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Review

What's cooking? Unverified assumptions, overlooking of local needs and pro-solution biases in the solar cooking literature

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ABSTRACT

Solar cookers have been tested and studied in various settings, but despite their envisioned benefits – reduction of deforestation, economic benefits, improved health, and empowerment of women – results have been modest at best. This article performs a critical review of the literature on solar cooking (SC), to scrutinise the assumptions and methodological choices that may explain this conundrum. The literature review yielded 32 articles on solar cookers in Sub-Saharan Africa, where most SC projects can be found. Four recurrent types of issues stand out: local needs are often not sufficiently considered, existing cooking and fuelwood practices are seen as obstacles, many articles show a prosolution bias and there is a lack of methodologically sound impact studies. To overcome these issues, practice theory – which analyses the practice of cooking from the logic of the practice, rather than from an external point of view – is proposed to guide and focus future SC projects and studies. Furthermore, ethnographical methods can provide new and grounded evidence and allow for a stronger focus on local needs. These approaches can provide a fruitful evidence base to analyse the role of solar-cooking in achieving sustainable and long-term development benefits in the Global South.

1. Introduction

In pursuit of achieving the Sustainable Development Goals (SDGs) – and previously the Millennium Development Goals – introducing clean cooking technologies remains a popular option for development actors. One such technology is the solar cooker (SC), a device that makes direct use of sunlight to cook food or pasteurise drinks. While there are multiple designs, the general principle is that these devices channel and concentrate sunlight through mirrors, which is then converted to heat and used for cooking [1]. SCs have long been heralded as a clean and low-cost solution for people in developing countries. In terms of the SDGs, for example, these technologies potentially contribute to several goals: by using solar energy the SCs can contribute to the development of sustainable and clean energy (goal 7); by providing a low-cost cooking solution they can help realising zero hunger in the world (goal 2); through enabling the pasteurization of water they can help to people to access safe water sources (goal 6); they can increase health and well-being by reducing smoke and other health impacts that result from using wood and charcoal as cooking fuel (goal 3); by focusing on women as key persons involved in cooking they can contribute to ensuring gender equality (goal 5); and finally, they can reduce wood collection and charcoal making and thereby enhance sustainable forest management (goal 15) [2].

SCs have been tried and tested in many countries and supported by many local and international organisations. There are various types of SCs, such as the box cooker, panel cooker, and the parabolic reflector cooker; these all have different designs with the same general principle of using solar radiation as cooking source (for a comparison and technical functioning, see Muthusivagami et al. [3] and Cuce & Cuce [4]. Most of these SC designs have been tested in practice in diverse places and settings such as rural India [5] and urban areas of Burkina Faso [6,7]. SCs are not always presented as a stand-alone technology, but as part of 'integrated cooking solutions', which combine the use of a solar cooker, improved cookstove, and/or a heat retention cooker [8].

Despite their potential sustainable development contributions and diverse implementations, SCs have not led to large-scale successes in terms of long-term integration into people's everyday lives [8–10]. Wentzel & Pouris [8] identify four typical factors responsible for the low levels of implementation in solar cooking programs in South Africa: the quality of locally produced SCs; their high prices; the lack of availability of the product on the market; the requirement of specific cooking tools – e.g. a black painted pot – for optimal use of SC technology. These

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factors all point to issues that could be improved by 'getting the technology and the price right'. However, in this article we raise additional questions: Do the promised benefits of SCs not materialise because of technological issues, or are there other implementation problems? What are the intentions and methodologies employed by those implementing and studying solar cooking projects? And, to what extent do these studies and projects take existing cooking practices into account?

We attempt to address the conundrum of solar cooking through a critical literature review. The first objective of this review is to assess the benefits of solar cooking in the academic literature. The second objective is to delve deeper into these studies and projects to uncover their underlying assumptions and methodological choices. Following this literature assessment, two recurrent types of issues are recognized regarding the problem analysis and needs assessment in studies on SCs. The first type of issues concerns the conceptualization of problems and needs by researchers, for instance the understanding of a universal applicability of certain needs and the pro-innovation bias in the literature. The second type of issues relates to the methodologies used in the literature, of which the most striking example is the lack of impact studies that results in untested assumptions about ascribed benefits of SCs.

This article follows scholars such as Asinobi & Yemi [11], Beltramo & Levine [12], and Vanschoenwinkel et al. [13] who have criticised SCs for their limited capacity to cater for local cooking practices and traditions; the lack of evidence for reduction in fuelwood consumption; and the overestimated benefits in terms of time saving for women. But while these scholars draw on specific case studies of solar cooking, our article does so through a comprehensive critical literature review. This approach allows for a more systematic analysis of SCs, their benefits and problems, but also on the problems within the academic and grey literature in this field. Furthermore, it continues the debate started by Sovacool [14] who addresses questions such as: In what ways do discourses of energy and climate erase indigenous or alternative forms of knowledge, or hide the particular history or assumptions underlying them? Can technology designed to improve efficiency (especially for women) backfire when unaccompanied by broader social and cultural change? How can researchers minimize bias—their own, and that of their subjects—when doing research? Furthermore, it contributes to scholarly discussions on household dynamics influencing everyday consumption of energy [15,16] and on clean technology and development, particularly regarding the way projects and research are framed, and the assessment and analysis of 'local needs'. As solar cooking is important in the context of Sub-Saharan Africa, we join Hancock [17], Ulsrud et al. [18] and Haselip et al. [19] – in the ERSS special issue on energy for Sub-Saharan Africa (2015, vol. 5) – who show the need for close attention to the socio-cultural context and the challenges for the different stakeholders of pursuing solar-based energy solutions for household level cooking. Finally, this article aims to provide a useful review for development practitioners involved with SCs to recognize pitfalls and adjust their programs to ensure a better fit between their goals and the issues that matter from a local perspective.

