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Review

Importance of solar cookers in women's daily lives: A review

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ABSTRACT

Most African women spend a lot of time on housework unpaid works, such as collecting fuel, cooking at home, and looking after children. They spend around 3.5–8 h a day collecting firewood from a long distance, sometimes coming back very tired. New technologies are using to reduce women time spent for unpaid working including solar cookers that also contribute to sustainable environment and health. With a view to reducing women's daily workload and contributing to sustainable development, this review aims to highlight the importance of solar cookers in women's daily lives. A total of 73 papers from Africa (39.73 %), Asia (17.81 %), America (6.85 %), Europe (4.10 %), and the rest of the world (31.51 %) were considered. Three types of solar cookers (SCs), namely box cookers, panel cookers, and parabolic cookers, were identified. Each had different performance and design parameters. SCs can save 1 to 5 h per day of time spent on fuelwood collection and between 18 and 48 h per month on cooking. Moreover, SCs can save about 9.1 USD (for home use), 136 USD (in snack bar), 600.6 USD (in hotels), 910 USD (in restaurants) and 391,667 USD (in city) monthly. In addition, each SC can save between 850 kg and 1 ton of wood monthly. The reduction in CO_2 emitted per month by using SCs was up to 60.55 kg (at home), 6055.2 kg (in restaurants), 3996.43 kg (in hotels), and 908.28 kg (in snack). SCs reduce or eliminate eye disease, respiratory disease, headaches, cardiovascular disease, cancer and nutritional deficiencies. The adoption rate of SCs remains low in Africa and ranges from 0.8 % (in Kenya) to 38 % (in South Africa). Economic, social, cultural, environmental, political, and technical barriers are factors limiting the adoption of SCs in developing countries.

Contents

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Introduction

Most African women spend quite a lot of time doing housework, such as collecting fuel, cooking, and looking after children. For instance, in Tanzania (8 h/day), Senegal (4–5 h/day), Kenya (3.5 h/day), Malawi (5 h/day) and South Africa (4-8 h/day), women spend between 3.5 and 8 h collecting fuelwood (Biran et al., 2004; Carmody & Sarkar, 1997; Lenfers et al., 2018; Sater & Tolly, 2021). Women often walk long distances to search for wood and then come back very tired, and this sometimes causes health problems (Wilson & Green, 2000). In addition to the time spent on fuelwood collection, the use of the wood induces the emission of greenhouse gases (GHGs), household air pollution (HAP), and biodiversity loss (Carmody & Sarkar, 1997). A total of 2.2 to 4.3 million women and children die each year from HAP (Foell et al., 2011; GBD, 2016; Quinn et al., 2018; World health Organization, 2014), and 95 % of these victims are from developing countries (WHO, 2014). The immediate effects of HAP are recognized as headaches, coughing, and sore eyes, which can cause long-term health impacts and morbidity (Clancy et al., 2012). Thus, to avoid increasing the consequences both on the environment and on health and to reduce women's daily workload and unpaid works, solar cooker (SC) technology appears to be an attractive alternative to meet vital needs without compromising biodiversity, while reducing GHG emissions and improving women's health (Krämer, 2002; Zampaloni, 2017).

SC is a fully emission-free technology that operates using only the Sun's thermal energy (Agha, 2017; Huynh, 2014). SC technology produces a small amount of waste compared to other cookers and reduces damage to the soil, water, and living organisms (Panwar et al., 2011). SC technology aligns with the scope of many Sustainable Development Goals (SDGs). SCs can help realize zero hunger in the world (SDG 2), while providing a quick and low-cost cooking solution. It can increase health and well-being by reducing smoke and other health impacts from using wood and charcoal as cooking fuels (SDG 3); contribute to gender equality (SDG 5), by focusing on women as key persons involved in cooking; can help people access safe water sources (SDG 6), by enabling the pasteurization of water; can contribute to the development of sustainable and clean energy (SDG 7), by using solar energy; and finally enhance sustainable forest management (SDG 15), through the reduction of wood collection and charcoal production (Adanguidi et al., 2020; Lessa et al., 2017).

Many reviews on the environmental and socioeconomic importance of SCs have been conducted, but they mostly related to qualitative assessments that did not mention the technical specification or the effectiveness of the technology. They did not give a clear explanation about the current amount of CO_2 reduction, reduction in quantity of wood needed, or economic gain due to the adoption of these technologies (Debbi et al., 2014; Lewis & Pattanayak, 2012). The synthesis of quantitative information about SCs can inform both women unpaid works and biodiversity conservation policies to enable the scaling-up of solar energy systems.

Thus, this literature review investigated the quantitative values of the socioeconomic, environmental, and health importance of SCs in women's daily lives and constraints to their adoption in developing countries.

Literature search approach

The literature review included keywords such as “work time reduction”, “time saving”, “workload reduction”, “economic benefit”, “socioeconomic importance”, “money saving”, “increase incomes”, “monetary profits”, “greenhouse gas emission”, “household air pollution”, “clean cooking”, “clean energy”, “firewood use”, “wood saving”, “modern energy”, “fuel saving”, “sustainable development”, “environmental importance”, “respiratory diseases”, “chronic obstructive”, “pulmonary disease”, “pneumonia”, “eye blindness”, “eye diseases”, “headaches”; “tuberculosis”, “asthma”, “cardiovascular disease”, “cancer”, “nutritional deficiencies”, “deaths smoke”, “adoption constraints”, “adoption rate”. The research combined each of these words with “solar cooker”. Then, original articles, theses (Masters and PhD), and official reports were obtained from various databases, including Google Scholar (www.scholar.google.fr), ScienceDirect (www.sciencedirect.com), African Journals Online (www.ajol.info), Web of Science (www.webofknowledge.com), and IDRC Digital Library (https://idl-bnc-idrc.dspacedirect.org). Thirty years of publications from 1990 to 2021 were considered during the review.

Inclusion/exclusion criteria and screening studies

A first search was conducted on articles published in all languages with an abstract in French or English. A second search was on the missed references by reviewing the references of the review articles identified in the first search. Screening for final inclusion was made using the analytical process of Harden et al. (2009). The abstracts were screened to identify the potential relevant publications from which the full text was reviewed to identify those that were relevant to the review objectives.

The search provided 495 abstracts (465 journal articles, 21 conference papers, 9 case-reports) that were read to find potential relevant publications. The abstracts were excluded if no information was provided on either the socioeconomic, environmental, health importance or adoption of SCs. From the abstracts, a total of 210 potential relevant publications were considered for the full review. The full text of these publications was reviewed to identify those that provide information on either the socioeconomic, environmental, health importance or adoption of SCs. Publications were excluded if the full text was neither in French, nor in English or if published in predatory journal. A total of 73 publications were ultimately used for this review. Overall, 15 of the papers were on qualitative studies focusing on the types, constraints, and adoption rates of SCs. A total of 50 papers were on quantitative studies (socioeconomic, environmental, and health importance), and the remaining 8 papers were on case studies. The data collected in the publications were grouped in five themes (SCs types, socioeconomic importance of SCs; environmental importance of SCs; health importance of SCs; rate and adoption constraints of SCs) for the analysis and discussion.

