Cookstove Energy Sector: Arenas in Transitions to Accessible and Affordable in Global South

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Abstract. According to the World Health Organization (WHO, 2014), around 3 billion people still cook using solid fuels (such as wood, crop wastes, charcoal, coal, and dung) and kerosene in open fires and inefficient stoves. Most of these people are poor and live in global south countries. Clean cookstoves are easy to handle but are not easily accepted by the communities. Sustainability transitions are necessary to promote changes in communities in poor regions to become more sustainable and healthier, especially in this cookstove energy industry that promotes transitions towards a low carbon future and involves multiple actors. When analysing the conditions and processes of transitions, the arenas of development (AoD) approach provides an alternative framework in the context of sustainability transitions in the cookstove energy sector. Though the problem has been investigated, how can actors and locations engaged promote sustainability transitions in the cookstove energy sector? Our research aims to characterize how actors' and locations' engagement promotes sustainability transitions in the cookstove energy sector. Based on the proposition for transformative social innovation (TSI) of Pel et al. (2020), this research will bring social innovation to the involved communities to create more sustainable and healthier conditions than the prior situation.

Keywords: Energy Transitions, Transformative Social Innovation, Arenas of Development, Actors

1 Introduction

Around 3 billion people (low- and middle-income countries) still cook using solid fuels (such as wood, crop wastes, charcoal, coal, and dung) and kerosene in open fires and inefficient stoves (Boudewijns et al., 2022; Hooper et al., 2018; WHO, 2014). These cooking practices are ineffective and use fuels and technologies that produce high levels of household air pollution with many health-damaging pollutants, including small soot particles that penetrate deep into the lungs. Exposure is exceptionally high among

women and young children, who spend most of their time near the domestic hearth. The situation resembles decades ago when the communities were cooking with pollutants and inefficient stoves. Now, we have technologies to mitigate this scenario. Even research reinforces this context of the able transition to clean cooking. Therefore, it is important to understand the problem. Indoor air pollution kills more people than tuberculosis, AIDS, and malaria together (Aemro et al., 2021). In other words, it is the same as putting a car in a room and working or making anything with this smoke.

These practices are changing because many policies, projects, and public and private institutions work to mitigate this situation. Furthermore, Sustainable development goal 7 of the United Nations highlights the social, public health, and environmental benefits of the transition to clean cookstoves (Maji & Kandlikar, 2020; Pachauri et al., 2021).

Sustainability transitions are necessary to promote changes in communities localized in poor regions. To make these communities more sustainable, we need to enable solutions like the cookstove energy industry that promote transitions toward a low-carbon future and involve multiple actors. Unfortunately, the energy transition is hampered by several factors: caste, socio-political position, a heritage structure, remoteness, culture, and access to technology (Goswami et al., 2017; Menghwani et al., 2019). However, rapid advances in technologies could facilitate the transition. For this reason, cultures need to be changed to achieve energy transition goals (Sovacool & Griffiths, 2020).

When analysing the conditions for and processes of transitions, the arenas of development (AoD) approach provides an alternative framework in the context of sustainability transitions in the cookstove energy sector. Based on this context, our research question is how can actors and locations engaged promote sustainability transitions in the cookstove energy sector? It aims to characterize how actors' and locations' engagement promote sustainability transitions in the cookstove energy sector. To attain this research aim, we adopt arenas of development as our framework (Jørgensen & Sørensen, 1999). The framework focuses on agency in a cognitive space that holds together the settings and relations that comprise the context for a product or process development, and the analysis of innovation and interactions from multiple points of view, corresponding to the different visions of other groups of actors involved in a particular arena (Sillig, 2022). Besides, the study of arenas of development (AoD) may contribute to understanding transitions in the cookstove energy sector and provide a background of information about how different actors can navigate and perform strategic interventions that support sustainable transitions.

In the following sections, this research introduces the energy transitions in the cookstove, the cleaner cookstoves, transformative social innovation, and the AoD approach and their theoretical foundations and assumptions. In the next section, the methodology is described. After that, an empirical case study of actor-networks involved in the cookstove energy sector in the arena of development of the global south is prescribed. Finally, the article concludes with a discussion of the findings of this research.

2 Theoretical framework

2.1 Energy transitions in the cookstove

Sustainability transitions are understood as multi-level, multi-phase processes of structural change in social systems. They are realized when the dominant social structures (regimes) come under pressure from external societal changes and endogenous innovations (Loorbach, 2010; Koop & van Leeuwen, 2017). Sustainability transitions research focuses on significant transformations in the established sectors such as energy, food, transport, or mobility associated with and triggered by sustainability challenges and has expanded, diversified, and deepened since 2010 (Markard, 2017; Sharp & Salter, 2017; Sovacool et al., 2020).

