepared by Medical Service Consultants Inc. for USAID.

Arnold, J. E. M., & Jongma, J. (1977). Fuelwood and charcoal in developing countries. South Asia, 267, 0–38.

Arnold, J. M., Köhlin, G., & Persson, R. (2006). Woodfuels, livelihoods, and policy interventions: changing perspectives. *World Development, 34*(3), 596–611.

Atanassov, B. (2010). *Socio-cultural dimensions in household cooking energy choice: implications for energy transition in Catembe*. Mozambique.

Bogdanski, A. (2012). Integrated food–energy systems for climate-smart agriculture. *Agriculture & Food Security, 1*(1), 1.

Brew-Hammond, A. (2012). Energy: the missing millennium development goal. *Energy for Development. Springer Netherlands, 35-43*.

Brouwer, I. D., den Hartog, A. P., Kamwendo, M. O., & Heldens, M. W. (1996). Wood quality and wood preferences in relation to food preparation and diet composition in Central Malawi. *Ecology of Food and Nutrition, 35*(1), 1–13.

Brouwer, I. D., Hoorweg, J. C., & Van Liere, M. J. (1997). When households run out of fuel: responses of rural households to decreasing fuelwood availability, Ntcheu District, Malawi. *World Development, 25*(2), 255–266.

Casey, J. (1981). Fuel and pole supplies for rural populations. *Southern African Forestry Journal, 117*(1), 2–5.

Cecelski, E. (1984). *Rural energy crisis, women's work and family welfare: perspectives and approaches to action (No. 232347*. International Labour: Organization.

Chikaire, J., Nwakwasi, R. N., Osuagwu, C. O., & Oparaojiaku, J. (2011). Renewable energy resources for women Empowerment in Nigeria. *Researcher, 3*(10), 348–357.

Damte, A, Koch, SF and Mekonnen, A (2011) Coping with fuel wood scarcity: household responses in rural Ethiopia. *Department of Economics Working Paper Series*: 2011.

Dewees, P. A. (1989). The woodfuel crisis Reconsidered: Observations on the Dynamics of Abundance and scarcity. *World Development, 17*(8), 1159–1172.

Du Toit, R. F., Campbell, B. M., Haney, R. A., & Dore, D. (1984). *Wood usage and tree planting in Zimbabwe's communal lands*. Harare: Forestry Commission of Zimbabwe and the World Bank.

Ejigie, D. A. (2007). Household determinants of fuelwood choice in urban Ethiopia: a case study of Jimma town. *The Journal of Developing Areas, 41*(1), 117–126.

FAO (1990). The impact of fuelwood scarcity on dietary patterns: hypotheses for research. *Unasylva, 41*(160), 169–342.

FAO (2013). Safe access to firewood and alternative energy in humanitarian settings in emergencies Guidance note, FAO.

FAO (2015). *Regional overview of food insecurity: African food insecurity prospects brighter than ever*. FAO: Accra.

GACC (2012). *Igniting change: A strategy for universal adoption of clean Cookstoves and fuels, global Alliance for clean Cookstoves*. Washington DC: UN Foundation.

Hiemstra-van der Horst, G., & Hovorka, A. J. (2008). Reassessing the "energy ladder": household energy use in Maun, Botswana. *Energy Policy, 36*, 3333–3344.

Hosier, R. H., & Dowd, J. (1988). Household fuel choice in Zimbabwe: an empirical test of the energy ladder hypothesis. *Resources and Energy, 9*, 337–361.

IEA (2014). *World Enegy Outlook 2014*. Paris: International Energy Agency.

Kamweti, D. (1980). *Role of wood in Kenya energy crisis*. Nairobi: Republic of Kenya, Forest Dept.

Kissinger, G., M. Herold, V. De Sy. Drivers of deforestation and Forest degradation: A synthesis Report for REDD+ Policymakers. Lexeme Consulting, Vancouver Canada, August 2012.

Köhlin, G, Sills, EO, Pattanayak, SK and Wilfong, C (2011). Energy, Gender and Development, What are the Linkages? Where is the Evidence? Background Paper to the 2012 World Development Report. *Report Policy Research Working Paper*, World Bank 75.

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., et al. (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. *The Lancet, 380*, 2224–2260.

Maconachiea, R., Tankob, A., & Zakariyac, M. (2009). Descending the energy ladder? Oil price shocks and domestic fuel choices in Kano, Nigeria. *Land Use Policy, 26*, 1090–1099.

Madubansi, M., & Shackleton, C. M. (2006). Changing energy profiles and consumption patterns following electrification in five rural villages, South Africa. *Energy Policy, 34*(18), 4081–4092.

Makayoto, M., Wangai, L., Shitote, P., Masenge, E., Omondi, C., Ndirangu, W., Nyaga, L., Muok, B., Kingiri, A., Nderitu, S., Sibler, S., & Kimathi, A. (2012). Water, food and energy nexus: the Kenyan context Workshop Report, 15th – 18th October 2012. *Naika, 51*.