This article is structured as follows. The methodology behind the literature review is described in section two. In the third part, some of the key reasons for the implementation of SCs in developmental contexts are elaborated. Finally, we suggest some theoretical and methodological approaches in which some of these conceptual and methodological issues in the current literature on solar cooking may be overcome.

2. Reviewing the literature

This article performs a critical review of the academic literature on solar cooking, with a specific focus on literature on Sub-Saharan Africa, where most solar cooking projects have been implemented. Rather than taking the literature at face value, this article performs a qualitative analysis of the methodologies and arguments used by the solar cooking researchers to develop critical perspective regarding the perceptions and possible biases.

The selection criteria for literature have been kept as open as possible to explore what has been written about solar cooking. First, keywords were selected based on a preliminary literature research with a focus on solar cooking in Sub-Saharan Africa, complemented with literature on solar cooking from other parts of the world to cross-reference issues not yet included. As such, the list of keywords was expanded with new keywords found in the literature using this snowball methodology.

The actual literature search was conducted in September 2015, through the use of the search engines Google Scholar, Web of Science and Scopus. The following keywords have been used in different combinations: acceptance, adoption, Africa, air pollution, cooking, cooker, deforestation, dynamics, environment, environmental impact, food, food safety, food security, forest, fuelwood, gender, health, household, household behaviour, household dynamics, household economics, impact, local perceptions, local needs, needs, preferences, roles, social practices, solar, solar cooker, solar oven, solar cooking, subjective needs, Sub-Saharan, universal needs, use, women, wood, wood fuel.

This literature research yielded 32 articles on solar cooking projects in Sub-Saharan Africa, covering a wide range of disciplinary perspectives (see Table 1). While occasionally reference is made to articles outside Sub-Saharan Africa, these were used for cross-checking issues and themes and have therefore been left out of the table. The methodological approach and the scope of the content of the literature has been analysed to identify the main topics related to solar cooking, and to study how the approach to solar cooking has been informed by certain perceptions and assumptions on solar cooking.

3. Reviewing the rationales for introducing solar cooking projects

We start by identifying the main rationale for introducing solar cooking projects, which can be grouped under four different themes: environment and energy (3.1); economic benefits (3.2); health benefits (3.3); and gender dynamics (3.4).

3.1. Environment and energy

Reviewing the studies conducted by different disciplines – most of which either have a technical, economic, or ecologic focus – leads to the identification of two main environmental impacts of SCs: the mitigation of deforestation, and the reduction of global pollution. In the last 40 years, SCs have been promoted by NGOs and international research institutions as a solution to implement low-cost and renewable energy in the context of poverty and energy resource scarcity [4,22,23]. In Sub-Saharan countries, energy derived from wood fuels covers 70% of the total household use, and this energy is mainly used for cooking practices [24,25]. The high dependence on wood as an energy source has led to the over-harvesting of wood, which created, according to some scholars and organisations, the so-called 'fuelwood crisis' in Africa [26,6,27,23]; World Bank in [28]. As Africa contributes, next to South America, the most to global deforestation [29], the introduction of SCs is seen as a way towards conservation and sustainability by scholars from different disciplinary backgrounds [30–32,28,33–35].

Global pollution as the result of using biomass as cooking fuel also features in the reviewed literature, because seven percent of all the worldwide greenhouse gas emissions – leading to potentially dangerous climate change effects – are emitted through the combustion of biomass [36,37]. Charcoal is, next to biomass, another main fuel source for cooking. Apart from the serious consequences of charcoal production regarding deforestation, the burning of charcoal produces a substantial amount of carbon monoxide. Charcoal as energy source is a relevant environmental issue as it is especially used in urban areas and, with

increased rates of urbanisation, the production and consumption of charcoal are likely to increase [38,35].

3.2. Economic benefits

While the environmental argument above is well-represented in the literature, the economic argument for using SCs is more applicable to the end-users [39–,41,35,42]. Households are expected to save money on fuel costs and reduce their dependency on wood by using SCs, sometimes by as much as 36% [39,43,44]. The money-saving aspect of the SC is said to be an important – if not the most important – motivational factor for adopting solar cooking at household scale, but also for government institutions and other organisations [45–47]. In their review of impact studies on SCs in South Africa, (Wentzel and Pouris [8][8]: 1911) state that "solar cookers were viewed as a mechanism to increase fuel security in low-income households and to broaden choice in terms of energy options available for cooking". Yet, 11 out of 32 studies highlight that families do not adopt SCs because they are too expensive compared to local income levels [7,48,11,49,43,40,50,51,8,52,53].

Two of the reviewed studies conclude that the costs and availability of conventional fuel alternatives in the area are important factors explaining the economic viability of solar cooking [32,47]. The prices of other fuel options such as kerosene, wood and charcoal are assumed to have a big influence on the adoption of SCs. Several authors compare fuel prices to determine whether there is an economic opportunity to introduce solar cooking [47]. Wentzel and Pouris [8] state that it is difficult to calculate (and thus foresee) savings arising from the use of SCs for the rural context of South Africa. Others, such as Beltramo and Levine [12] in their Randomized Control trial in Senegal on solar cookers (HotPot), found that there was no statistically significant reduction in wood consumption (and hence monetary expenditure) of the household. Thus, regarding the economic aspects of SC projects, Otte [45] concludes that the first step for anyone wanting to promote solar cooking is to carry out an assessment on the availability and price of alternative solid fuels (biomass) in potential target areas.