The data collected on the theme related to SCs types included the structural type, cooking method, thermal storage and designs of SCs as well as the economic value and payback period of SC types. For the theme related to socioeconomic importance of SCs, the data collected included worktime reduction (time spent on fuel collection and cooking) and economic benefits (money saved by the use of a solar cooker). With regards to the environmental importance of SCs, the data collected included the reduction in demand for wood, the reduction in GHGs and the preservation of the environment. With the health importance of SCs, the data collected were related to the reduction of air pollution and the preservation of women and children's health. Concerning the rate and adoption constraints of SCs, the data collected included the adoption rate and the adoption constraints of SCs.

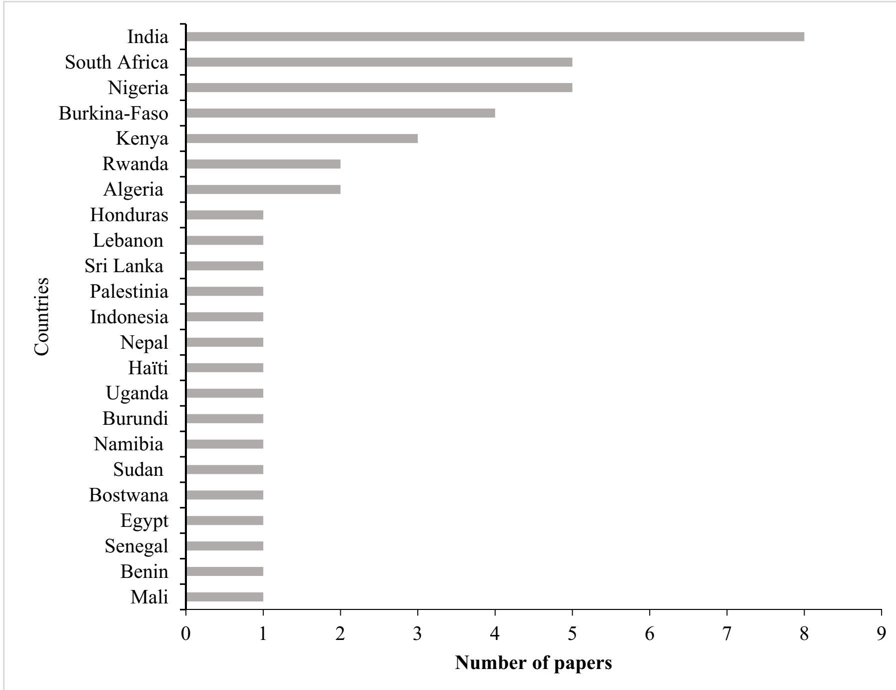

Fig. 1. Number of publications recorded on the importance and adoption of SCs per developing country.

Spatio-temporal patterns and focus of the studies

The number of papers related to the importance and adoption of SCs in developing countries increased over the three-decade period. About 69.78 % of the papers were published in the two last decades (2010–2021). This reflects the interest in the development of solar energy uses in developing countries for green jobs opportunities. The main concerns in the findings were on the role of solar energy in climate change risk mitigation through biodiversity conservation and reduction of GHGs. Most of the publications (39.73 %) were carried out in Africa mainly in South Africa, Nigeria, Burkina-Faso, Kenya, Rwanda and Algeria (Fig. 1). A total of 62 % of the publications focused on the importance of SCs for women and children's well-being, 42 % on fuelwood reduction, 33 % on SC types, 33 % on reduction in GHG emissions, 25 % on economic importance, and 23 % on worktime reduction.

Solar cooker types

Classifications of solar cookers

Three factors — structural type, cooking method, and thermal storage — were taken into account for the classification of SCs (Lewis et al., 2015; Mathis, 2014; Sesan, 2012). Three main designs of SCs (box cookers, panel cookers, and parabolic cookers) were noted in accordance with structural type (Agha, 2017; Arunachala & Kundapur, 2020). Each of the SC designs showed different performances and parameters (Agha, 2017; Arunachala & Kundapur, 2020; Chartier et al., 2017; Devan et al., 2020; Jürisoo et al., 2018; Lewis et al., 2015; Mathis, 2014; Muthusivagami et al., 2010; Sesan, 2012). Among the three types, parabolic cookers proved to be the most efficient, with a heating temperature sometimes exceeding 400 °C (WHO, 2014). Based on thermal storage, the SC method can be direct or indirect (Devan et al., 2020; Riva et al., 2017). Moreover, Muthusivagami et al. (2010) distinguished cooking methods using sensible heat and methods using latent heat. Some models of SCs are Ulog, REMS 5, Sunstove, SK12, Schwarzer 1, Schwarzer 2, and REM15, with SK12 and REM5 being the most efficient and used by large families and REM 5 most commonly used by small families.

Description

A box cooker has double glazing that covers the whole thing and creates a greenhouse effect (Fig. 2A). It easily achieves temperatures of 120 °C to 150 °C. Easy to manufacture, box cookers are the most widely used (Yettou et al., 2014).

A panel cooker combines the elements of a box cooker and a parabolic cooker. Very easy to build, a panel cooker is not equipped with glass or an insulation system. Its reflective surfaces are safe for the eyes. It easily achieves temperatures of 250 °C (Riva et al., 2017). Since its temperatures are regular, it does not need to be adjusted during cooking (Fig. 2B).

A parabolic cooker is a curved concentrator cooker that can quickly reach very high temperatures, but requires frequent adjustment and many safety precautions (Fig. 2C). With an estimated power of 400 W, they are the most expensive.

The energy used by these SCs is renewable energy that comes entirely from the Sun.

Solar cookers and payback period

The prices of SCs varied according to size, type, cooking capacity, region, and local materials. The cooking capacities of the SCs are mostly close to the lower-priced stoves. Based on the information presented in Table 1, the price of a box SC varied between 40 USD and 350 USD. They were cheap in Pakistan (40 USD–50.28 USD) and expensive in Lebanon (350 USD), with a payback period of 3.25 years at home and 1–3 months in shopping centers (restaurants, hotels, snack, etc.). The SCs in Lebanon are used for business (restaurant, hotel and snack bar) with high capacity (composed of booster mirrors, glazing, absorber plate, cooking pots, heat storage materials and insulation) compared to the SCs in Pakistan used at home for households foods with box cooker one fireplace without heat storage materials (Herez et al.,

Fig. 2. Different types of SCs: (A) box SC (Joshi & Jani, 2015), (B) panel SC (Aramesh et al., 2019), (C) parabolic SC (Arunachala & Kundapur, 2020).

