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ORIGINAL ARTICLE

A multi-stakeholder perception analysis about the adoption, impacts and priority areas in the Kenyan clean cooking sector

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Abstract

Many stakeholders are involved in the Kenyan clean cooking sector, often having different perspectives, interests and agendas about the adoption, impacts and scaling-up of clean cooking interventions. Understanding the perceptions of non end-user stakeholders can enrich current debates about clean cooking options that are usually informed by rigorous, yet highly compartmentalized research. Through expert interviews, we elicit the perceptions of 27 stakeholder organizations involved in the clean cooking sector in Kenya. The analysis offers unique insights about the divergences and convergences of their perceptions regarding the key drivers, barriers, and impacts of clean cookstove adoption. Furthermore, it hints how such diverse perspectives can be mobilized to inform ways forward to enhance stove uptake and sustained use, eventually increasing the sustainability in the sector.

Keywords Stakeholders · Stove adoption · Sustainability impacts · Clean cookstoves

Introduction

The Sustainable Development Goal 7 (SDG7) advocates for universal access to affordable, reliable, and modern energy services, including clean cooking fuels and technologies (UN 2015). There have been long discussions about how to transition to a modern and reliable energy system in Sub-Saharan Africa (SSA) (Simon et al. 2014; Janssen and Dominik 2012). National debates have often focused on electrification, national grid development, and the appropriate mix of fuels for power generation (Owen et al. 2013; UNEP 2016). However, even though cooking energy dominates domestic energy demand in most SSA counties (World Bank 2017) there has been insufficient attention on how to modernize and enhance the sustainability of current cooking energy options (UNDP 2009). This is particularly pertinent considering that solid biomass (usually in the form of firewood, charcoal, dung, and agricultural waste) dominates cooking energy options in most countries, and accounts for the largest share of energy use from the domestic sector (GACC 2016; IEA 2017).

There is a broad consensus that replacing (or at least reducing the demand for) traditional biomass fuels and increasing the demand for clean/efficient cooking alternatives could have multiple positive sustainability impacts related to energy security, public health, women empowerment, and ecosystem conservation, among others (Karekezi et al. 2012; Anenberg et al. 2013; Mengistu et al. 2015; WHO 2016; UNEP 2017). While progress in the large-scale adoption of clean cooking options has been painfully slow in SSA, there is some evidence from countries such as Senegal and Ghana to suggest that accelerated change is possible (Karimu 2015; ECA and GLPGP 2017).

Kenya is one of the SSA countries where the large-scale adoption of clean cooking options has the potential to catalyse widespread sustainability transitions (IEA 2017;

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Karanja and Gasparatos 2019). Despite large economic growth, only 13% of Kenyans have access to clean cooking options such as LPG, electricity, solar and ethanol stoves (World Bank 2017). Approximately 42 million Kenyans still rely on traditional biomass fuels for cooking, with 30–40% of this population owning improved biomass stoves and the rest relying on rudimentary and traditional open fires for cooking (i.e. three stone fire) (Rosenbaum et al. 2015). The continuous reliance on traditional cooking energy is largely responsible for the lack of significant progress for meeting SDG7 in Kenya (GACC 2016).

Many reasons have contributed to this slow progress including low affordability/awareness/willingness to pay for clean cooking, easy access to free traditional fuels, last-mile distribution constraints, and cultural, technical, and environmental barriers (SE4ALL 2015; Loo et al. 2016; Shankar et al. 2015). Other macro-level challenges include financing gaps, and slow progress in the development of new cookstoves and fuel options (ESMAP 2015; Foster et al. 2015). This seems quite paradoxical considering that Kenya has a long-established and highly developed clean cookstove sector compared to other SSA countries (Karanja and Gasparatos 2019). Nonetheless, clean cooking is steadily gaining some traction in national policy (GoK 2014, 2015, 2017). The government has also committed to advance the clean cooking sector and helped formulate the Sustainable Energy for All Country Action Plan that seeks to promote clean cooking options to 7 million households by 2020 (GoK 2016). The international community is also boosting financing in the Kenyan clean cooking sector through various partnerships (GACC 2013, 2014; Winrock International 2017).

The above suggest that the clean cookstove sector is currently at a crossroads in Kenya. Despite the myriad of clean cooking options (both domestic and imported), their large-scale adoption and sustained use has been slow and marred with complications. Many different stakeholders are operating in the sector including stove manufacturers, government agencies, research institutes, civil society organizations, and international donors, among others (Karanja and Gasparatos 2019) (see "Methodology"). Even though these organizations hold the same goal of promoting clean cooking options in Kenya, they hold radically different perceptions and agendas of how to catalyze the large-scale adoption of clean cookstoves and improve the sustainability of the sector. This often results in uncoordinated and fragmented actions, which curtail the effective large-scale adoption of clean cooking options in the country (Johnson et al. 2016; Karanja and Gasparatos 2019).

This paper elicits the perceptions and insights of the main non end-user stakeholders involved in the Kenyan stove sector. Our focus on non end-user stakeholders reflects the scarcity of such studies compared to household-level studies on the determinants and impacts of stove adoption based on demographic and socioeconomic attributes such as income, age, gender and education (Silk et al. 2012; Rhodes et al. 2014; Sovacool et al. 2015; Sola et al. 2017). Many scholars have argued the importance of understanding the interests, agendas, and priorities of wider stakeholder groups involved in the clean stove sector, as they can influence significantly the adoption and scaling-up of clean cooking interventions (Rosenthal et al. 2018; Shankar and Onyura 2015; Sovacool et al. 2015; Lambe et al. 2015). Thus, by focusing solely on the perspectives of non end-user stakeholders, this paper complements previous studies from Kenya and other SSA countries, e.g. see Karanja and Gasparatos (2019) for an extensive review of the literature. In particular, we identify convergences and divergences in non end-user stakeholder perceptions, providing a holistic understanding of the main issues in the clean cookstove sector through the eyes of different actors, something that is missing in the rich, yet highly compartmentalized body of literature for Kenya. Our specific focus is on stakeholder perceptions about the adoption, impacts and priority areas to enable the large-scale adoption and sustained use of clean cooking options in Kenya, which is a pre-condition for enhancing the sustainability of the cooking sector.

Methodology

Research approach

The large-scale adoption and sustained use of clean cookstoves can have positive sustainability impacts at different scales (Karekezi et al. 2012; Mengistu et al. 2015; Drigo et al. 2015; WHO 2016; UNEP 2017). However, certain factors either favour or prevent clean stove adoption and sustained use, which is a pre-condition for the manifestation of most the positive sustainability impacts of clean stove (Sola et al. 2017; Olopade et al. 2017). Hence it is necessary to put in place actions to reinforce the factors that favour adoption and sustained use, and/or correct those that prevent it (Simon et al. 2014; Pilishvili et al. 2016). These three elements of drivers and barriers to adoption (see "Drivers and challenges of stove adoption"), sustainability impacts (see "Impacts of clean cooking adoption") and priority action areas (see "Priority areas") are the main thematic areas of this study as discussed below. The study has been informed from (and builds upon) an extensive literature review about the adoption and sustainability impacts of clean cookstoves in Kenya (Karanja and Gasparatos 2019).