3.3. Health benefits

In five of the articles, SCs are regarded to be beneficial to the health of people who otherwise would cook with biomass fuels [54,55]. However, health is often mentioned as a 'side-benefit' while studies with a medical focus have not been found by us. Instead, the majority of the articles on SCs are published in journals related to energy issues. Out of 23 journal articles, 13 were published in energy journals (see Table 1). Most commonly cited health benefits of SC technology are the reduction of hazards related to gathering fuelwood, the reduction of health hazards due to increased energy security [56,8,51,2,57,43,50,45]; and the reduction of health hazards of indoor air pollution [58,59,6,56,8,40,55,60]. Indoor air pollution is one of the main health risks of 'traditional cooking' mentioned in the articles [61,62,41,45,63,40]. According to these articles, exposure to these pollutants can cause serious respiratory damage, cancer or any other smoke related disease.

Besides indoor air pollution, health risks of gathering fuelwood play a big role in the articles on SCs. Transporting fuelwood by head can lead to physical injuries and increase the risk of exposure to wild animal attacks, extreme weather conditions, back or foot injuries, rape, abduction and landmines [8,57,51,2]. While these health aspects are mentioned in the SC literature, a conclusive study with a medical focus is yet to be performed.

3.4. Gender dynamics

Six out of thirty articles on SC's in a Sub-Saharan context suggest that the use of fuelwood is affecting women and their health, as well as the health of other members of their household [62,41,45,63,40,61]. Men and women play different roles and have different tasks within their household system and culture; they have different needs, motivations and face different constraints [64]. This is why men and women are affected differently by resource scarcity. Additionally, the different daily tasks that men and women perform affect their power and ability to access resources [36]. That is why the asymmetrical burden of men and women and health risks associated with biofuel cooking is an important topic in the SC literature [41,61,65,62,33,34,66].

Women are said to carry most of the risks, because they commonly collect the firewood and are in most cases responsible for cooking. Sovacool [2] and Ki-Zerbo [43] mention that by carrying their children with them during the long hours of absence from their homes, women expose those children to the same health risks. In some areas, men are also involved in the collection of fuelwood, but usually as a supplementary source of income [43]. Generally, women and girls spend more time on gathering firewood than adult males and boys. In some cases, such as in Singida (Tanzania), women travel approximately 10 km to find firewood [2]. It can be said that on average, women in Africa have to travel every day more than 5 kilometres carrying around 20 kg of wood [2]. As the major part of the burden of energy and food provision is often on the women, most of the health risks associated with wood consumption affect women and their households [62,45,2,43,8,67].

Because of these health effects, women empowerment is a key aspect in the promotion of solar cooking projects [68,60,50,40,8,64]. The time saving aspect of SC is claimed to benefit them the most, as SC can save time and potentially require less active engagement. Researchers point out that more time can result in higher participation in schools and other activities; such as leisure, child care, social networking, and other domestic chores [8,64]. Finally, using clean and efficient strategies for cooking can also improve the economic contribution of women in society and, through that, improve their standard of living [40,50].

4. Discussing common issues in the solar cooking literature

In this section, we go beyond the rationales and benefits to focus on common issues in the solar cooking literature which may explain the SC's limited success in the field. This discussion is divided into four arguments. First, the literature on solar cooking does not always take local needs into consideration in the analysis of problems and impacts. Secondly, the SC as a solution is often imposed, while 'traditional' practices are ignored or even seen as obstacles. Third, there are some persistent and untested assumptions, weakening the link between the problem and the solution. Fourth, methodologically sound impact studies of an SC are scarce, making them difficult to base conclusions on and compare.

4.1. Consideration of local needs

The problems identified by development practitioners and scholars in the reviewed literature are not necessarily seen as problems for the intended end-users of the SC. The local view on problems and needs is scarcely analysed in academic literature. Of all articles reviewed that focus on SCs in Sub-Saharan Africa, five of these articles analyse the needs of local people from the point of view of the local people themselves [13,7,69,51,43]. In most of the literature, a 'need' or a 'problem' is framed independently from a specific case or context, and subsequently analysed as something that is universal. These problems and needs are then superimposed on all locales and applied to a specific target situation. Examples of such problems are the 'fuel wood crisis', 'indoor air pollution', and 'health hazards'.

The identification of problems to which the SC could be a solution is mainly done by governments and environmental organisations; in effect overruling people's perception [36]. Furthermore, in much of the literature reviewed, the concept of 'needs' is understood as being

universally applicable. Through such a conceptualisation, 'needs' is used as a means (or justification), to come to a problem analysis for intervention programs. A result of the abovementioned approach is that the existing cooking practices are often not taken into account when considering an intervention. Indeed, in many of these cases, SCs were not accepted as a feasible solution by the end-user [70].[1]

Non-acceptance of the SC can be the result of practical objections of the end-users. For example, whether a device has the capability to cook traditional dishes was considered as central to accept or decline the technology introduced [13,6,11,49]. The slowness of cooking with an SC is highlighted as a limiting factor when SCs are compared to cooking with wood or charcoal [6,11,53,49]. In addition, the capacity of the SCs is incompatible with the traditional family sized pots used in Burkina Faso [6,53] and Senegal [13,12]. Furthermore, in a practical sense, the traditional cooking practices cater to the need for flexibility in food provision: "it can be made anywhere, at any time" ([36][36]: 2804). Another example of non-acceptance of an SC concerns the replacement of wood as a resource for cooking. Several studies state that the fact that using wood as a source of fire has multiple practical and symbolic values is often not taken into account [71,50,70,55,72,65,51]. For example, besides providing food a woodfire provides light, warmth and facilitates social gathering [71]. Furthermore, SCs do not necessarily fit the daily pattern of cooking. Wilson and Green [50], for example, found that most women in the Maphephethe area (South Africa) prefer cooking at night over cooking in daylight when the sun is high (and useful for the SC).