2018; Joshi & Jani, 2015). The price of a panel SC was cheap (40 USD and 86 USD) due to it easy construction and low cost material. It can be built from a single cardboard box and some aluminum foil (Joshi & Jani, 2015). However, it performance is extremely affected by the reflected radiation. It doesn't work under dark, windy or cloudy weathers. It can only bake cakes and breads. The price of a parabolic SC varied between 240 USD and 349 USD. An SC with thermal storage (a variant of parabolic SC) was expensive, with a price varying between 460 USD and 640 USD. The size, cooking capacity, storage capacity and local materials are the mains factors of the variation in the price of the thermal storage SC. It can store energy during sunshine as a sensible or latent energy, and exploit it later during cloudy weather, evening or even at night (Joshi & Jani, 2015). When considering the size, type, cooking capacity, region, and local materials, SCs were expensive in Mexico (2500 USD) and cheap in African countries (Table 1). The expensiveness of SCs in Mexico is due to the quality of local materials, requirements and the life stand of the populations.

Socioeconomic importance

Worktime reduction

Time spent on fuel collection and cooking can be screened with regards to women's daily worktime reduction (Joon et al., 2009; Otte, 2014; Wentzel & Pouris, 2007). However, the extent of time reduction may depend on family size, the season, type of food, and the type of SC (Asinobi & Yemi, 2008; Rikoto & Garba, 2013). In comparison to box SCs, parabolic SCs can save from 30 to 50 min of cooking time (Agha, 2017; Amer, 2003; Arunachala & Kundapur, 2020). A double exposure cooker (a variant of parabolic SC) can give 50 min of time reduction in rice cooking compared to conventional cookers (Table 2). SCs can save 1 to 5 h per day of time spent on fuelwood collection in areas where wood is scarce (Cecelski, 2000; De Lange & Wentzel, 2002). For other authors, the time save can range from 3 to 20 h per week for firewood collection (Clancy et al., 2012; Harmim et al., 2014), and between 18 and 48 h per month (about 36 % of time) for firewood collection and cooking with 15 frequencies of firewood collection per month (Singh & Sethi, 2018; Wentzel & Pouris, 2007). The use of SCs is less tiring and save time that can be spent on others incomes generating activities (Wentzel & Pouris, 2007). According to many authors, the time gained from the use of SCs can be spent in taking care of children, training and educational purposes, or on other household chores (Puzzolo et al., 2013; Troncoso et al., 2007). It will generally be of interest for women's empowerment (Carmody & Sarkar, 1997; Clancy et al., 2012), and contribute to it.

Economic benefits

Monetary profits from promoting SCs depended on country location (Table 3), activities, use frequency per month and scenarios (home, hotel, restaurant and snack) (Asinobi & Yemi, 2008; Biermann et al., 1999). Therefore, SCs can provide benefits of about 14 USD of liquid gas and 20 USD of electricity consumption per month (Agha, 2017). Global studies carried out by Craig and Dobson (2015) and Aramesh et al. (2019) showed that SCs can save up to 167 USD per month with 10 households using SCs (Table 3). The potential users of SCs reported savings of between 40 % and 50 % of the cost of fuelwood in Nigeria (Biermann et al., 1999; Cecelski, 2000; De Lange & Wentzel, 2002;

Table 1
Economic value and payback period of SC types per country.

SC type	Country	Estimated prices in USD	Period	Payback period in years	References
Box	India	120–138	2015–2018	–	(Aramesh et al., 2019; Joshi & Jani, 2015)
Box	Indonesia	79.35–96.60	2001–2018	–	(Joshi & Jani, 2015)
Box	Tanzania	115–253	2007–2018	–	(Joshi & Jani, 2015)
Box large-size	India	198–321.46	2009–2018	–	(Joshi & Jani, 2015)
Box	Pakistan	40–50.28	2013–2018	–	(Joshi & Jani, 2015)
Box	Algeria	75.5–100.35	2012–2018	–	(Joshi & Jani, 2015)
Box with mirrors	Algeria	105.5–126.85	2014–2018	–	(Joshi & Jani, 2015)
Box	Senegal	103–105.59	2014–2018	–	(Joshi & Jani, 2015; Vanschoenwinkel et al., 2014)
Box	Nicaragua	100–109.28	2014–2018	–	(Joshi & Jani, 2015)
Box	Lebanon	350	2018	3.25 at home; 1–3 months in restaurant and hotel	(Herez et al., 2018; Joshi & Jani, 2015)
Panel	Mexico	40–50.13	2012–2018	–	(Joshi & Jani, 2015)
Panel	Tanzania	40–73.33	2012–2018	–	(Joshi & Jani, 2015)
Panel	Lebanon	86	2014–2018		(Joshi & Jani, 2015)
Parabolic	Mexico	280–346.5	2007–2018	7 months; 0.6 year	(Herez et al., 2018; Joshi & Jani, 2015; Sosa et al., 2014)
Parabolic	Lebanon	349	2014		(Joshi & Jani, 2015)
Parabolic (indirect vacuum tube)	Pakistan	125–157.14	2013–2018	–	(Herez et al., 2018; Joshi & Jani, 2015)
Parabolic (indirect with thermal storage)	–	460	2013–2018	–	(Joshi & Jani, 2015)
	Lebanon	640	2018	–	(Herez et al., 2018)
Box (SCHW1)	South Africa	180.1	2018	-	(Biermann et al., 1999)
Box (Papillon Cooker SK-14)	Burkina Faso	205.44	1999	–	(Krämer & Westafrika, 2010)
	Burkina Faso	177.27	2010		(Krämer & Westafrika, 2010)
Not specified	India	25–650	2018	–	(Joshi & Jani, 2015)
Not specified	Mexico	80–2500	2018	–	(Joshi & Jani, 2015)
Not specified	Pakistan	21–1800	2018	–	(Joshi & Jani, 2015)
Not specified	Tanzania	19–748	2018	–	(Joshi & Jani, 2015)
Not specified	Indonesia	30–1900	2018	–	(Joshi & Jani, 2015)
Not specified	Mali	184–223	2002	–	(Krämer, 2002)
Not specified	Kenya and Zambia	120–140	2016		(Jürisoo et al., 2018)

Lessa et al., 2017). The money saved per month at household level through the use of SCs varies from 5 USD (Asinobi & Yemi, 2008) to 32.61 USD (Aramesh et al., 2019). The variation of the money saved is related to the type and characteristics of SCs and number of times it is used per month. SCs with two fireplaces save more money than SC with one fireplace (Indora & Kandpal, 2018; Ojo et al., 2018; Venkataraman et al., 2010; Wentzel & Pouris, 2007). The money saved per month through the use of SCs vary from 9.1 USD (at home), 136 USD (at snack bar), 600.6 USD (in hotels) to 910 USD (at restaurant) (Herez et al., 2018). This difference is related to the activity, characteristics and use frequency of SCs. At the town level with 25 % of household using SCs, the money saved per month is more than 391,667 USD (Herez et al., 2018; Indora & Kandpal, 2018; Ojo et al., 2018; Venkataraman et al., 2010; Wentzel & Pouris, 2007; Wilson & Green, 2000) (Table 3).