According to Fig. 1, clean stove adoption and sustained use is affected by various factors related to stove demand, stove supply, stove characteristics, as well as some underlying policies and regulations. Even though supply and demand factors can influence stove adoption, they do not translate automatically to sustained stove use (Anenberg

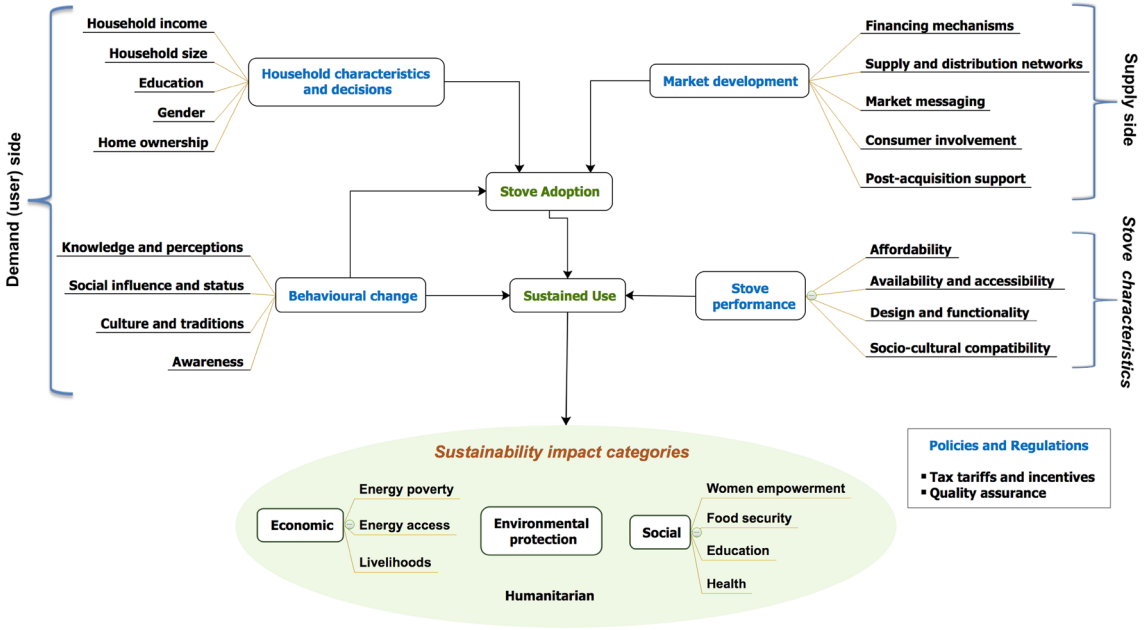

Fig. 1 Conceptual framework related to clean stove adoption and sustained use in Kenya (Adapted from Karanja and Gasparatos 2019)

et al. 2013; Lee et al. 2013; ESMAP 2015), which is a precondition for the manifestation of the positive sustainability impacts of clean cooking. Various stove characteristics related to costs, performance and cultural appropriateness mediate sustained stove use (Karanja and Gasparatos 2019). All these factors can act as drivers or barriers of stove adoption and sustained use in different contexts and are discussed throughout the section "Drivers and challenges of stove adoption".

The adoption and especially the sustained use of clean stoves can have many different sustainability impacts related to energy security, ecosystem conservation, human health, climate change mitigation and female empowerment, among others (see "Introduction") (Anenberg et al. 2013; Mengistu et al. 2015; ESMAP 2015). Many studies have quantified individual impacts and the mechanisms through which they manifest (Bailis et al. 2003, 2015; Lee et al. 2013; Olopade et al. 2017; Smith et al. 2017). In this study, rather than quantifying the impacts through the eyes of stakeholders, we instead capture which of them are most commonly evoked and/or perceived as the most important. This allows the identification of which impacts can act as a meeting point between stakeholders, forging consensus and facilitating the way forward (see "Impacts of clean cooking adoption").

To unlock the full potential of clean cooking in improving sustainability and enabling sustainability transitions in the household sector, it is important to reinforce the factors that drive the large-scale stove adoption and sustained use and suppress the factors that act as barriers. However, due to the many interlinked activities within the stove sector it is not easy to pinpoint a single priority area as having the largest potential. Instead, we use stakeholder perceptions to identify a range of priority target areas that can catalyze the large-scale stove adoption and sustained use (see "Priority areas").

Data collection and analysis

We use the conceptual framework outlined above to guide data collection and analysis, as well as to systematize the perceptions of key stakeholders in the clean stove sector. We use primary data collected through expert interviews that were conducted with the main non end-user stakeholders actively involved in the Kenyan clean cookstove sector. These organizations were identified through an extensive institutional analysis of the clean cookstove sector in Kenya (Karanja and Gasparatos 2019).

We selected institutions that are heavily involved in different aspects of the clean stove sector, without being actual clean stove users. By heavily involved, we refer to organizations that play a leading role in the different activities within the sector ranging from stove manufacture, to stove dissemination, consumer education, policy formulation, and funding provision, among others. Within each organization we identified respondents that were highly engaged in clean cookstove activities in a senior capacity, and thus have a good understanding of the organizations' activities, from strategy to implementation. Targeting experienced participants ensured the elicitation of rich information on how the

Table 1 Description of interviewed stakeholders

	Organisation	Department	Affiliation	Reference code
Academia and research	Kenya Forest Research Institute	Forest products development (bioenergy utilization)	Senior Researcher	KEFRI
	Stockholm Environment Institute	Household energy	Research Associate	SEI
	The University of Nairobi	Chemistry	Director/Professor	UoN
	Jaramogi Oginga Odinga University	Centre for research, innovation and technology	Director/Professor	CRIT
	Maasai Mara University	Forestry and wildlife	Professor	MMU
Government	Ministry of Energy	Renewable energy	Director	MoE
	Ministry of Public Service, Gender and Youth Affairs	Gender affairs	gender officer	MoGYA
	National Environment Management Authority	Environmental planning and research coordination	Climate change coordinator	NEMA
	Kenya Forest Service	Forest management and conservation	Ecosystem conservator	KFS
	Ministry of Health	Public health	Deputy director	MoH
	Ministry of Agriculture	Home economics unit	Head officer	MoA
Private Sector	AFRISOL Ltd	Management	CEO	AFRISOL
	Sustainable Energy Strategies	Management	CEO	SES
	Burn Manufacturing Ltd	Management	Founder	BML
	Devaletech Ltd	Management	Founder	DVL
	MotoPoa Limited	Management	CEO	MPL
	ECO_2Librium	Stove for Life project	general manager	ECO2
	Equity Bank	EcoMoto loan program	Financial advisor	EB
Donors and international organisations	SNV Netherlands	Global energy sector	Sector lead	SNV
	German Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	Energy development programme (EnDev)	Programme manager	GIZ-1
	German Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	Energy development programme (EnDev)	Cluster Manager, Western Kenya	GIZ-2
	The International Fund for Agricultural Development	Mt. Kenya East Project	Desk officer	IFAD
Non-governmental Organisations (NGOs)	Practical Action Consulting (East Africa)	Sustainable Energy Access	Project manager	PAC
	Clean Cooking Alliance	East African region office	Regional representative	GACC
	Kenya Climate Innovation Centre	Corporate services	CEO	KCIC
	Clean Cooking Association of Kenya	Management	CEO	CCAK
	Kenya National Biogas Development Program	Management	Programme coordinator	KNBDP
	New Improved Stoves Association of Kenya	Management	Executive secretary	ISAK

different organizations view and approach activities in the clean stove sector.

Overall, we performed interviews with 27 organizations grouped into five main categories: (a) government agencies ($n=6$); (b) non-government organizations (NGOs) ($n=6$) (c) donors and international development organizations ($n=3$) (d) private sector ($n=7$), and (e) research organizations and academia ($n=5$). Respondents were mostly senior within their respective organization's (Table 1).

Note: We include two respondents from GIZ as they work at different scales. GIZ1 is involved heavily in the national clean stove discussions, while GIZ2 works directly with local communities. We have not double counted their responses in the analysis presented throughout this study.

The overall themes of the interview elicited the (a) drivers and barriers of clean cooking adoption; (b) impacts of adoption (both positive and negative); (c) national market trends, pitfalls and way forward towards universal access to clean cooking by 2030. The main thematic components of the questionnaire were structured along this order to link responses directly to the conceptual to the conceptual framework outlined above.

Each respondent was required to reflect the position of their organization, rather than their personal opinion. As the purpose of this survey was to capture the width of the perceptions of these stakeholders, the actual questions (not thematic areas, see above), were semi-structured and open-ended. Thus, respondents were allowed to elaborate freely on their answers, and occasionally we used follow-up probes to elicit, systematically but flexibly, the stakeholders' opinions and experience. In particular through repeated questions we asked stakeholders to discuss all the different drivers/barriers and impacts of clean cooking adoption they are aware of, and subsequently to identify the most important (see "Discussion").

Most interviews were conducted in person ($n = 25$) at the participant's venue of choice, but due to logistical issues some interviews were conducted through phone/Skype ($n = 3$). Each interview lasted 30–45 min and was audio-recorded with the participant's consent. All interviews were conducted between July–December 2016.