SC projects and studies are often directed at women, because most of the benefits are assumed to pertain to this group. However, focussing solely on women neglects the important role of men. Only two studies explicitly explain why both the role of women and the role of men should be considered in the process of introduction of solar cookers; namely Rodgers [49] and Toonen [6]. Men and women have different daily tasks which they perform, but these are interrelated when it comes to relations of power and access to resources [36,43,50]. While women are the ones responsible for the cooking practices, it is the men who are often in charge of decision-making regarding these practices. For example, when it comes to household expenses and the use of new technologies in the household, men are often the ones who decide [36,43,50]. As a result, there are cases in which the adoption of solar cooking by African households created gender conflicts, resulting in negative rather than positive impacts on women [72,64,50]. These problems are also highlighted in the following quote:

> *"Some of the men who had attended the solar cooker building workshops said that they would not allow their wives to use the ovens [49]. In a similar vein, researchers based in Lesotho encountered resistance from the men in the community towards the introduction of solar cooking because they were concerned about what the women would do with their spare time. One man then suggested that the men 'could get more work out of their wives, since the solar cookers would reduce the time the women spent cooking'!*
>
> (Cited by Grundy & Grundy (1999):2 in Wilson & Green ([50]:60).

While the women may be the targeted beneficiaries of an SC, their husbands may in fact greatly influence the impact of the technology on the lives of their wives.

4.2. Changing local practices

In most studies in this review, existing local practices are seen as obstacles or as context within which the intervention should take place, rather than an object of study in itself [13,20,5,4,6,48,11,32,34,67,72,50,47,84,85], The extent to which the local practices are changed then becomes the object of study, captured in the concepts of adoption and acceptance.

Acceptance can be defined as the degree in which a new technology is integrated in people's view and culture. Influencing this integration, there are the perception of the technology's usefulness, easiness and the relation to subjective norms [86,87]. Adoption relates to the degree with which actors, in a complex decision making process, cognitively and emotionally accept – or not – a technology in their normal life and to which extent they integrate the use of it in their daily practice Rodgers, 2003. Between the two terms of adoption and acceptance, the commonality seems to be a 'key in a lock' idea of fitting a technology into a context; presupposing the lock, and the ability of the key to open the door. Interestingly, 13 of the 32 articles discuss the adoption and/or the acceptance of the SC by the target population [13,5,45,48,40,8,67,72,50,47,49,43,86], thus assuming the existence of a problem to which the SC is a solution while disregarding the point of view of the local people on what they actually identify as a need or problem. Consequently, there is a pro-innovation bias as the studies only analyse the appropriateness of the SC as a solution, rather than studying the local reality.

Nineteen of the articles in this review do not mention adoption or acceptance explicitly, even though they focus on the introduction of SCs in a local context. These studies are focused on the innovation instead of the local practice. In most studies, the acceptance of solar cooking technology is found to be low, because it requires radical adaptation of families' cooking habits and kitchen management [50,8,49]. In other words, it seems that solar cooking technologies are often not accepted because they do not respond to the cooking practices in specific contexts, and they are often perceived as not useful or difficult to use.

There are a number of studies that illustrate the need to look at context and cooking practices [13,7,69,51,43]. In countries such as Burkina Faso and Zimbabwe, it is shameful for a woman to not have a meal ready for an unexpected visitor [49] or not have enough food to offer [6]. These examples illustrates that the SC does not correspond with the notion of hospitality in certain contexts and cooking with fire remains the preferred cooking practice. According to Sesan [7], in some of the literature the local cooking practices are framed as unsustainable or problematic, while the perspective of local actors of these practices may differ greatly from this framing [70]. A study from Matinga [54] suggested that women perceived the assumed negative effects of the firewood gathering as normal. Asinobi and Yemi [11] present a contradicting finding with regard to time saving due to the use of SCs; they found that the SC is actually perceived as very time consuming. In addition, collecting firewood can have a social function as opposed to being a burden for women. And thus firewood collecting can be perceived as a social activity and not be regarded as a "waste of time". Hence, the technology may be regarded as irrelevant from a local perspective and may or may not gain social hold.

The majority of the studies emphasize the importance of education, trainings and illustrative workshops to convince users of the benefits of cooking with this new technology ([6,50,48,8], [53][53]; 101). Also, the level of education of a local actor is believed to be a reason for understanding the importance of the SC. Women who do not accept the use of an SC are referred to as "ignorant" ([53][53]: 72). A limitation of this reasoning is, however, that merely the exchange of information and education are considered to be enough for a person to adopt an innovation. These studies do not consider the social habits, socio-cultural perceptions and economic and infrastructural limitations that inform the adoption of SCs.

It seems that the reasoning of the majority of the reviewed literature focuses on 'how to fit SCs the best way in a society' without considering the needs of that society or a deeper analysis and reflection on how that technology fits into the socio-cultural context. Studies with a techno-logic approach outnumber the studies on SCs with an ethnographic or anthropological focus on practices and social habits. As a result, the

[1] Some recent studies recognize this problem. Otte [20,5] for example, shifts the focus from a "solution looking for a problem" approach to an approach in which the end-users' needs are considered first.

technology may be regarded as irrelevant from a local perspective and may or may not gain social hold. This comment illustrates that solar cooking is perceived as a solution for assumed problems, which are not necessarily supported by evidence. Moreover, most of these factors are not even known and are highly context-dependent; cultural and gender dynamics are different not only by country but by household and perceptions of problems and needs often have a 'Western' bias.

Even when these studies do present evidence to some of the assumptions, there is still an intervention, or pro-solution, bias [36,70,71]; this may influence the outcomes of these studies. Fourteen out of 32 studies in our literature review which focus on local practices and cooking habits are conducted against the backdrop of an intervention programme [13,20,5,4,6,48,11,32,34,67,72,50,47,84,85]. Being so connected to an intervention, these studies perpetuate a bias towards a certain predefined problem analysis and the assumed need and urgency of an improved way of cooking. Indeed, the researcher him or herself may be seen as a representative of future development projects which could influence the answers of participants in interviews or surveys [36]. Furthermore, by aligning the research with an intervention a pro-solution bias is likely, since the study is performed with the assumption of the need of a solution [71].