The payback period depends on the type and the number of SCs in use and the scenarios (Cuce & Cuce, 2013). The payback period in the home was 39 months for a box cooker, 19 months for a panel cooker, and 77 months for a parabolic cooker. For a restaurant, the payback period was 1 month for a box cooker or a panel cooker and 3 months for a parabolic cooker (Herez et al., 2018; Indora & Kandpal, 2019). It can be acknowledged that a panel cooker is the best choice to be used whatever the type of scenario. The short payback period shows that the use of an SC is economically viable (Panwar et al., 2012; Puzzolo et al., 2013; Yadav et al., 2016). Apart the initial purchase cost of SCs, the free cooking cost can reduce the amount of fuel needed to cook and the amount of money spent on fuel (Otte, 2014; Williams, 2016). Compared to microwaves, SCs could reduce the annual life cycle costs by up to 40 %, and 26.87 million USD could be saved per year (Mendoza et al., 2019).

Environmental importance of solar cookers

SCs contribute to a reduction in demand for wood and then to a reduction in GHGs (Lessa et al., 2017). About 70.5 % of women agreed with the role of SCs in maintaining and preserving the environment (Agha, 2017). According to Williams (2016), the fact that no energy source is needed other than the Sun leaves forest ecosystems untouched. Therefore, any SC used in a sunny and arid climatic area can save between 850 kg and 1 ton of wood per year (Ojo et al., 2018; Panwar et al., 2012; Yettou et al., 2014). In West Africa, Cecelski (2000) and Troncoso et al. (2007) showed that households using SCs save on average 33 % of wood collected. In America, the amount of fuelwood saved through the use of SCs was estimated at over 16.8

Table 2
Cooking time reduction for some foods according to SC type (Amer, 2003; Arunachala & Kundapur, 2020).

Food type and activities	Conventional cooker (h:min)	Panel SC (double exposure cooker) (h:min)	Box SC with one reflector (h:min)	Parabolic SC (h:min)	References
1/4 kg of lady's finger in 400 cm^3 tomato sauce	1:10	0:45	–	–	(Amer, 2003; Arunachala & Kundapur, 2020)
2 kg of roasting potatoes + ¼ oil	0:45	0: 20	–	–	(Amer, 2003; Arunachala & Kundapur, 2020)
Cook, bake and fry	–	–	1–1:30	0:30–0:40	(Amer, 2003)
¼ kg of rice + 500 cm^3 of water	1:40	0:50	–	–	(Amer, 2003)
½ kg of chicken + 500 cm^3 of water	2:00	1:24	–	–	(Amer, 2003)

Table 3
Average money saved by the use of a solar cooker in different countries.

Monetary profit (USD)	Country	Reference
17/month/household	General	(Agha, 2017)
32.61/month/household	Palestine	(Aramesh et al., 2019)
5/month/household	Mali	(Asinobi & Yemi, 2008)
17/month/household	South Africa	(Craig & Dobson, 2015)
9.1/month/household 910/month/restaurant 600.6/month/hotel 136/month snack bar	Lebanon	(Herez et al., 2018)
5/year/household	South Africa	(De Lange & Wentzel, 2002)
391,667/month/city with 25 % of household	Nigeria	(Ojo et al., 2018)
15 to 24/month/household	India	(Indora & Kandpal, 2018)

million tons per year (Cuce & Cuce, 2013). The use of solar energy would then considerably reduce the use of wood energy, which leads to deforestation, soil erosion, and the advance of deserts in Africa, America, and Asia (Foell et al., 2011; Sheyin, 2005).

In terms of GHG reduction, SCs contribute to a reduction of 381.8 kg/year in CO_2 emission (Aramesh et al., 2019; Suharta, 2009). A total of 38.4 million tons of CO_2 emitted per year can be prevented and 5175 MJ of energy can be saved (Cuce & Cuce, 2013; Puzzolo et al., 2013; Yettou et al., 2014). The CO_2 reduction is specific to each use scenario for SCs. Thus, the reduction can be from 6.05 to 60.55 kg/month at home, 605.52 to 6055.2 kg/month at a restaurant, 399.64 to 3996.43 kg/month at a hotel, and 90.82 to 908.28 kg/month at a snack (Herez et al., 2018). The use of SCs significantly reduces CO_2 emissions in all scenarios (Aramesh et al., 2019; Young et al., 2019). In addition, on a daily basis, the use of SCs reduces the emission of particulate materials within 24 h by 42 % to 48 % (Lewis et al., 2015; Rosa et al., 2014). This represents more than 42,600 tons of CO_2 eq. avoided annually (Johnson et al., 2009; Mendoza et al., 2019). Recently a study showed that 50 % of CO_2 emissions and 75 % of emissions of particulate matter could be reduced with the adoption of SCs (Shrestha et al., 2021). Herez et al. (2018) concluded that SCs are environmentally eco-friendly, because they served to reduce GHG emissions.

Health importance of solar cookers

In terms of health, using SCs can reduce about 95 % of household air pollution (Lessa et al., 2017) and preserve women and children's health (WHO, 2014; Wimmer et al., n.d.). The primary benefit from SCs is the reduction in eye disease (Fig. 3) (Herez et al., 2018) followed by respiratory disease (Cecelski, 2000; Jürisoo et al., 2018; Sheyin, 2005). In other concerns, the use of SCs can reduce by 97.5 % infections caused by water contamination, such as dracunculiasis (Bisaga et al., 2021; Craig & Dobson, 2015; Rosa et al., 2014). Being smokeless, SCs contribute to better air quality indoors; there is no danger of fire; and they reduce the physical strain of carrying wood (Mathis, 2014; Williams, 2016).

Rate and adoption constraints of solar cookers

Despite the recognized importance of SCs, the adoption rate was low and varied from 0.8 % to 38 % in Africa (Biermann et al., 1999; Kaburu et al., 2019; Wentzel & Pouris, 2007). In Kenya (Kakuma Refugee Camp) with 122 households systematically sampled, the adoption rate of uptake of SCs was 0.8 % (Kaburu et al., 2019). In South Africa, with four studies carried out in four different areas (the Northern Cape, North-West and Limpopo provinces of South Africa), the adoption rate of SCs was 38 %, 31 %, 34 %, and 33 % respectively (Biermann et al., 1999). Whereas the adoption rate remains low in Africa, it was estimated to be as high as 86 % in Asia (the Gaza Strip region of Palestine) with 44 female housewives sampled (Agha, 2017). It has also been acknowledged that SCs are far from being a main means of cooking in Africa (Jürisoo et al., 2018; Muneer, 2003) or Asia (Lewis et al., 2015).