Each interview was transcribed verbatim for further analysis through NVivo, a computer assisted qualitative data analysis software. Responses were classified, coded and code categories were generated as appropriate. We used an inductive content analysis approach to identify the main themes. These themes were informed through an extensive literature review on the state, adoption, impacts and policy instruments in the clean cooking sector in Kenya (Karanja and Gasparatos 2019), and were complemented from other similar reviews and meta-analyses (e.g. Debbi et al. 2014; Puzzollo et al. 2016). They largely reflect the components and logic of the conceptual framework outlined above (Fig. 1).

Results

Drivers and challenges of stove adoption

Demand-side factors

The interviews identified a series of demand-side factors that affect stove adoption, namely (a) household characteristics and decisions; (b) awareness and behavioral change; (c) social influence and status.

Regarding (a), some stakeholders indicated that clean cookstove technology designers and programme implementers often over-simplify or inaccurately abstract the role of household characteristics and social complexities of rural life for stove adoption (personal comm: SEI; IFAD). For instance, women are likely to be the main "audience" of many efforts/activities to increase the awareness of (and enhance demand for) clean cooking options (personal comm: CCAK; MoGYA). However, as males often make household decisions regarding expenditures and budget allocation, investing in a new clean stoves seldom becomes a priority (personal comm: MoE; ECO2; GIZ-2). Such abstractions and over-simplifications may in turn lead to misconceptions about the target market segments (i.e. women) including who has the purchasing power in households. Regarding (b), multiple stakeholders identified awareness as a major driver and barrier of clean cooking adoption as it is often the first step to any action and progress (personal comm: MoH; MOGYA; MoE; MoA; BML; DVL; AFRISOL; SES; CCAK; GACC; KCIC; NEMA; IFAD; GIZ1; SEI; CRIT; UoN; KEFRI; MMU). Many potential clean cookstove users in Kenya are either completely unaware of alternative cooking technologies (i.e. do not know their existence) or are ignorant about their operation, intended benefits and personal relevance to them (personal comm: GACC; MoE; MoA).

Consumer behaviour was perceived as a complex and yet difficult factor to catalyse new cooking practices and habits because clean cookstoves typically operate differently compared to the traditional biomass stoves (personal comm: CCAK; SNV; PAC). Adopting one of the many different cooking options available in the market would require a significant shift in cooking practices and overall user behaviour change, which is not to be underestimated until the new stove becomes part of the daily household routine (personal comm: SNV; ISAK; CRIT). This for example could require the adaptation of recipes and the development of new cooking habits to make the most of the new stove (personal comm: ISAK; UoN). The critical role of consumer education on stove usability and kitchen management (e.g. ventilation, positioning of fuel/cooking pot, fuel management) is also particularly important (personal comm: MoGYA; KCIC; MMU). One stakeholder highlighted how in some areas development agencies disseminated stoves freely without explaining their benefits or mode of usage, resulting in the beneficiaries simply discarding them (personal comm: IFAD).

Regarding (c) as will be discussed at a later section, costs and good stove performance is important for their sustained adoption. Consumers use mainly social networks such as women groups or Savings and Credit Cooperatives Societies (SACCOs) to learn about product functionality, recommend good products, and raise grievances about bad product performance (personal comm: MoGYA; ISAK; KENDBP).

Bad product experiences can, more often than not, result to negative messaging, which can hurt substantially adoption, especially in close-knit communities (personal comm: ISAK; GIZ-2). Such networks can also facilitate the adoption by spreading experiences/comparisons (e.g. clean kitchen walls due to clean stoves compared to black walls due to traditional cooking). In this sense, social networks can forge immensely social acceptability that can either facilitate stove adoption or pose a major barrier (personal comm: GIZ-2; SEI; BML). Finally, some respondents asserted that clean cooking often conveys modernity, wealth, or sophistication, all of which can elevate the social status of adopting households (personal comm: GACC; SNV). In some cases, such social status or aspirational goals might be as important (or even more important) than the more tangible benefits of smoke reduction or cost savings.

Supply-side factors

The respondents evoked various drivers and barriers of stove adoption related to the supply side including (a) community involvement and post-acquisition support; (b) market messaging; (c) supply and distribution networks; (d) business financing mechanisms; and (e) consumer finance mechanisms. Regarding (a) understanding of consumer preferences, constraints and behaviour, can influence the design of clean cooking products and interventions. Stakeholders asserted that central to achieving the objectives of clean cooking interventions is preventing or solving mismatches between the capabilities of local communities and the characteristics/functionalities of new technologies (personal comm: SNV; GIZ-2). It was suggested that clean stove dissemination programs actually focus on the technology itself, failing to achieve the active user participation and understand the local context (personal comm: GIZ-1).

Stove manufactures and innovators should involve consumers (particularly during stove design) to facilitate the development of stoves that meet local needs and preferences (personal comm: CRIT; UoN). In particular, women involvement is critical as they are typically the primary stove users, and often command a significant knowledge about local conditions and resources (personal comm: MoGYA; SEI). Some stakeholders quoted regularly a study commissioned by GACC (Shankar et al. 2015), which identified that if/when equipped with the same entrepreneurial training, females have a better capacity to sell clean cookstoves than males (e.g. SEI; KCIC; UoN). Similarly, as women tend to sell stoves to other women, they are more likely to report consistent/correct cookstove use and clean cookstove benefits (personal comm: SEI).

Respondents also stressed that there is a need for an iterative approach to stove promotion that should not end with clean cookstove acquisition (personal comm: GIZ-2; KCIC). Thus, an extra challenge in the cookstoves market is to not only stimulate demand for the initial sale, but also to maintain interest in the product throughout its lifetime (personal comm: BML). To achieve this product manufacturers and distributors should identify cost-effective ways and feedback mechanisms for engaging with customers (both existing and new) (personal comm: SEI; CCAK; GACC).[1]

Regarding (b) strategies to generate stove demand vary across target markets due to regional differences in fuel resources, taste preferences, and other cultural factors (see below). Tailoring stove promotion messages to such a dynamic set of circumstances is integral to scaling up clean cookstoves adoption (personal comm: KCIC; GACC; BML). When considering consumer psychology, it might be better to advertise clean stoves as modern, healthy, attractive, and something that everyone *'must have'* (personal comm: BML). This is because some of the tangible positive impacts of clean stoves such as climate change mitigation, health improvement, and environment conservation are still abstract for many Kenyans (personal comm: CCAK; GIZ-1; UoN). The effects of indoor air pollution on health could be the easiest and more straightforward to communicate (personal comm: CCAK; MoH). Sensitization messages should focus on easy to comprehend messages such as that 14,000 people die prematurely every year in Kenya due to indoor air pollution, or as one respondent aptly expressed: "…*let them hear the figures to visualize the impact and instill their confidence in the efficacy of the product"* (personal comm: MoH).

It is also important to channel effectively this information to resonate to consumers' needs and utilizes creative marketing tools such as social marketing (e.g. SACCOs, women groups) (personal comm: CCAK; BML). Collaborating with recognized consumer brands that inspire consumer confidence, trust and willingness to buy clean stoves might allow this (personal comm: GACC). Important enablers to strengthen marketing outreach would be to mobilize (a) community leaders (e.g. chiefs, religious leaders) (b) local administrators, and (c) cultural icons (e.g. popular musicians and television programs) (personal comm: GACC; BML; MoE).

Regarding (c), poor clean stove/fuel distribution models can increase prices and reduce availability. Improving distribution networks can encourage distributors and

[1] The Founder of Burn Manufacturing outlined that their success lies in fostering consumer loyalty, establishing customer relationships, and building trusting relationship for the longer-term support. He stated that: "… *we often check in with our customers 6 months after purchase to measure their initial satisfaction with the stove and ask them about their usage. …we also encourage repeat purchase behaviour if their stove is at the end of its useful life, we can send them SMS messages about our latest products and may offer them a purchase discount"* (personal comm: BML).

manufacturers to roll out their products to more markets and local distribution centres (personal comm: DVL; BML; MPL). For many low-income customers, lack of infrastructure (e.g. lack of road access and formal addresses), and large distance from city centers, is a reality that hinders the adoption of clean cooking options (personal comm: BML). This often complicates the last mile distribution of clean cooking options (such as LPG and pellets) contributing to unpredictable fuel supply, whereas other non-clean fuel such as kerosene is easily available (personal comm: BML; CCAK). As a result, the ever-growing number of LPG marketing companies is concentrated in urban areas where the market is already fully developed, the distribution infrastructure is established, and the overall market risks are low (personal comm: KCIC). For exactly the same reasons the LPG market remains untapped and underdeveloped in rural settings (personal comm: MoE; DVL).