Makungwa, S. D., Epulani, F., & Woodhouse, I. H. (2013). Fuelwood Supply: A Missed Essential Component in a food security Equation. *Journal of Food Security, 1*(2), 49–51.

Masera, O. R., Saatkamp, D. B., & Kammen, D. M. (2000). From linear switching to multiple cooking strategies: a critique and alternative to the energy ladder model. *World Development, 28*, 2083–2103.

McIntire, J., Bourzat, D., & Pingali, P. (1992). *Crop livestock interaction in sub-Saharan Africa*. Washington: World Bank.

Mekonnen, A. (1999). Rural household fuel production and consumption in Ethiopia: A case study. *Journal of Forest Economics, 5*(1), 69–97.

Melgar-Quinonez, H. R., Zubieta, A. C., MkNelly, B., Nteziyaremye, A., Gerardo, M. F. D., & Dunford, C. (2006). Household food insecurity and food expenditure in Bolivia, Burkina Faso, and the Philippines. *The Journal of Nutrition, 136*(5), 1431S–1437S.

Palmer, C., & MacGregor, J. (2009). Fuelwood scarcity, energy substitution, and rural livelihoods in Namibia. *Environment and Development Economics, 14*(06), 693–715.

Rehfuess, E., Mehta, S., & Prüss-Üstün, A. (2006). Assessing household solid fuel use: multiple implications for the millennium development goals. *Environmental Health Perspectives, 373-378*.

Shindell, D., Kuylenstierna, J. C., Vignati, E., van Dingenen, R., Amann, M., Klimont, Z., et al. (2012). Simultaneously mitigating near-term climate change and improving human health and food security. *Science, 335*(6065), 183–189.

Simon, G. L., Bumpus, A. G., & Mann, P. (2012). Win-win scenarios at the climate–development interface: challenges and opportunities for stove replacement programs through carbon finance. *Global Environmental Change, 22*(1), 275–287. doi:10.1016/j.gloenvcha.2011.08.007.

Soussan, J., Mercer, D. E., & O'Keefe, P. (1992). Fuelwood policies for the 1990s. *Energy Policy, 20*(2), 137–144.

UNEP and WMO (2011). *Integrated Assessment of black carbon and Tropospheric Ozone: summary for Decision Makers*. UNEP and WMO: Nairobi.

WHO (2014). *Burden of disease from Household Air Pollution for 2012: summary of results*. Geneva: Public Health, Social and Environmental Determinants of Health Department, World Health Organization. http://www.who.int/phe/health_topics/outdoorair/databases/FINAL_HAP_AAP_BoD_24March2014.pdf?ua=1.

WHO and UNDP (2009). *The energy situation in developing countries: A review on the Least Developed countries and sub-Saharan Africa*. New York: WHO and UNDP.

Phosiso Sola is a Programme Coordinator at ICRAF working on a dry lands development programme promoting water, income and food security. She was previously the Regional Coordinator for CIFOR in east and southern Africa**.** She has over 20 years work experience, most of which has been spent in action research and development projects in Africa and Asia focusing on natural resource management and forest governance. Her current research focuses on governance of forest products value chains (timber, charcoal, firewood, natural pesticides), policy analysis and legal reforms in eastern and southern Africa. She obtained her PhD from the University of Wales, Bangor focusing on impacts of commercialisation of non-timber forest products.

Caroline Ochieng is a Research Fellow at Stockholm Environment Institute, where she works on developing and implementing research projects on energy access in developing countries. Her interest lies in understanding the multidimensional impacts of energy access, which include health, environment, climate and food security. She is currently leading an Expert Group on Energy Access and Food Security that is part of Swedish International Agricultural Network Initiative (SIANI). Caroline has over 12 years of research experience in the energy sector in developing countries. She holds a PhD in Public Health and Policy from the London School of Hygiene & Tropical Medicine, and combines research with academic teaching.

Dr. Jummai Yila is a Programme Officer with the African Forest Forum (AFF) in Nairobi, Kenya. Jummai is a social scientist with a great strength in qualitative research and gender analysis. Her research expertise covers household livelihood analysis; vulnerability and adaptability analysis in relation to climate change impact; food security processes and institutional changes; forestry and natural resource management in many countries of Africa and Southeast Asia. Jummai Yila has a PhD in Gender and Development Studies from Asian Institute of Technology.

Miyuki Iiyama is a Research Scientist of ICRAF. With a PhD in economics from the University of Tokyo, she has extensive experiences in quantitative and qualitative analyses of integrated farming/agroforestry system evolution, technological adoption, and sustainable livelihoods in rural Africa. At ICRAF, she is especially assigned research the evaluation of socio-economic and environmental viability of biofuel provision and resource management within smallholder systems.