The adoption constraints on SCs in developing countries are numerous and can be classified into six categories: (1) economic, (2) social, (3) cultural, (4) environmental, (5) political, and (6) technical. The citation classification of constraints scored the economic constraint in the first position (89.74 %), followed by technical (58.97 %), cultural (56.41 %), social (38.46 %), environmental (30.76 %), and political (25.64 %) (Agha, 2017; Aramesh et al., 2019; Debbi et al., 2014; Puzzolo et al., 2013; Sheyin, 2005). The economic constraint was therefore the main factor that mostly prevents the adoption of SCs in developing countries (Otte, 2013; Wentzel & Pouris, 2007). Moreover, the high cost of photovoltaic panels and electric cooking appliances, as well as maintenance difficulties, make this technology marginal. In addition, the low economic power of households and the low price of other fuels, such as kerosene, wood, and charcoal, are the main economic factors that influenced the implementation and adoption of SCs in sub-Saharan Africa (Achudume, 2009; Anozie et al., 2007; Beltramo et al., 2014; Jürisoo et al., 2018; Sesan, 2012). In respect of technical constraints, the low availability of materials used in designing improved stoves remains the main reason for their non-adoption (Rhodes et al., 2014). A stove design that allows users to continue cooking traditional dishes using traditional pots and cooking utensils would be important for adoption and sustainable use.

Cultural resistance and social barriers are also factors preventing the adoption of SCs, especially in Africa (Beltramo et al., 2014; Debbi et al., 2014; Mathis, 2014; Otte, 2013). Thus, the fact that SCs do not produce a visible fire, like conventional three-stone ovens is considered to limit their adoption. Since SCs prepare food without a visible fire, people remain skeptical about the proper functioning of these cookers. In some African cultures, food intended for certain deities must be prepared on a visible fire. Then, during this time, praises and libations are made as the smoke of the wood coming out of the preparation is released. This is a sign of the acceptance of the offering by the gods (Mmolotsi Rantao, 2006). SCs are therefore considered to be culturally disruptive. Johnson et al. (Johnson et al., 2009) explained that, despite growing interest in SCs, one of the main environmental and political obstacles to improving stove projects in carbon-trading systems was the lack of accountability in estimating CO_2 equivalent savings (CO_2-e). In addition to this, organizational barriers and barriers related to skills, information, and awareness also hamper the implementation and adoption of SCs in developing countries. Communities must therefore be sensitized and involved in the establishment and management of adoption projects for short and long-term success.

Conclusion

This literature review focus on the quantitative values of the socio-economic, environmental, and health importance of SCs in women's daily lives and constraints to their adoption in developing countries. A total of 495 abstracts were screened to identify the potential relevant publications from which 73 publications were used for this review. Three designs of SCs — box cookers, panel cookers, and parabolic cookers — were found, with parabolic SCs being the most expensive and efficient. SCs can save 1–5 h per day of time spent on fuelwood collection and 18–48 h per month on cooking. The use of SCs can save up to 9.1 USD (for home use), 136 USD (in snack bar), 600.6 USD (in hotels), 910 USD (in restaurants) and 391,667 USD (in city) per month. In addition, more than 1 ton of wood and 3996.43 kg of CO_2 could be reduced monthly. SCs can reduce eye disease, respiratory disease, headaches, cardiovascular disease, cancer, and nutritional deficiencies, and the deaths of women and children. However, despite the importance of SCs, their adoption rate was very low (0.8 % in Kenya to 38 % in South Africa) in developing countries. Economic barriers and cultural resistance were the main factors preventing adoption, especially in Africa. This review could help in the decision-making and elaboration of

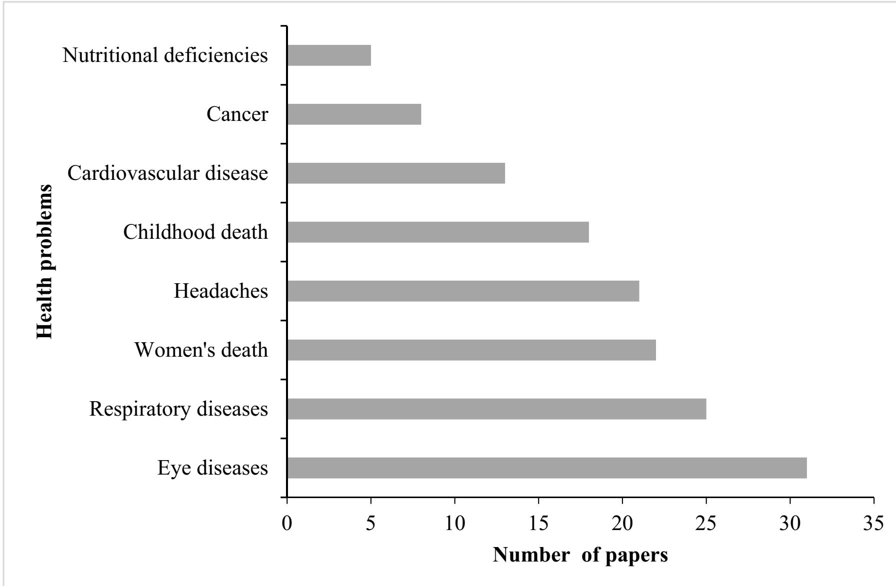

Fig. 3. Citation score for reduction in health conditions following the adoption of SCs.

adoption strategies, for the better adoption of the SC technology in developing countries.

The review focused on 30 years period (1990–2021) and excluded potential relevant publications neither in French nor in English. This may reduce some information pertain to the focus of the review. However, the evidence provide in this review on the socioeconomic, environmental, and health importance of SCs in women's daily lives and constraints to their adoption in developing countries is an important step for the upscaling of SCs in developing countries.

Declaration of competing interest

The co-authors have no conflict of interest to declare.

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Appendix A. Articles published worldwide on solar cookers from 1990 to 2021