Some respondents advocated that investors can take advantage of the widespread adoption of mobile money payment methods in Kenya to increase the convenience of their services (personal comm: CCAK; GACC; PAC; ISAK). For instance, the PayGo Energy system enables access to LPG by providing a smart meter and a pay-as-you-go service through mobile money to tackle last mile delivery challenges (personal comm: CCAK; UoN). With the PayGo smart metering system, consumers are able to conveniently prepay for small amounts of cooking fuel based on their disposable income at the time (personal comm: CCAK).

Regarding (d) funding availability often constraints the development of innovative clean cooking options and hinders the growth of many clean cooking enterprises (personal comm: GACC; E-bank). Many traditional financial institutions do not understand well the viability of clean cooking investments viability or the underlying business models (which are sometimes still new in the market) (personal comm: GACC; AFRISOL; SES). In addition, few investors are prepared to support companies at their early stages, particularly those in unproven markets such as clean cooking (personal comm: BML; MPL; DVL). The current funding options in Kenya can act both as drivers or barriers depending on the ability of companies to meet their requirements.

Regarding (e), innovative funding strategies can curb such funding constraints to consumers (personal comm: GACC). For instance, the CEO of Sustainable Energy Strategies Ltd. commented that for about 95% of their installed biogas units, the company has to work with micro-finance institutions to help those who cannot afford the high upfront costs (personal comm: SES). Offering micro-credit opportunities and longer payment periods could actually be more effective than giving out free stoves (personal comm: SEI; SNV; UoN). Some stakeholders mentioned the benefits of such initiatives, and particularly the partnership between Equity Bank and Micro-Energy Credits (MEC) that provided clean energy financing for end-users through its *EcoMoto* Loan (personal comm: E-bank; MPL; KCIC).[2]

Stove design and performance

Overall a series of stove and fuel characteristics and performance mediate adoption and sustained use. The main themes related to (a) affordability, accessibility and availability; (b) stove design, functionality and performance; and (c) sociocultural compatibility.

Regarding (a), the upfront cost for clean cookstoves are not only high for consumers at the bottom of the energy pyramid but does not often align with their generally unstable income characterised by multiple, variable and informal income streams.[3] For such income groups, clean cookstoves essentially become unreachable, as they often compete with food and other household basic necessities (personal comm: MoGYA; CCAK; BML; E-bank). This makes many consumers reluctant to adopt for the fear that it might take a very long time to recuperate the investment without any added incentive beyond fuel cost savings (personal comm: MPL). Furthermore, an added barrier for some stove types are extra and recurring costs (e.g. pellets, LPG) (personal comm: MoE; CCAK). For instance, the upfront cost of a complete set of a 6 kg LPG cylinder and a burner is USD 45–60 (and requires periodic refilling depending on use patterns), but there could be potential for adoption and sustained use in rural areas if dispensed in small portions (e.g. through licensed distributors and retailers) and at affordable prices (personal comm: MoE; MoA; SEI). On the other hand, even when accessible, the high and variable costs associated with electricity were cited as major barriers of adoption (personal comm: SEI; CCAK; KCIC).

Regarding (b), cookstove design can affect the its overall quality and functionality, contributing significantly in their adoption and long-term sustained acceptance (personal comm: GACC; UoN). In this regard, there is a significant

[2] Through a USAID-funded project ["Developing a Sustainable Cookstove Sector" (DSCS)], Winrock supported the expansion of this program to sell improved cookstove products through Equity Bank branches and retail shops, offering improved charcoal cookstoves from Burn Manufacturing, EcoZoom and Envirofit (personal comm: E-bank;BML). By 2017 more than 11,500 improved cookstoves were sold through cash and loan sales. With its mobile lending tool, the program possibly reached more potential customers with affordable loans for clean cookstoves (personal comm: E-bank).

[3] There is large variation in the upfront costs of clean cooking options. For example, in rural Kenya the average cost for an advanced biomass stove is about USD 40 (personal comm: GIZ-1;BML), while for a biogas installation USD 1000–1500 depending on bio-digester capacity (personal comm: SES;MPL).

mismatch in rural areas between products and market, which prevents mass adoption (personal comm: MoA; BML). Design quality and good performance are often related/associated with convenience, ease of use and appealing appearance (personal comm: BML; GACC). Stove design is often critical for enhancing convenience and meeting user needs, e.g. by allowing the preparation of local dishes and compatibility with traditional cooking utensils (personal comm: MoA). Furthermore, households also value convenient stove designs that have added functions, such as space heating, portability for outdoor cooking, easy ignition, and the ability to hold larger/multiple cooking pots (personal comm: MoA; CCAK; SEI). Women (who are the most common stove buyers) also tend to value highly appearance and aesthetic appeal (e.g. modern and attractive appearance including stove colors) (personal comm: MoE; BML). Conversely, poor design such as inconvenient size, instability, failure to accommodate specific cooking styles and lack of versatility in fuel use can be significant barrier of stove adoption and sustained use (personal comm: BML; ECO2; SEI; UoN). Although some of cookstove types may be efficient, they might cook very slowly (e.g. ethanol stoves) (personal comm: MoE; CCAK), which may limit the type of dishes that can be cooked, reducing thus their appeal to some consumers (personal comm: MoA).

Regarding (c), stove adoption and sustained use in rural Kenya is often affected by local capabilities, tastes and preferences. There is a relationship between stove types and the type of traditional dishes that can be cooked (personal comm: CRIT). For instance, kneading and mashing *ugali* (a common dish in Kenyan households) require a strong and stable stove, especially when cooking for large families (personal comm: GIZ-1; GIZ-2). Many other cultural practices related to taste and health can deterring stove adoption and sustained use, including smoke utilization as insect repellent (personal comm: MMU), perceived health benefits through exposure to smoke (personal comm: SES), and taste preference for smoky food (personal comm: MoA).

Underlying policies and regulations

Tax incentives and tariffs are major underlying policies affecting stove adoption and sustained use as they permeate multiple aspects discussed above. Some respondents lauded the Kenyan government for taking steps in the 2016–2017 budget to reduce import duties for improved cookstoves (from 25 to 10%) and not placing a VAT on clean cookstoves, raw materials, and their accessories (personal comm: GACC; CCAK; PAC; MoE; CRIT; BML). The budget proposal also enforced a zero VAT on clean cookstoves, in an effort to make the cooking technologies more affordable. Furthermore, the Kenyan government announced the removal of the 16% VAT on LPG and increased kerosene costs by Kshs 7.20 (USD 0.07) to disincentive its use while at the same time incentivizing the adoption of cleaner cooking fuels (personal comm: CCAK). Similarly, in the 2015–2016 budget the excise duty for imported ethanol gel was set to zero.

However, many domestic stove manufacturers and assemblers still face difficulties (personal comm: BML; DVL). Stakeholders (especially from the private sector) lamented that the government strategic tariff increases for raw materials from the US and decreases for Chinese imports (personal comm: BML). Due to these circumstances, the use of subpar material for stove production has taken a toll on stove quality, affecting both stove sales but also brand/product reputation (personal comm: BML, DVL, CCAK).

Quality assurance mechanisms are underlying regulatory factors that can facilitate stove adoption through ensuring improved stove performance (personal comm: AFRISOL; MoE; MoH; GACC). These mechanisms include stove standards, quality control and enforcement mechanisms when rolling out new cooking technologies at a large-scale (personal comm: AFRISOL; MoE; SEI; UoN). Implementing verifiable and replicable stove standards and management systems is important for both the technical and operational sides of cookstoves supply and demand (personal comm: MoE; KCIC; PAC). Reliable testing procedures and quality assurance at source are critical (personal comm: GACC; CCAK; PAC; MoH). However current standards are either incomplete or only regulate stove sales in supermarkets, which is a small fraction of the stove market (personal comm: MoE; CCAK; UoN).[4] Furthermore, many of the stove products entering the market need to be subjected to systematic performance and quality evaluation (personal comm: GACC; MMU; SEI). Labelling after installation (to identify and blacklist counterfeits) or rating can provide useful information and build consumer trust having a positive effect on adoption (personal comm: CCAK).