4.3. Assumptions and counter narratives

There are a number of methodological problems in the literature reviewed. Many statements are not backed up by empirical findings and can therefore be considered assumptions. The unquestioned reproduction of such assumptions in scholarly literature may create a false scientific validity of the benefits of SC. Furthermore, the arguments for the use and importance of a solar cooker regarding these impacts are often contested, and conflicting findings can be found in the literature. This section deals with these assumed impacts and the counter narratives that can be found in scholarly literature.

While SCs may be seen as a solution to the problem referred to as the 'fuelwood crisis', the link between this problem and the cause is debatable, as well as the link between this problem and the SC as the solution. Some scholars say the crises that occur regarding fuelwood are related to commercial (and illegal) logging, and thus introducing a device such as an SC will not solve these crises [73,74,26,75]. According to Hosonuma et al. [76], agricultural expansion is the main driver for deforestation in Africa, and fuelwood harvesting and charcoal production merely lead to forest degradation (not deforestation). Only when most forests have been converted into other types of land-use, fuelwood harvesting becomes more important due to high pressure on the last forest plots. In addition, fuelwood harvesting often occurs in forest areas that are already designated as new agricultural lands. Thus, there are some misconceptions concerning the linkage between fuelwood harvesting and deforestation, and, the potential importance of this linkage [74,36,26]. In these cases, introducing the SC to stop deforestation will not help.

According to Bielecki & Wingenbach [71] and Rhodes et al. [70] authors also make assumptions regarding local problems and needs without testing them explicitly. Furthermore, they do not refer to other studies to validate their assumptions or statements, nor do they reflect on the nature of their assumptions. Additionally, local problems are often depicted as homogenous problems that apply to the entire population, while in reality this may not be the case. For example, research found that men and women define the word benefit in different terms when asked. For men, the financial benefit is an important reason, while for women the extra time gained due to using SCs was described as an important benefit [45,64]. However, it cannot be automatically assumed that the free time that is generated by using an SC is used for other livelihood activities contributing to the economic improvement of the situation for the household. In addition, alternative income generated with the "free" time largely depends on the opportunities available to the women, and therefore depends "on the organisation of the household economy and the extent to which the household is linked to the wider economic network" [8,11].

4.4. Impact studies

There are not many impact studies to verify the assumed benefits of solar cooking: six of the 32 articles attempt to measure or analyse the impacts of the technology [12,33,48,8,67,52]. Despite the mention of health benefits of SCs as a reason to introduce the technology, only one article actually discusses the health impacts [12]. It should also be noted that some authors that write about health benefits of SCs (e.g. [45,4,63,77]) are not primarily concerned with the relation between health and solar cooking in their publications. The health benefits arising from the use of solar cooking are presented as fairly obvious but untested assumptions.

There is limited empirical evidence to back the assumptions on SCs. Several studies question whether SCs actually reduce health risks, or rather introduce new ones Kuhnke et. al. (1997) [61,12,78]. Also, there seems to be limited understanding of the impact of SCs on women's lives. Studies are paying almost no attention to the strategic energy needs of women and the impact of solar cooking in women's lives and their productive activities. Detailed and comprehensive descriptions of the process of enabling women empowerment are also lacking in the studies on solar cooking [69]. Similarly, literature addressing food quality or food characteristics in connection with solar cooking is scarce, despite several authors arguing that food quality is an important factor for local people whether or not to adopt a food-related technology [5,48,42,79].

5. Theoretical approaches to support SC studies

One of the key arguments of this article is that there is little understanding of the local reality of the target population before an intervention on solar cooking is performed or research projects defined. The last part of this article puts forward one theoretical approach and one methodological principle which may inspire researchers and practitioners to pursue different paths when it comes to research and implementation of SC projects and other projects involving 'new' technologies. Practice theory may be suitable for scholars, and ultimately policymakers, to understand what the practice of cooking actually entails in a certain context. Additionally, we argue that ethnographic methods can be used to study such local realities and provide a more comprehensive understanding from a local perspective.

5.1. A practice-theoretical lens on solar cooking

Practice theory provides a framework to ask new and different questions related to solar cooking, as compared to much of the literature reviewed in this article; it can be used to understand social change beyond individuals or specific technologies [80]. Social reality, from the lens of practice theory, is seen as a multitude of interconnected practices, which are constantly enacted and re-enacted in order to sustain them. We understand 'practice' in the way Reckwitz [81] defines it, as "a routinized type of behaviour which consists of several elements" and all these elements are interconnected to each other (p. 249). Put simply, the introduction of SCs interferes in certain routinized ways of cooking and may create new routines.

A practice-theoretical framework would reframe the discussions around SCs in a number of ways. First of all, it would put the 'practice' at the centre stage, rather than taking the technology or the people involved in using the technology as starting points.[2] For solar cooking,

[2] This does not mean that these practices are somehow at another 'level' than people. Rather, practices link the people, the technology (materials) they use, their skills and the meanings [21].

this means that the practice of cooking becomes the primary focus of study. An understanding of the existing practices regarding cooking can then be created through focused questions such as: What elements are involved in the practice of cooking? What kinds of technologies, meanings and skills, are involved? But also, how are cooking practices related to other practices and what social meanings are ascribed to these practices, such as fetching firewood and collecting water? [21]. In answering these questions, the likelihood of adopting/accepting SCs as an alternative cooking practice in a certain context can be assessed, while broadening the scope for other potential solutions.