Continent/country	Number of papers	References
Africa (36.98 %)	28	
Mali	1	Asinobi & Yemi (2008)
Senegal	1	Vanschoenwinkel et al. (2014)
Kenya	3	Jürisoo et al. (2018); Kaburu et al. (2019); Sesan (2012)
Benin	1	Adanguidi et al. (2020)
Nigeria	5	Anozie et al. (2007); Rikoto & Garba (2013); Ojo et al. (2018); Sheyin (2005); Achudume (2009)
Burkina-Faso	4	Krämer (2002); Krämer and Westafrika (2010); Otte (2014); Zampaloni (2017).
South Africa	5	Biermann et al. (1999); De Lange & Wentzel (2002); Wentzel & Pouris (2007); Craig & Dobson (2015); Wilson & Green (2000);
Egypt	1	Amer (2003)
Botswana	1	Mmolotsi Rantao (2006)
Sudan	1	Muneer (2003)
Namibia	1	Nhi Huynh (2014)
Algeria	2	Yettou et al. (2014); Harmim et al. (2014)
Burundi	1	Riva et al. (2017)
Uganda	1	Beltramo (2014)
Rwanda	2	Bisaga et al. (2021); Rosa et al. (2014)
Europe (4.11 %)	3	
Germany	1	Cecelski (2000)
Austria	1	Wimmer et al. (2017)
Spain	1	Mendoza et al. (2019)
America (06.85 %)	5	
Mexico	3	Johnson et al. (2009); Troncoso et al. (2007); Sosa et al. (2014)
Haïti	1	Williams (2016)
Honduras	1	Young et al. (2019)
General studies (34.25 %)	23	Aramesh et al. (2019); Arunachala & Kundapur (2020); Carmody & Sarkar (1997); Clancy et al. (2012); Cuce & Cuce (2013); Debbi et al. (2014); Foell et al. (2011); GBD (2016); Carmody & Sarkar, (1997); Lessa et al. (2017); Lewis & Pattanayak (2012); Muthusivagami et al. (2010); Otte (2013); Panwar et al. (2011); Panwar et al. (2012); Puzzolo et al. (2013); Quinn et al. (2018); Mathis (2014); WHO (2014a); WHO (2014b); Joshi & Jani (2015); Rhodes et al. (2014); Harden et al. (2009)
Asia (17.81 %)	13	
Nepal	1	Shrestha et al. (2021)
Indonesia	1	Suharta (2009)
Palestine	1	Agha (2017)
Sri Lanka	1	Chartier et al. (2017)
India	8	Devan et al. (2020); Indora & Kandpal (2018); Indora & Kandpal (2019); Joon et al. (2009); Lewis et al. (2015); Singh & Sethi (2018); Venkataraman et al. (2010); Yadav et al. (2016)
Lebanon	1	Herez et al. (2018)

References

Achudume, A. C. (2009). Environmental health, development and economic empowerment of rural women in Nigeria. *Environment, Development and Sustainability*, *11*, 459–469. https://doi.org/10.1007/s10668-007-9124-1.

Adanguidi, J., Padonou, E. A., Zannou, A., Houngbo, S. B., Saliou, I. O., & Agbahoungba, S. (2020). Fuelwood consumption and supply strategies in mangrove forests-Insights from RAMSAR sites in Benin. *Forest Policy and Economics*, *116*, Article 102192. https://doi.org/10.1016/j.forpol.2020.102192.