Synthesis of perceptions

Figure 2 synthesizes the main drivers and barriers of clean cooking adoption alluded by the different stakeholders as outlined in the previous sub-sections. As expected, there is some variation between stakeholder groups about specific drivers and barriers, reflecting to some extent their unique interests and role in the clean cooking value chain (Fig. 2).

[4] The Kenya Bureau of Standards (KEBS) developed in 2005 household stove standards (KS 1814–1:2005). These standards currently address thermal efficiency, durability and the testing approach, but not the volume of toxic emissions (GoK 2013a). Similarly, the KS 2520:2013 has established parameters to ensure the efficiency, safety, and durability of biogas stoves and digesters installed in Kenya (GoK 2013b).

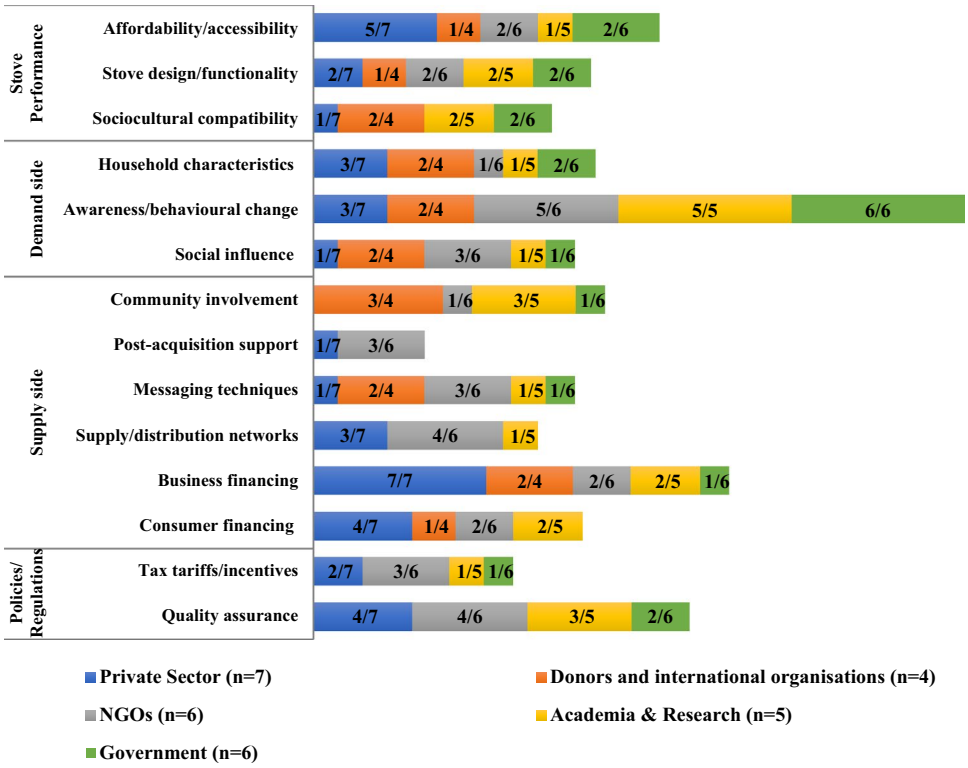

Fig. 2 Perception about drivers and barriers of clean cooking adoption in Kenya

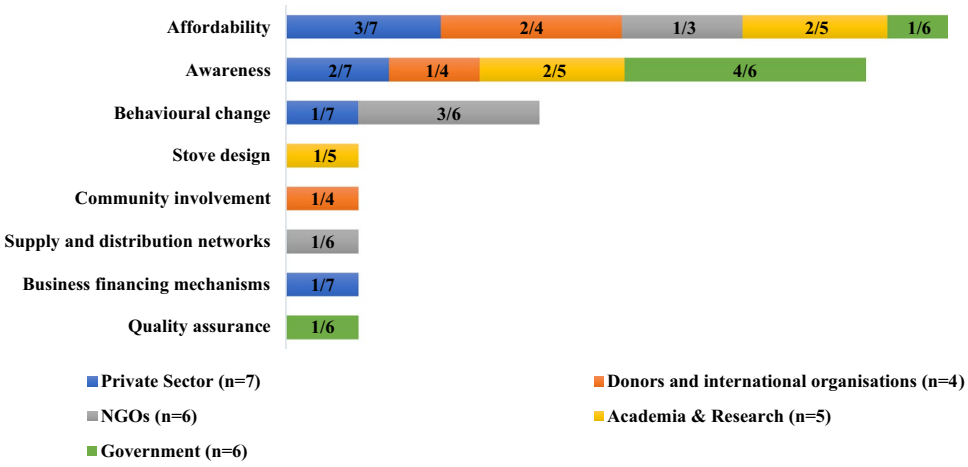

Fig. 3 Perception about the most important drivers and barriers of clean cooking in Kenya

For example, stakeholders from the private sector tend to mention more consistently issues related to stove/fuel affordability and business financing, while stakeholder from government, academia/research and NGOs focus more on issues related to awareness and behavioral change (Fig. 2). Donors and international development organization's strongly highlight community involvement and participation in stove development (Fig. 2).

However, despite this variation in perceptions about the drivers and barriers of clean cooking adoption, there is a large degree of consensus about what stakeholders consider as ***the most important*** barrier or drivers. By far stove affordability ($n = 10$) and awareness ($n = 9$) were identified as the most important factors, mentioned by practically all stakeholder groups (Fig. 3). The other top-ranked barriers/drivers reflect again the specific roles of some stakeholders within the clean cooking sector and include: (a) behavioral change (3 NGO and 1 private sector stakeholders) (b) reliable supply/distribution networks (1 NGO stakeholder) (c) business financing mechanisms (1 private sector stakeholder) (d) stove design (1 academia/research stakeholder) (e) community involvement

Table 2 Stakeholder perceptions about the sustainability impacts and impact mechanisms of clean cooking adoption

Impacts	Impact mechanism	Stakeholder citation
Energy access and energy poverty	Facilitate access to affordable and dependable cooking technologies and fuels which: reduce household energy poverty, especially for vulnerable households **(household level)** contribute to a transition to a renewable and sustainable energy system for the household sector (**national/regional level**)	BML; GACC; PAC; SNV; GIZ-1; MoH; MoGYA; GACC; PAC; AFRISOL; BML MoE; NEMA
	Curb or totally diminish fuelwood demand and its high recurring costs (especially in areas of fuelwood scarcity)	BML; MoE; KEFRI; KFS; GIZ-1; MoA; KEFRI; CCAK
	Deliver modern energy services in rural areas and increase easy access to modern energy markets	MoE; MoH; GACC; SEI
Environmental protection	Alleviate the pressure on the forest resources and ecosystems exerted by unsustainable fuelwood harvesting, which is a major cause of deforestation and land degradation	KEFRI; NEMA; UoN; CCAK; GACC; SNV; SEI; KFS; IFAD; NEMA; MoE; KEFRI; CRIT
	Reduce the high GHG emissions associated with traditional methods of charcoal cooking and production (e.g. inefficient kilns)	KEFRI; KFS; KEFRI; NEMA; IFAD
Health	Reduce the likelihood of negative health impacts associated with traditional cooking methods related to: respiratory and other health complications from indoor air pollution; drudgery from carrying heavy firewood loads injury and sexual assault from spending substantial time outdoors burns (e.g. little children falling in open fires) poisoning (e.g. from kerosene stored in soft beverage bottles)	MoH; MOGYA; MoE; MoA; BML; DVL; AFRISOL; SES; CCAK; GACC; KCIC; NEMA; IFAD; GIZ-1; SEI; CRIT; UoN; KEFRI; MMU' GIZ-2; SNV; ISAK; MPL
Livelihoods	Reduce recurring fuelwood costs, with the monetary savings invested to improve household productive capacity (e.g. invest in income-generating activities)	UoN; KEFRI; GIZ-1; MoE; BML; SEI; IFAD
	Contribute to the development of micro-economies and the modernization of small commercial enterprises (e.g. food preparation kiosks, local restaurants)	MoA; GIZ-2; CCAK; IFAD
	Generate employment across the clean cooking value chains (e.g. stove producers, marketers, installers, and small-scale artisans)	GIZ-1; ECO2; SNV; AFRISOL; SES; KNBDP
Education	Reduce the time children spend on firewood collection, and the associated time loss for school attendance (especially for girls)	MoA; MoGYA; GIZ-2; MoE
	Reduce the likelihood of health issues from indoor air pollution and fatigue, and the associated time loss for school attendance (especially for girls)	SEI; MoH; UoN; IFAD
	Decrease fuel costs to schools that offer feeding programs, with the savings invested for improving the quality of educational programmes	MoA; CRIT; SNV