Asking such questions would help to get a sense of what cooking really involves and how SCs and other outside influences interact with this practice. Furthermore, it could enable an understanding of what other social changes could be the result of the introduction of a technology such as solar cookers. It would almost certainly reveal that cooking is not something that can easily be changed through the introduction and explanation of a new technology only, since this is but one element of practice. In order for a practice theoretical approach to work, researchers or practitioners must be open to the idea that solar cooking might not be the best fit in all circumstances and that there may be other ways in which some of the aspired development benefits can be achieved. Or, in the words of Bourdieu ([82]: 86), "practice has a logic which is not that of the logician". Finally, it provides a critique on approaches which are focused on macro-level 'drivers', such as deforestation, and micro-level analyses of people's attitudes towards solar cooking. Instead, a more fine-grained mode of analysis is needed, for example using ethnographic methods.

5.2. Ethnographic methods to study local realities

Approaching solar cooking from a practice theory perspective does not only require asking different questions, but also to use different methods. Ethnographic methods may be helpful to collect the data required and overcome other biases in SC studies outlined above. One of the recurrent problems in the literature is the limited understanding of the context in the process of implementing SC technology. In 14 out of the 32 studies that analysed SC in Sub-Saharan Africa, the social meaning and practice of cooking and fuelwood is not studied as an intrinsically meaningful subject; rather these studies attempt to understand the local reality in terms of its relation to the SC itself [13,20,5,4,6,48,11,32,34,67,72,50,47,84,85]. Ethnographic methods, which aim to create holistic fieldwork-based insights in the lived experience of people in a certain area, allow for the recognition of social practices and for an understanding of the interlinkages between these practices in a certain social context [83]. Ethnographic studies can be used to understand how the cooking practices and the SCs – as objects of practice – form and reform social relations and thereby (re) create realities. Performing ethnography thus prevents the analysis on the practice of solar cooking from being based on an a priori defined framework. It rather takes the practice itself, its social role and meaning, and the logic of the people for performing that practice, as subject of study.

Simply put, ethnographic methods would start from the local reality, implicitly testing assumptions about aspects such as people's practices, health effects, and deforestation. Typically a researcher may spend an extended period of time within one or more places, employing a variety of methods, e.g. interviews, focus groups, and (participant) observation. Another important feature is for researchers to be reflexive and aware of potential biases in their framing of the research and interpretation of the results.

In combination with practice theory, ethnographic methods would open up a number of perspectives above and beyond the potential for SCs and their (perceived) immediate effects. In our literature review, five out of 32 articles were found using such ethnographic methods in a modest way [13,7,69,51,43]; these methods were used mostly to assess the adoption or acceptance of SCs by the target population. The article by Sesan [7] is a good example of a study that takes the social reality of rural households as starting point in assessing their needs and the (potential) role SC technology can play in their lives. If such aspects are not studied or misunderstood, projects may start based on erroneous assumptions and impacts may be misunderstood or left unobserved.

6. Conclusion

This article has shown that in the academic literature on SCs the problem analysis and needs assessments are often made from an external perspective. We have recognized two types of issues in which this perspective is revealed. The first issue relates to the conceptual position of the researchers; i.e. how development and reality are perceived by them. The literature regarding SCs tends to regard needs and problems as universal concepts, and consequently overlooks the local realities. In doing so, change is often imposed by external parties which regard contemporary cooking practices as obstacles that must be addressed in order to achieve development. Priorities that are identified by the proponents of SC technologies may thus not be recognized as such by the target population. Following this logic, the change that is intended by the intervention may not fit the local reality. Additionally, the arguments used by proponents regarding the positive effects of SCs often are coloured by a pro-innovation bias and only occasionally contested by other scholars. An example is the assumption that the use of an SC will allow women to engage in other economic activities, and that it will lead to a reduction in fuelwood consumption by households. However, our review shows that the links between the SC and its impacts are not systematically tested, and therefore may or may not be as strong as claimed.

The second issue relates to the methodologies that are applied (or not applied) in order to recognize the needs and problems regarding SCs. Much of the literature reviewed has a so-called 'solution bias', meaning that all needs and problems are seen in light of SC technology. Even when studies are performed on local practices, these are often carried out within the context of an intervention. Because there is a general absence of impact studies to empirically verify the assumptions, many of these assumptions remain untested. As a result, the link between the "problem" and the "solution" is also contested. The perspective on problems and needs is exacerbated by a lack of attention or recognition of the local realities. A typical example is the focus on gender needs; while the plea is to reinforce women's position, the role of men – as the flipside of the gender coin – is often ignored. Another example is the assumption of SC related health benefits which seem to be hardly tested.

While we do not want to offer strict guidelines, as this would run counter to our own arguments, we have argued that practice theory and ethnography can provide ways to remedy some of the issues flagged above. Practice theory approaches cooking from the logic of the practice itself, rather than from an external point of view, resulting in a study that is not based on a predefined framework; ethnography will allow for a focus on the local reality, from a methodological approach. Together, these approaches may inspire a different way of approaching solar cooking and other projects involving technology in a development context. This article serves as an invitation to develop new projects and additional approaches offering better analyses of problems, contexts and possible solutions closer to the local realities.

Fortunately, our article also shows that some of the more recent SC literature and projects start to think more carefully about the local realities and practices, such as the need to align with evening and early morning cooking practices, and a careful gendered approach which considers the roles of both women and men (Table 1). Such approaches, in addition to more longitudinal studies, adapted to each particular context, would provide a fruitful evidence base for the impact of solar-cooking necessary to achieve sustainable and long-term development benefits in the Global South.

Table 1
Literature reviewed for this article.