Agha, D. H. (2017). *An assessment of the environmental and economic benefits of using solar cooker according to households perception in the gaza strip: Case study.* Master thesisIslamic University–Gaza 92 p.
Amer, E. H. (2003). Theoretical and experimental assessment of a double exposure solar cooker. *Energy Conversion and Management*, *44*, 2651–2663. https://doi.org/10.1016/S0196-8904(03)00022-0.
Anozie, A. N., Bakare, A. R., Sonibare, J. A., & Oyebisi, T. O. (2007). Evaluation of cooking energy cost, efficiency, impact on air pollution and policy in Nigeria. *Energy*, *32*, 1283–1290. https://doi.org/10.1016/j.energy.2006.07.004.
Aramesh, M., Ghalebani, M., Kasaeian, A., Zamani, H., Lorenzini, G., Mahian, O., & Wongwises, S. (2019). A review of recent advances in solar cooking technology. *Renewable Energy*, *140*, 419–435. https://doi.org/10.1016/j.renene.2019.03.021.
Arunachala, U. C., & Kundapur, A. (2020). Cost-effective solar cookers: A global review. *Solar Energy*, *207*, 903–916. https://doi.org/10.1016/j.solener.2020.07.026.
Asinobi, C. O., & Yemi, I. (2008). Attitudes of rural and urban women in Bamako District and Koulikoro Region of Mali to the use of a solar cooker. *Proceedings of the 24th annual meeting.* Costa Rica: E.A.R.T.H. University 13 p.
Beltramo, T., Levine, D. I., & Blalock, G. (2014). The effect of marketing messages, liquidity constraints, and household bargaining on willingness to pay for a nontraditional cookstove. CEGA working paper no. 35. Retrieved fromhttp://escholarship.org/uc/item/4vj3w941.
Biermann, E., Grupp, M. Y., & Palmer, R. (1999). Solar cooker acceptance in South Africa: Results of a comparative field-test. *Solar Energy*, *66*, 401–407. https://doi.org/10.1016/S0038-092X(99)00039-0.
Biran, A., Abbot, J., & Mace, R. (2004). Families and firewood: A comparative analysis of the costs and benefits of children in firewood collection and use in two rural communities in Sub-Saharan Africa. *Human Ecology*, *32*(1), 1–25.
Bisaga, I., Parikh, P., Tomei, J., & To, L. S. (2021). Mapping synergies and trade-offs between energy and the sustainable development goals: A case study of off-grid solar energy in Rwanda. *Energy Policy*, *149*, Article 112028. https://doi.org/10.1016/j.enpol.2020.112028.
Carmody, E. R., & Sarkar, A. U. (1997). Solar box cookers: Towards a decentralized sustainable energy strategy for sub-Saharan Africa. *Renewable and Sustainable Energy Reviews*, *1*, 291–301. https://doi.org/10.1016/S1364-0321(97)00008-7.
Cecelski, E. (2000). *The role of women in sustainable energy development (No. NREL/SR-550-26889).* Golden: National Renewable Energy Lab.
Chartier, R., Phillips, M., Mosquin, P., Elledge, M., Bronstein, K., Nandasena, S., & Rodes, C. (2017). A comparative study of human exposures to household air pollution from commonly used cookstoves in Sri Lanka. *Indoor Air*, *27*, 147–159. https://doi.org/10.1111/ina.12281.
Clancy, J., Winther, T., Matinga, M., & Oparaocha, S. (2012). Gender equity in access to and benefits from modern energy and improved energy technologies: World development report background paper. *Gender and Energy WDR Background Paper*, *44*.
Craig, O. O., & Dobson, R. T. (2015). Stand-Alone Parabolic solar cookers and rural industrialization in South Africa. *3rd Southern African solar energy conference, South Africa 11-13 May.*
Cuce, E., & Cuce, P. M. (2013). A comprehensive review on solar cookers. *Applied Energy*, *102*, 1399–1421. https://doi.org/10.1016/j.apenergy.2012.09.002.
De Lange, E., & Wentzel, M. (2002). Harnessing solar stove technologies in South Africa to promote improved household energy provision. *Boiling Point*, *48*, 30–32.
Debbi, S., Elisa, P., Nigel, B., Dan, P., & Eva, R. (2014). Factors influencing household uptake of improved solid fuel stoves in low-and middle-income countries: A qualitative systematic review. *International Journal of Environmental Research and Public Health*, *11*, 8228–8250. https://doi.org/10.3390/ijerph110808228.
Devan, P. K., Bibin, C., Gowtham, S., Hariharan, G., & Hariharan, R. (2020). A comprehensive review on solar cooker with sun tracking system. *Materials Today: Proceedings*, *33*, 771–777. https://doi.org/10.1016/j.matpr.2020.06.124.
Foell, W., Pachauri, S., Spreng, D., & Zerriffi, H. (2011). Household cooking fuels and technologies in developing economies. *Energy Policy*, *39*, 7487–7496. https://doi.org/10.1016/j.enpol.2011.08.016.
GBD (2016). Risk Factors Collaborators, Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: A systematic analysis for the Global Burden of Disease Study. *The Lancet*, *390*, 1345–1422.
Harden, C. L., Meador, K. J., Pennell, P. B., Hauser, W. Allen, Gronseth, G. S., French, J. A., & Guen, C. Le (2009). Management issues for women with epilepsy—Focus on pregnancy (an evidence-based review): II. Teratogenesis and perinatal outcomes: Report of the Quality Standards Subcommittee and Therapeutics and Technology Subcommittee of the American Academy of Neurology and the American Epilepsy Society. *Epilepsia*, *50*, 1237–1246. https://doi.org/10.1111/j.1528-1167.2009.02129.x.
Harmim, A., Merzouk, M., Boukar, M., & Amar, M. (2014). Solar cooking development in Algerian Sahara: Towards a socially suitable solar cooker. *Renewable and Sustainable Energy Reviews*, *37*, 207–214. https://doi.org/10.1016/j.rser.2014.05.028.
Herez, A., Ramadan, M., & Khaled, M. (2018). Review on solar cooker systems: Economic and environmental study for different Lebanese scenarios. *Renewable and Sustainable Energy Reviews*, *81*, 421–432. https://doi.org/10.1016/j.rser.2017.08.021.
Huynh, S. Nhi (2014). *Solar cooking in Namibia.* Department of Energy Sciences/ Lund University – Faculty of Engineering Bachelor's Thesis.
Indora, S., & Kandpal, T. C. (2018). Institutional and community solar cooking in India using SK-23 and Scheffler solar cookers: A financial appraisal. *Renewable Energy*, *120*, 501–511. https://doi.org/10.1016/j.renene.2018.01.004.
Indora, S., & Kandpal, T. C. (2019). A framework for analyzing impact of potential financial/fiscal incentives for promoting institutional solar cooking in India. *Renewable Energy*, *143*, 1531–1543. https://doi.org/10.1016/j.renene.2019.05.097.
Johnson, M., Edwards, R., Ghilardi, A., Berrueta, V., Gillen, D., Frenk, C. A., & Masera, O. (2009). Quantification of carbon savings from improved biomass cookstove projects. *Environmental Science & Technology*, *43*, 2456–2462.
Joon, V., Chandra, A., & Bhattacharya, M. (2009). Household energy consumption pattern and socio-cultural dimensions associated with it: A case study of rural Haryana, India. *Biomass and Bioenergy*, *33*, 1509–1512. https://doi.org/10.1016/j.biombioe.2009.07.016.
Joshi, S. B., & Jani, A. R. (2015). Design, development and testing of a small scale hybrid solar cooker. *Solar Energy*, *122*, 148–155. https://doi.org/10.1016/j.solener.2015.08.025.
Jürisoo, M., Lambe, F., & Osborne, M. (2018). Beyond buying: The application of service design methodology to understand adoption of clean cookstoves in Kenya and Zambia. *Energy Research & Social Science*, *39*, 164–176.
Kaburu, G. M., James, R., & Mortimer, K. (2019). Social determinants and uptake of solar cooking projects-Kakuma Refugee Camp In Kenya. *Journal of Poverty, Investment and Development*, *4*, 1–20. https://www.iprjb.org/journals/index.php/JPID/article/view/803.
Krämer, P. (2002). *The fuel wood crisis in Burkina Faso, solar cooker as an alternative. Solar cooker archive.* Ouagadougou: Burkina Faso.
Krämer, P., & Westafrika, V. S. Für (2010). Why are solar cookers still unpopular among development experts? *Journal of Engineering Science and Technology*, *5*, 75–84.
Lenfers, U. A., Weyl, J., & Clemen, T. (2018). Firewood collection in South Africa: Adaptive behavior in social-ecological models. *Land*, *7*(97), 1–17. https://doi.org/10.3390/land7030097.
Lessa, L., Vries, Y. A. De, Swinkels, C. E., Smits, M., & Butijn, C. A. A. (2017). What's cooking? Unverified assumptions, overlooking of local needs and pro-solution biases in the solar cooking literature. *Energy Research & Social Science*, *28*, 98–108.
Lewis, J. J., Bhojvaid, V., Brooks, N., Das, I., Jeuland, M. A., Patange, O., & Pattanayak, S. K. (2015). Piloting improved cookstoves in India. *Journal of Health Communication*, *20*, 28–42. https://doi.org/10.1080/10810730.2014.994243.
Lewis, J. J., & Pattanayak, S. K. (2012). Who adopts improved fuels and cookstoves? A systematic review. *Environmental Health Perspectives*, *120*, 637–645. https://doi.org/10.1289/ehp.1104194.
Mathis, P. (2014). Biomasse énergie, pollution atmosphérique et santé biomass energy, air pollution and health. *Pollution Atmosphérique*, *71*, p.
Mendoza, J. M. F., Gallego-Schmid, A., Rivera, X. C. S., Rieradevall, J., & Azapagic, A. (2019). Sustainability assessment of home-made solar cookers for use in developed countries. *Science of the Total Environment*, *648*, 184–196. https://doi.org/10.1016/j.scitotenv.2018.08.125.
Mmolotsi Rantao, P. (2006). *Setswana culture and tradition.* Gaborone: Pentagon Publishers.
Muneer, S. E. T. (2003). Adoption of biomass improved cookstoves in a patriarchal society: An example from Sudan. *Science of the Total Environment*, *307*, 259–266. https://doi.org/10.1016/S0048-9697(02)00541-7.
Muthusivagami, R. M., Velraj, R., & Sethumadhavan, R. (2010). Solar cookers with and without thermal storage—A review. *Renewable and Sustainable Energy Reviews*, *14*, 691–701. https://doi.org/10.1016/j.rser.2008.08.018.
Ojo, S., Baba, M., & Thlimabari, A. (2018). The ecological, economical and social impact of adopting solar cookingin Mubi Metropolis Adamawa State, Nigeria. *Journal of Scientific Research and Reports*, *18*, 1–6. https://doi.org/10.9734/JSRR/2018/37401 Ouagadougou: Burkina Faso.
Otte, P. P. (2013). Solar cookers in developing countries—What is their key to success? *Energy Policy*, *63*, 375–381. https://doi.org/10.1016/j.enpol.2013.08.075.
Otte, P. P. (2014). A (new) cultural turn toward solar cooking—Evidence from six case studies across India and Burkina Faso. *Energy Research & Social Science*, *2*, 49–58. https://doi.org/10.1016/j.erss.2014.04.006.
Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. *Renewable and Sustainable Energy Reviews*, *15*, 1513–1524. https://doi.org/10.1016/j.rser.2010.11.037.
Panwar, N. L., Kaushik, S. C., & Kothari, S. (2012). State of the art of solar cooking: An overview. *Renewable and Sustainable Energy Reviews*, *16*, 3776–3785. https://doi.org/10.1016/j.rser.2012.03.026.
Puzzolo, E., Stanistreet, D., Pope, D., Bruce, N., & Rehfuess, E. (2013). *Factors influencing the large-scale uptake by households of cleaner and more efficient household energy technologies.* London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London 302 p.
Quinn, A. K., Bruce, N., Puzzolo, E., Dickinson, K., Sturke, R., Jack, D. W., & Rosenthal, J. P. (2018). An analysis of efforts to scale up clean household energy for cooking around the world. *Energy for Sustainable Development*, *46*, 1–10. https://doi.org/10.1016/j.esd.2018.06.011.
Rhodes, E. L., Dreibelbis, R., Klasen, E., Naithani, N., Baliddawa, J., Menya, D., & Checkley, W. (2014). Behavioral attitudes and preferences in cooking practices with traditional open-fire stoves in Peru, Nepal, and Kenya: Implications for improved cookstove interventions. *International Journal of Environmental Research and Public Health*, *11*(10), 10310–10326. https://doi.org/10.3390/ijerph111010310.
Rikoto, I. I., & Garba, I. (2013). Comparative analysis on solar cooking using box type solar cooker with finned cooking pot. *International Journal of Modern Engineering Research (IJMER)*, *3*, 1290–1294.
Riva, F., Rocco, M. V., Gardumi, F., Bonamini, G., & Colombo, E. (2017). Design and performance evaluation of solar cookers for developing countries: The case of Mutoyi, Burundi. *International Journal of Energy Research*, *41*, 2206–2220. https://doi.org/10.1002/er.3783.
Rosa, G., Majorin, F., Boisson, S., Barstow, C., Johnson, M., Kirby, M., & Clasen, T. (2014). Assessing the impact of water filters and improved cook stoves on drinking water quality and household air pollution: A randomized controlled trial in Rwanda. *PloS one*, *9*, Article e91011. https://doi.org/10.1371/journal.pone.009101.