Table 2 (continued)

Impacts	Impact mechanism	Stakeholder citation
Women empowerment	Reduce the disproportionate time loss, and the associated opportunity costs related to education, income-generating activities, and self-care	BML; DVL; ECO2; ISAK; GACC; CCAK; MoGYA; PAC; SNV; GIZ-1; MoA
	Decrease the disproportionate likelihood of health complications from cooking (e.g. indoor air pollution, burns) and fuelwood collection (e.g. injury, harassment, rape)	SES; PAC; MoH; KEFRI; CRIT; KCIC
	Increase participation and power in household decision-making, and enable the ownership of technologies and operation skills	ECO2; MoA; AFRISOL; CCAK
	Facilitate access to income-generating opportunities related to stove production and marketing	GIZ-2; GACC; SNV; MoE; BML
Food security	Improve nutrition due to fuelwood saving (especially in areas of high fuelwood scarcity) by: allowing the regular preparation of highly nutritious meals that have a high cooking energy requirement (e.g. legumes, beans) reducing reliance to fast-cooking food of lower nutritional value	MoA; CRIT; MoH; UoN
	Enhance food availability by increasing food crop production (e.g. biogas provides bio-slurry that is used as an organic fertiliser)	KENBDP; AFRISOL; SES; SNV
Humanitarian	Enhance food security by reducing the need to barter the received food for firewood	MoA; GIZ-1; SEI
	Reduce the likelihood of health issues associated with traditional cooking, especially considering the poor medical services in refugee camps	MoH; MoA
	Reduce social conflict with local communities due to resource competition	MoGYA; MMU
	Reduce the *added* environmental pressure from fuelwood harvesting in already degraded ecosystems	KEFRI; NEMA

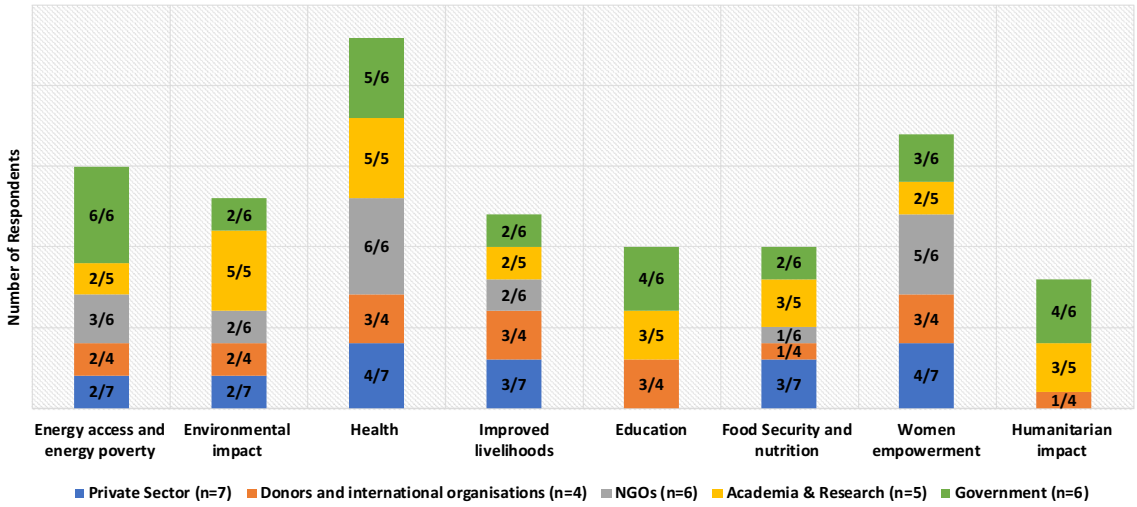

Fig. 4 Multi-stakeholder perception about impacts of clean cooking adoption

Table 3 Stakeholder perceptions about the most important impacts of clean cooking adoption

Impacts	Private Sector ($n=7$)	Donors and international organizations ($n=3$)	NGOs ($n=6$)	Academia and research ($n=5$)	Government ($n=6$)	All $n=27$
Energy access and energy poverty	4	1	2	1	1	9
Environmental impact	0	0	0	1	2	3
Health	1	1	3	2	3	10
Women empowerment	2	2	1	1	1	7

(1 donor stakeholder) (f) quality assurance (1 government stakeholder).

Impacts of clean cooking adoption

Most stakeholders are well aware of the main sustainability impacts of stove adoption and use in Kenya. Table 2 present the main impacts and impact mechanisms as highlighted by the interviewed stakeholders. Practically all stakeholders identified the positive effect of clean cooking interventions on health ($n=23$) (Fig. 4). Many stakeholders also outlined the positive effects of clean cooking for women empowerment ($n=17$), energy access ($n=15$), environmental protection ($n=13$), and livelihoods ($n=12$) (Fig. 4). These were also largely identified as the ***most important*** impacts (see Table 3).

Some interviews also highlighted possible complications from the adoption of clean cooking practices. For example, a stakeholder suggested that clean cookstoves could only offer a short-term solution to deforestation in areas where fuelwood demand already exceeds the available supply, simply prolonging the ultimate consequences of deforestation (personal comm: DVL). Another stakeholder mentioned that life-cycle effects are rarely considered during stove manufacturing and promotion, especially related to the negative environmental impacts of waste generation from stove disposal (personal comm: BML).

The adoption of clean cooking options may alter the preparation of traditional dishes, driving cultural change and affecting social interactions in cooking places and firewood collection areas (personal comm: SEI,MoA). Finally, some stakeholders suggested that the wide adoption of clean cooking options can have some negative livelihood outcomes through the loss of jobs and income from fuelwood and charcoal value chains that dominate livelihoods in some rural and urban contexts (personal comm: BML; KEFRI; CRIT).

Priority areas

User sensitization

Unanimously, and across all interviews, respondents emphasized the importance of increasing consumer awareness for both the benefits and procedures for effective stove use. Many respondents pointed that the lack of end-user knowledge about the health and economic benefits of clean cookstoves and fuels can suppress demand (personal comm: MoH; SEI; SES; GIZ-2; SNV). Rural communities should not be expected to rapidly acquire or develop such skills (and simply "*leapfrog*" into using new cooking technologies)

without the sufficient accumulation of technological knowledge coupled with appropriate social, cultural, and economic conditions (personal comm: MoE; UoN; IFAD; NEMA).

Behavioral change on the demand side can be addressed through awareness-raising campaigns especially, related to the public health benefits of clean cooking (personal comm: CCAK; ISAK; MoGYA; ECO2). In this regard, relevant agencies of the Kenyan government can take a leading role in showcasing the negative human health impacts of traditional cooking to sensitize local communities (especially in rural areas), as for other public health issues (e.g. HIV/AIDS, malaria) (personal comm: CCAK; SEI). To counter consumers' skepticism it would be critical to develop and communicate tailored messages that will resonate with their needs and preferences of different consumer groups (personal comm: GACC; CCAK; SNV; MoH). Consumer research can inform the development of appropriate marketing strategies and branding techniques that can have tangible consumer benefits (personal comm: MoE; CCAK; BML).

Technical and industrial support

A crucial factor for achieving the sustained use of clean cookstoves is the timely stove replacement after its lifetime (personal comm: GIZ-1; GIZ-2; MoE). Thus stove providers (whether private companies or international organization's) must have clear strategies on how to facilitate stove replacement after the end of its lifecycle (personal comm: GACC; SNV; KFS).