Author	Year	Journal	Key words	Methodology	Region	Findings
Achudume, A. C.	2009	Environment, Development and Sustainability	Fuel wood, Rural women, Environmental health, Development, Economic sustainability	Field surveys	Nigeria	Improved solar designs could provide adequate attention to the cultural (e.g., provision of food), social (e.g., time saving), ecological (e.g., revise deforestation) and economic (e.g., job opportunities significance) aspects of cooking. Local authorities could be expected to disseminate information on the use of different solar devices.
Afrane, G., & Ntiamoah, A.	2012	Applied Energy	Life-cycle assessment; Life-cycle costing; Cookstoves; Woodfuels; Emissions costing	Life-cycle costs and environmental impacts analysis	Ghana	Using traditional methods, firewood was found to be the cheapest, but most polluting cooking source. Solar energy provides an alternative sustainable solution due to high level of solar radiation. Regarding adoption of solar cookers, health impacts are more important drivers to developing countries than the global environment.
Anozie, A.N., Bakarea, A.R., Sonibarea, J.A., & Oyebisi, T.O.	2007	Energy	Cooking energy; Cost; Efficiency; Impact on air pollution; Policy	Policy analysis, energy cost calculation	Nigera	Fuel wood predominant rural energy source as it is cheapest. This has negative health and environmental impacts. Energy policies have had no impact.
Asinobi, C. O., & Yemi, I.	2008	N/A	Solar cooker, rural women, urban women, and attitude.	Trainings on SC; Interviews (N = 180)	Mali	Limiting factors for the adoption of SCs are: attitude, cooking time, large family, climate, and acquisition cost.
Beltramo, T. & Levine, D.I.	2013	Journal of Development Effectiveness	indoor air pollution; randomised controlled trial; improved stove; environment; acute respiratory illness	Phased Randomized Control Trial on solar ovens (HotPot) and impact study of the technology	Senegal	The capacity of the solar ovens is too small for the amount of people for who food has to be prepared. There is no statistically significantly lower fuel consumption, time spent collecting fuel, or time spent next to the cooking fire. No evidence that solar ovens reduced exposure to carbon monoxide or self-reported respiratory symptoms such as coughs and sore throats.
Biermann, E., Grupp, M. & Palmer, R.	1999	Solar Energy	N/A	Randomized Control trial, with 7 different cooking technologies.	South Africa	Overall fuel savings on household level were around 38% (gas (57%), wood (36%), and paraffin (33%). It takes 8 months to 5 years for the payment of a SC in installments. Indirect impacts on household economics might occur due to time-savings and subsequent pursuit of other income-generating activities.
Bond, T., Venkataraman, C., & Masera, O.	2004	Energy for Sustainable Development	N/A	Computer simulation of global emission based on estimations of residential biofuel usage	Sub-Saharan Africa	Pollution from residential use of bio-fuels in Sub-Saharan Africa could be mitigated with improved cooking technologies
Bugaje, I.M.	2006	Renewable and Sustainable Energy Reviews	Renewable energy; Sustainable development; Environment; Africa	Desk study	South Africa, Egypt, Mali, Nigeria	Africa has the potential to solve its energy crisis if infrastructural support can be provided for harnessing the abundant renewable resources in the continent.
Carmody, E. & Sarkar, S.	1997	Renewable and Sustainable Energy Reviews	N/A	Desk study	Sub-Saharan Africa	Limiting factors for adoption of SC are the initial investment costs and the cost and availability of conventional fuel alternatives. Local production of SCs may be a good solution.
Carmona N. E., & Michler, J. D.	2016	African Association of Agricultural Economists (AAAE)	Deforestation, Dietary Diversity, Field Experiment, Zambia	Comparative case study	Zambia	provisioning of solar cookers is cost effective and increases dietary diversity
Clancy, J.	2002	N/A	N/A	N/A	Africa	A broader defenition of household energy is needed to reach more sustainable energy inventions, and to include interlinkages with other sectors. Both men and women play an important role in household energy decisions.
Clancy, J. S., Skutsch, M., & Batchelor, S.	2002	N/A	Women's Empowerment; Energy technologies,; Biomass fuel	N/A	Africa	The energy dimensions, both of the poverty-gender nexus and the livelihoods analysis, have been poorly understood and, hence, their significance underestimated.
Clancy, J., & Dutta, S.	2005	N/A	N/A	N/A	Africa	The benefits to men and women in the project areas