Sater, A. A., & Tolly, J. (2021). *Solar cooking in Kenya – Development of a concept to increase diffusion.* Master thesisGothenburg, Sweden: Department of Industrial and Materials Science, Chalmers University of Technology 145 p.

Sesan, T. (2012). Navigating the limitations of energy poverty: Lessons from the promotion of improved cooking technologies in Kenya. *Energy Policy*, *47*, 202–210. https://doi.org/10.1016/j.enpol.2012.04.058.

Sheyin, F. T. (2005). *Solar cooking in Nigeria. RIO 5 - World climate & energy event.* Master thesis 145 p.

Shrestha, B., Sapkota, N., Adhikari, P., Adhikari, A., Basnet, S., Puri, R., & Binaya, K. C. (2021). Comparative study on performance and design optimization of natural draught institutional improved cooking stoves. *Kathmandu University Journal of Science, Engineering and Technology*, *15*, 1–5.

Singh, M., & Sethi, V. P. (2018). On the design, modelling and analysis of multi-shelf inclined solar cooker-cum-dryer. *Solar Energy*, *162*, 620–636. https://doi.org/10.1016/j.solener.2018.01.045.

Sosa, L. B. L., Avilés, M. G., Pérez, D. G., & Gutiérrez, Y. S. (2014). Rural solar cookers, an alternative to reduce the timber resource extraction through the use of renewable energy sources: Technology transfer and monitoring project. *Energy Procedia*, *57*, 1593–1602. https://doi.org/10.1016/j.egypro.2014.10.151.

Suharta, H. (2009). Future prospect of CDM solar cooker project Aceh 1, Indonesia. *Jurnal Ilmiah Teknologi Energi*, *1*, 1–15.

Troncoso, K., Castillo, A., Masera, O., & Merino, L. (2007). Social perceptions about a technological innovation for fuelwood cooking: Case study in rural Mexico. *Energy Policy*, *35*, 2799–2810. https://doi.org/10.1016/j.enpol.2006.12.011.

Vanschoenwinkel, J., Lizin, S., Swinnen, G., Azadi, H., & Van Passel, S. (2014). Solar cooking in Senegalese villages: An application of best–worst scaling. *Energy Policy*, *67*, 447–458. https://doi.org/10.1016/j.enpol.2013.12.038.

Venkataraman, Sagar, A. D., Habib, G., Lam, N., & Smith, K. R. (2010). The Indian national initiative for advanced biomass cookstoves: The benefits of clean combustion. *Energy for Sustainable Development*, *14*, 63–72. https://doi.org/10.1016/j.esd.2010.04.005.

Wentzel, M., & Pouris, A. (2007). The development impact of solar cookers: A review of solar cooking impact research in South Africa. *Energy Policy*, *35*, 1909–1919. https://doi.org/10.1016/j.enpol.2006.06.002.

WHO (2014). World Health Organization, Indoor air quality guidelines: Household fuel combustion. Retrieved fromhttp://www.who.int/indoorair/guidelines/hhfc/HHFC_guidelines.pdf.

Williams, L. S. (2016). *Social entrepreneurship as a response to the energy crisis, climate change and women's inequality in developing countries: Women managed solar cooker production business in Rural Haiti* (pp. 87). Haiti: Clark University Master thesis.

Wilson, M., & Green, J. M. (2000). The feasibility of introducing solar ovens to rural women in Maphephethe. *Journal of Consumer Sciences*, *28*, 54–61.

R. Wimmer, M.J. Kang, C. Pokpong, A. Mahdavi, Analysis of user needs for solar cooker acceptance. In: Matsumoto M., Masui K., Fukushige S., Kondoh S. (eds) Sustainability Through Innovation in Product Life Cycle Design. EcoProduction (Environmental Issues in Logistics and Manufacturing). Springer, Singapore. https://doi.org/10.1007/978-981-10-0471-1_11.

World health Organization. (2014). *WHO household energy database.* retrieved, February 08, 2021, fromWHO. https://www.who.int/airpollution/data/household-energy-database/en/.

Yadav, B., Yadav, S., & Yadav, L. (2016). Perception and attitude of rural women towards solar cooker. *Indian Research Journal of Extension Education*, *9*, 22–24.

Yettou, F., Azoui, B., Malek, A., Gama, A., & Panwar, N. L. (2014). Solar cooker realizations in actual use: An overview. *Renewable and Sustainable Energy Reviews*, *37*, 288–306. https://doi.org/10.1016/j.rser.2014.05.018.

Young, B. N., Clark, M. L., Rajkumar, S., Benka-Coker, M. L., Bachand, A., Brook, R. D., & Peel, J. L. (2019). Exposure to household air pollution from biomass cookstoves and blood pressure among women in rural Honduras: A cross-sectional study. *Indoor Air*, *29*, 130–142. https://doi.org/10.1111/ina.12507.

Zampaloni, I. T. (2017). *The broken promise of solar cooking. The case of Goudoubo Refugee Camp in Burkina Faso.* Master thesisLondon school of Economics and political sciences 67 p.