While advanced stoves have lower emissions than traditional stoves they are not always convenient and or user-friendly. Conversely, even though the local stove innovations tailored to local needs are often cost-effective and reduce fuel consumption, they have little-to-no emission reductions (personal comm: MoE; KEFRI). Thus, some stakeholders argued that setting the bar too high in terms of emission reductions might kill the local stove industry (personal comm: GIZ-1; ISAK).

Finally, fostering local technical and marketing expertise could guarantee the development of successful local innovations in the long run (personal comm: SNV; KCIC; MoE; KEFRI). International donors and NGOs (especially local) can identify promising local innovations and strengthen their capacity by providing critical support functions related to technical assistance, innovation funding and capacity building (personal comm: KCIC; UoN; MoE).

Multi-stakeholder collaboration

As discussed throughout this paper, ensuring the successful promotion, adoption and sustained use of clean cooking is a multi-faceted challenge. These would most certainly require the combined effort of stakeholders from different sectors, both between government agencies at different levels but also between non-government stakeholders (personal comm: CCAK; GIZ-1; UoN).

However, there are clear policy gaps that hinder stakeholder collaboration especially between different government levels. In particular the Energy Act of 2015 does not recognize household cooking energy at the county government level (GoK 2015). Some respondents highlighted the need for stronger cooperation between stove promoters (e.g. private sector, NGOs, international organizations) and the devolved governments (personal comm: GACC; KCIC; MoE; SES; KENDBP). Furthermore, energy planning expertise from the national government should be better linked to broader rural development and stove capacity development efforts, as there are few renewable energy experts and officers at the county level (personal comm: GIZ-1; MoA).

There is also an evident lack of coordination between international organizations, NGOs and government agencies responsible for stove dissemination (personal comm: MoE; MoGYA; KFS). Some stakeholders were concerned about the lack of information about the development, dissemination and use status of clean cookstove interventions, which is essential for tracking the rates of adoption and sustained use, identifying better high impact areas that can be targeted in the future (personal comm: SEI; BML; ISAK). This would require a coherent monitoring and evaluation system to track progress, but in largely hampered by the failure of many entities to disclose accurately relevant information (personal comm: CCAK).

Finally, there is also a need for stronger collaboration between private sector companies (personal comm: KENDBP). For instance, to create viable LPG markets there is a need for a working dialogue between the different stakeholder groups at the national and local levels (personal comm: MoE; GACC; IFAD). Such networks should first aim at identifying the reasons curtailing the delivery of clean cooking options to local communities, and based on the sober analysis these bottlenecks, they should prioritise target areas before implementing large-scale interventions (personal comm:GIZ-1; AFRISOL; ISAK).

Enabling environment

The development of an enabling environment that fosters both growth in the clean cookstove sector, but also cross-sectoral coordination should build on multi-stakeholder collaboration (personal comm: GACC; SNV). The Kenya Country Action Plan for cooking energy (GoK 2016) is a good first step towards that direction, as it has a clear view on how to strengthen supply, demand and foster an enabling environment for clean cooking (personal comm:MoE). Fostering an enabling environment, as discussed below, entails several processes ranging from offering financial incentives

to producers to enshrining quality standards to ensure consumer protection.

Some stakeholders highlighted the need to improve standards to ensure the delivery of high-quality products (personal comm: CCAK; SNV; MoE; KEFRI). They also advocated for governmental support in reducing duties on clean cookstoves and fuels, to attract further investments in the sector and reduce stove costs (personal comm: KEFRI; E-bank; BML; MPL). Some stakeholders proposed that well-structured subsidies could help in the development of rural distribution systems that can further enhance access to clean cooking options (personal comm: MoA; SEI).

However, the lack of robust evidence and evaluation of the performance of interventions has curtailed the commitment of government agencies and donors to secure the necessary investments to support technology development and support the implementation of stove interventions (personal comm: KEFRI; MMU; CRIT; DVL). Impact evaluation studies should become the norm in the sector, as they could verify whether the intended development outcomes were actually achieved, as well as the possible reasons for underperformance. This would provide a much needed evidence base to support decision-making across the constellations of involved institutions and better guide future clean cookstove interventions in the country (personal comm: KEFRI; MoE).

Innovative finance instruments

Financial aspects underline practically all of the priority areas discussed above, and are key for enhancing the adoption, sustained use and positive impacts of clean cooking interventions. As discussed below, adequate financing is important to practically all stakeholders involved the clean cooking sector.

When it comes to consumers, clean cooking options must be affordable, accessible, safe and reliable in the local marketplace. To achieve strong market development and long-lasting impacts, a fully commercial approach towards stove promotion and adoption would possibly ensure the viability of clean cooking initiatives after the end of the initial support (personal comm: GACC; PAC). Self-sustaining funding mechanisms could possibly support consumers and local enterprises (see also below) to unlock market growth potential and stimulate demand for clean cooking solutions (personal comm: GIZ-1; SNV; MoE). Some of the suggested possibilities are appropriate incentives, well-structured subsidies, and micro-finance loans with flexible payment modalities (e.g. through the widely adopted mobile banking system *M-Pesa* used in the solar energy sector) (personal comm: SEI; GACC; UoN; ISAK; SES). Companies and NGOs should explore opportunities to scale-up existing grants and financing options, as a means of supporting cookstove entrepreneurs for developing high quality stoves in large numbers and reducing costs passed to consumers (personal comm: CCAK; PAC).

When it comes to investors and businesses, the limited access to working capital is a critical challenge (personal comm: AFRISOL; DVL; SES; ISAK; MoA; E-bank). This is because few investors are prepared to provide funds and technical assistance to clean cooking companies at their early stages (personal comm: KCIC; AFRISOL). For such companies it was suggested that funds can be sought from a diverse set of organizations including multilateral/bilateral donors, national/local governments and private entities (personal comm: GACC; CCAK; UoN).

Possible financing mechanisms include: (a) seed funding and grant investments to reduce the risk to investors and bridge the gap of working capital (personal comm: KCIC; GIZ-1; SNV; MoE); (b) specialized funds from the government (e.g. rural energy funds often used to support rural electrification) (personal comm: MoE); (c) climate funds from the Global Environmental Facility (GEF), Clean Development Mechanism (CDM), Climate Investment Funds (CIFs) (personal comm: NEMA; KEFRI; UoN); funding assistance from NGOs such as GIZ-EnDEV and SNV Netherlands Development Organisation for result-based projects, micro-finance, SACCOs, and financial institution for developing stove credits (personal comm: GIZ-1; SNV). However, it was emphasized that the nature and sustainability of financing models and subsidies for cookstove promotion programs are often complex and require longer-term government and donor commitment to respond better to sustained user demand (personal comm: SEI; PAC; GIZ-1; CRIT).

Discussion

Our analysis highlights the radically different perceptions among non end-user stakeholders involved in the clean cooking sector of Kenya about the drivers/barriers of stove adoption, subsequent impacts, and priority areas. Often these perceptions reflect the unique roles and vested interests of these stakeholders within the clean stove sector. Such divergences could in theory become points of contention and stifle progress towards the large-scale adoption and sustained use of clean stoves, taking a toll on the possible long-term sustainability benefits that a transition to cleaner cooking technologies could bring.