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Table 1 *(continued)*

Author	Year	Journal	Key words	Methodology	Region	Findings
						include improved health and time savings for users of the energy efficient stoves, as well as relief from pressures caused by wood fuel shortage.
Cuce, E., & Cuce, P.M.	2013	Applied Energy	Solar cooker; Efficiency; Cooking power; PCM; Exergy	Literature review	Senegal	Maximum payback period of solar cookers is 2 years. Solar cooking technology is a key item in order to deal with deforestation and environmental pollution.
Edelstein, M., Pitchforth, E., Asres, G., Silverman, M., & Kulkarni, N.	2008	BMC International Health and Human Rights	N/A	single, administered questionnaire and interviews	Ethiopia	Eighty percent of rural women cook indoors using biomass fuel without ventilation. Rural women report two to three times more respiratory diseases in their children and in themselves compared to the other two groups. Once aware of adverse effects, women were willing to change cooking practices but were unable to afford cleaner fuels or improved stoves.
Goldemberg, J., Reddy, A.K., Smith, K.R., & Williams, R.H.	2000	United Nations Publications	Energy; development; technology; Environment; Health	Desk study	Africa	Technological options for rural energy, leapfrogging to new rungs on the energy ladder
Green, M.	2002	Agenda	N/A	Renewable energy project, interviews with female household heads	South Africa	In assessing a SC, women look at the benefits regarding the practice of cooking, while men look at the financial side. In the long term, both sexes benefit from shared responsibility, and from the adoption of a new technology and cooking activities. Besides empowering women, solar cookers also preserve the environment in that less wood is required for cooking.
Green, M. G.	2001	N/A	N/A	In-depth interviews and discussions	South Africa	While women are the ones who are mainly responsible for cooking and for the kitchen, it is men who make decisions when it comes to adoption of a new technology.
Harmim, A., Merzouk, M., Boukar, M., & Amar, M.	2014	Renewable and Sustainable Energy Reviews	Solar box cooker; double exposure; finned cooking vessel; non-tracking; building- integrated	Review on the development of different solar cooking technologies	Algeria	They came up with a solar cooker that stores thermal energy, and can be used in the winter − technical solution for the adaptation problem
Ki-Zerbo, J.	1981	Unasylva	N/A	N/A	Sahel	Apart from technical improvements of wood-burning stoves, it must be recognized that the human factor − in other words the housewife's talents play an absolutely determining role in conserving fuel.
Otte P. P.	2014	Energy Policy	Solar cooking; Mozambique; SCOT	Interview with 12 health institutions	Mozambique	SC considered useful for lunch preparation but less for dinner meals; limiting factors for adoption in health institution: weather dependency.
Otte, P.	2013	Energy Policy	Solar cooking; Developing countries; Social adoption	Literature review (practitioners and researchers), qualitative interviews (N = ?)	Sub-Saharan Africa	Variables that influence adoption: Economic (price affordability); Social (power and gender relationships); Cultural (food characteristics); Environment (availability of alternative fuels); Political (dissemination strategies); Technical (user friendliness).
Otte, P.	2009	(Book)	Solar Cooking; Capability Approach; Innovation Diffusion Theory; Energy	Interviews, participatory observation and text analysis (N = ?)	Tanzania	Limiting factors for the use of SCs: poor performance during rain season; economic affordability; enormous space of storage needed; high reflectance of the cooker; and the lack of infrastructure to spread the technology. Therefore, it is necessary to promote awareness on SCs among the intended users to promote its use.
Otte, P.P.	2014	Energy Research & Social Science	Solar cooking, culture, India, Burkina Faso	Semi-structured interviews with 6 institutions that had solar cookers installed.	India and Burkina Faso	Solar cooking proponents often address households, but tech could be applied beyond hh level (bakeries, shea nut butter producers, and kitchens); cultural factors can be constraints but also enablers for the social acceptance of solar cookers
Rodgers, P.M.	1994	N/A	N/A	SC workshops, interviews	Zimbabwe	Limiting factors for adoption of SC: 53% need for special

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Table 1 *(continued)*

Author	Year	Journal	Key words	Methodology	Region	Findings
				(N = 171)		equipment; 29% requires maintenance; 24% cooking takes too long, and 14% cooking at night is not possible. Furthermore: the relationship between needed change in lifestyle and radical benefit reported was unbalanced; materials are scarce and expensive; typical dishes are difficult to cook; SC is not fast enough to prepare a fast meal for visitors; goats break SCs; misinformation on its functioning; no subsidy; gender tug-of-war; multifunctionality of fire (insect repellent, warmth, safety, baking bread).
Sesan, T.	2012	Energy Policy	Energy poverty; Improved stoves; Appropriate technology	Interviews (N = 24)	Kenya	Solar CooKit was technologically appropriate for the local context, but it was not culturally (fit in living practices) and economically appropriate (cost related to income level). Therefore adoption of the technology was low.
Sovacool, B.K.	2012	Energy for Sustainable Development	Energy access Energy poverty Rural electrification	Literature review	Africa	Dependence on biomass for energy needs gives a series of cumulative negative social and environmental consequences. The barriers involved in facilitating access to modern energy are difficult to overcome without coordinated action, as they transcend technical, economic, political, and socio-cultural domains. The evidence in this review suggests that by targeting only one aspect of the current system, deeper political, cultural and social barriers may not be overcome.
Toonen, H.M.	2009	Physics and Chemistry of the Earth	Sustainable energy; Solar cooking; CooKit; Jatropha; Urban area; Burkina Faso	Participant observation, field visits, semi-structured interviews and surveys (N = 97)	Burkina Faso	Limiting factors for the use of SCs: 1) they do not respond to urban lifestyle requirements (fast cooking); 2) existing gender patterns have great influence on adoption (CooKit used mostly when the husband is not present); and 3) a pitfall of solar cooking is the high dependency on weather conditions.
Vanschoenwinkel, J., Lizin, S., Swinnen, G., Azadi, H., & Van Passel, S.	2014	Energy Policy	Nontraditional cookstoves; Product-specific preferences; Best–worst scaling	Best–worst scaling (BWS); questionnaires (N = 126)	Senegal	Adoption of SCs is influenced by programme factors, miscommunication, and product-specific factors.
Wentzel M., & Pouris A.	2007	Energy Policy	Household energy; Solar cooking; Developing impacts	questionnaires, observation, interviews and focus groups (N = 114)	South Africa	Motivation, promotion, and training are important factors in the adoption of SCs. Users experience savings in time and money. SCs should be understood as an 'add-on-solution' next to other cooking technologies and fuels.
Wilson, M., & Green, J. M.	2000	Journal of Family Ecology and Consumer Sciences	N/A	Local survey and SC project.	South Africa	Solar ovens were well received in the community. It is believed that this experiential learning is likely to be more beneficial than simply being told about the ovens and how they work.
Wilson, M., & Green, J.M	2009	Tydskrif vir Gesinsekologie en Verbruikerswetenskappe	N/A	Questionnaires, focus group discussions, demonstration of SC (N = 204)	South Africa	Factors influencing the adoption of SC: it requires changes in cooking habits; it needs to be seen as additional cooking tool and not as replacement; (un) willingness of local shop owners to stock the ovens; education.

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