However, there is surprisingly a broad consensus about what stakeholders consider as the most important drivers/constrains and impacts (see "*Drivers and challenges of stove adoption*" and "*Impacts of clean cooking adoption*"). This implies both some degree of shared understanding concerning the main issues in the sector, as well as some alignment about the possible priority areas for policies, interventions, and promotion efforts related to

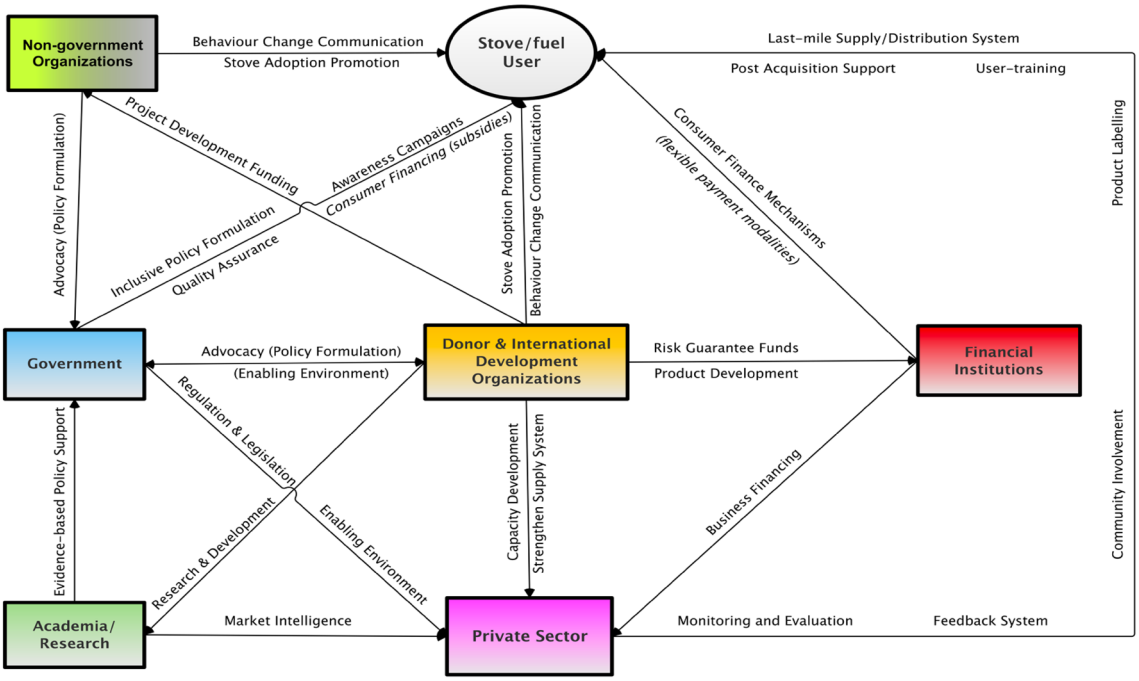

Fig. 5 Stakeholders interactions and possible interventions areas

clean cooking (see "*Priority areas*"). Such points of convergence can be mobilized to coordinate efforts in the otherwise fragmented institutional landscape (Karanja and Gasparatos 2019). For example, consumer awareness and affordability emerged as the main barriers of stove adoption (see "*Drivers and challenges of stove adoption*"). The former can be tied to the influence of campaigns (communication channels), peer effects and social networks (Rhodes et al. 2014; Vulturius and Wanjiru 2017; Kumar and Igdalsky 2019). The latter is often determined by the household socioeconomic status and purchasing power (Sovacool et al. 2015; Bruce et al. 2018; Karanja and Gasparatos 2019), which can be directly impacted by income and availability of incentives to offset part of the upfront stove cost (Treiber and Grimsby 2015; Mutua and Kimuyu 2015). Both can indicate priority areas related to user sensitization and financing that were identified by many respondents as key priority areas to enable the large-scale adoption and sustained use of clean stoves. Furthermore, the comparative analysis of stakeholder perceptions allows for the identification and mapping of both the main interactions between stakeholders, as well as the possible policy and practice options to strengthen the Kenyan clean cooking sector (Fig. 5). This comprehensive map shows the linkages between various strategic policy and practice areas identified through our consistent protocol and complemented with insights from the literature (e.g. Karanja and Gasparatos 2019). Below we discuss some of the linkages that emerged as particularly important from the different interviews.

First, consumer financing mechanisms must take into account the affordability of the different clean cooking options, and how it is affected by infrastructure constraints and regional differences. This is particularly important for scaling up the adoption of technologies such as LPG, ethanol and biogas, whose reach is limited to households that afford either the recurring monthly costs or the high upfront costs. Although the Government of Kenya has reduced VAT for LPG and ethanol stoves as a means of improving its affordability, evidence from other countries such as Ghana (Ahunu 2015; Asante et al. 2018; Dalaba et al. 2018;), Senegal (Kojima 2011) and Indonesia (Andadari et al. 2014; Toft et al. 2016; Thoday et al. 2018) suggest that such subsidies tend to only benefit high- and middle-income households. However, it is worth mentioning that none of the respondents expressed that VAT alleviation might benefit only the relatively better-off households in Kenya.

Second, community involvement and post-acquisition consumer support can play a key role in ensuring the transition from old cooking habits and keep consumers motivated using the new technology (Lambe et al. 2015; Johnson et al. 2016; Mudombi et al. 2018). The promotion and adoption of local stove innovations can be the most immediate pathway for steering a transition to clean cooking, as they closely resonate to local cooking cultural sensibilities, especially in the rural areas (see also similar findings in Johnson et al.

(2016), Tamire et al. (2018), Hooper et al. (2018)). However, enabling a successful transition would undoubtedly require a certain level of change in behaviour, cooking habits, cultural traditions, housing design or other related household practices (Jürisoo et al. 2018).

Third, government agencies play an important role by creating an enabling and coherent policy environment for lifting liquidity constraints on the supply side (particularly for local industries and entrepreneurs) and increasing the reliability of clean fuel delivery and availability in rural areas. Targeted subsidies, economic incentives and support to microfinance organizations might contribute significantly towards this end. However, it is important to ensure that these mechanisms are not at odds with other financing options or wider policy goals. For example, LPG is a fossil fuel, which can curtail its financial viability under climate funds (Bruce et al. 2017; Shen et al. 2018), while subsidies to promote its uptake may (depending on the context) be at odds with the implementation of SDG Target 12c regarding the rationalization of fossil fuel subsidies.

Fourth, related to this last point, it is important to capitalize on the synergies between household cooking energy, health and climate mitigation, including their financing strategies. For example, by acknowledging that clean cooking options provide multiple co-benefits (see "*Impacts of clean cooking adoption*"), it might be possible to use them as vehicles to increase the cost-effectiveness of policies and practices in individual policy domains. In this sense it is imperative to understand the inherent trade-offs in every phase of the adoption process.

Finally, it should be noted that stakeholders are not well-versed with some impact categories such as humanitarian impacts and food security and nutrition. For the former there is a large body of knowledge emphasizing how traditional cooking technologies/practices affect life in/around refugee camps (Owen et al. 2002; Gunning 2014; Lehne et al. 2016; Barbieri et al. 2017). For the latter, even though some stakeholders mentioned the possibly positive food security outcomes of clean stoves, these links were rather anecdotal, and actually remain some of the least studied impact categories in the existing literature (Kituyi and Kirubi 2003; Anderman et al. 2015; Sola et al. 2016).

Conclusion

The benefits of clean cooking options cut across many sustainability impact categories and SDGs. The widespread adoption and sustained use of clean cooking solutions can contribute to wider sustainability transitions in the household sector. However, apart from end-users (i.e. households) many different stakeholders are involved in the clean cooking sector in Kenya, much like other SSA countries. These non end-user stakeholders play different roles across the clean stove sector, holding distinct interests and agendas. It is important to understand better their entrenched positions to ensure wide stakeholder support when designing policies and interventions for promoting clean cooking options.

This paper provides the first comprehensive outlook of the perspectives of 27 non end-user stakeholder organizations actively engaged in ongoing clean cooking activities in Kenya. We used a consistent protocol to elicit their perceptions about the drivers, barriers, impacts and priority areas related to the adoption and sustained use of clean stoves.

Despite some variations in stakeholder perspectives, there is a good level of consensus about the main drivers, barriers and impacts of clean cooking options in Kenya. In particular, there is a good shared understanding about the need for establishing solid funding mechanisms, not only for facilitating consumer affordability, but also for ensuring the financial viability of the entire clean cooking sector. At the same time there is a shared understanding about the positive sustainability impacts of clean cooking, which offers a good starting point to explore appropriate financial instruments in a coordinated fashion.

The main priority areas that can be targeted to catalyze the large-scale adoption of stoves include customer sensitization, technical/industrial support, multi-stakeholder collaboration, enabling policy environment, and innovative funding mechanisms. However, local capabilities and contexts are equally important, so they need to be carefully considered when developing relevant policies and interventions.

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