When we talk about the inequality of means between the Global North and the Global South, it has cost way too many lives so far. Moreover, if that was not enough, when the response has been overly slow or insufficient, the socioeconomic impacts of the COVID-19 pandemic have been much more acute than necessary, pushing many more into deeper poverty and so jeopardizing the prospects of future generations ("The Cost of Inequality," 2022). Indeed, the energy transition decelerated, too, in poor communities. However, Goswami et al. (2017) affirm that bringing clean energy again to enable a rural energy transition in developing countries needs to provide clean energy for bare subsistence, such as cooking and lighting. The same authors say it is also about access to services provided through the energy grid.

The energy transition in countries of the global south is hampered by several factors, such as caste, socio-political position, a heritage structure, remoteness, culture, and access to technology (Goswami et al., 2017). In addition, despite incentives, the transition by local, regional, and international actors depends on several factors, such as education, wealth, caste, family size, gender responsibilities, and others (Menghwani et al., 2019). However, transitions are facilitated by rapid technological advances; cultures need to be changed to achieve energy transition goals (Sovacool et al., 2020). Furthermore, regardless of technology options, implementation strategy choices, or geographic contexts, a successful transition at the domestic level essentially involves taking new behaviours into action (Kar & Zerriffi, 2018).

In sum, removing access to modern fuel in an economically and spatially stratified society is a highly negotiated and contested process. An example is the use of Liquefied Petroleum Gas that continues to be limited by structural conditions, especially existing infrastructure. In addition, a transition is made difficult by the rooted culture (Wang & Bailis, 2015). Another study stated that the current interventions promoted by the Promotion Program are insufficient to promote the sustainable use of other kinds of energy, such as cookstoves (Carrión et al., 2021).

2.2 Cleaner Cookstoves

Sustainable development goals (SDGs) have been stated as a global priority. The discussion on just and sustainable energy transitions and the clean cooking fuel that defines the end of poverty and inequality, energy for all, good health and well-being, gender equality, and sustainable growth to protect the environment, among others (Schilmann et al., 2021; Ravindra et al., 2021). The transition process has been framed in the cookstove literature as a technology-centric issue about the identification of a multitude of factors that encourage or discourage technology acquisition/uptake (purchase or acceptance) and technology usage of traditional cookstoves to Improve cookstoves (Goswami et al., 2017; Kar & Zerriffi, 2018). Furthermore, other studies have focused on understanding the determinants of adoption and on the sustainable use of improved and cleaned cookstoves (Carrión et al., 2020).

Improve cookstoves technology is characterized by improving fuel combustion efficiency and reducing household air pollution by redesigning the simple biomass fuel-burning cookstoves (Hooper et al., 2018). These improved or cleaner cookstoves are advancing as instrumental in expanding access to modern energy services (Sovacool & Griffiths, 2020) through a shift to clean, efficient cooking energy from inefficient ones with a rise in the income ladder is not unidirectional (Goswami et al., 2017). For this reason, a clean cooking energy transition necessitates effortful behaviour changes by cookers, financial decision-makers, and other family members (Kar & Zerriffi, 2018).

Despite continual efforts, the likelihood of a rapid transition to cleaner cooking fuels is low (Menghwani et al., 2019). The recent COVID-19 lockdowns have impacted the transition towards clean cooking fuels. In many countries, especially in the global south, the lockdown affected households' ability to access essential needs. On the one hand, this was accentuated in rural and remote areas already struggling to access clean fuels (Ravindra et al., 2021). On the other hand, evidence worldwide indicates that very seldom, particularly in rural areas, are clean fuels such as liquefied petroleum gas (LPG) used exclusively, which also faces problems reaching the poorest and more remote households (Serrano-Medrano et al., 2018). Moreover, there is a research and policy gap regarding the commercialization of clean cooking technologies, consumer preferences between Ghana-made stoves and imported ones, and the evaluation of locally made ones (Ackah et al., 2021).

Therefore, conventional energy transition models emphasize households' socioeconomic improvement as the most critical driver of the energy transition. However, a clearer understanding of various factors determining stove ownership and selection gives breadth to our conception of energy transition globally (Wang & Bailis, 2015). For this reason, renewed efforts are needed to ensure a sustainable and just household energy transition in the global south (Schilmann et al., 2021).

According to previous studies (Wiedinmyer et al., 2017; Medina et al., 2019; Mazzone et al., 2021), it is essential to bring cultural practices and cooking traditions because specific

cooking methods are the main barriers to increasing adoption rates of improved cooking technologies (Fingleton-Smith, 2022). Additionally, the need to know which factors cause people to decrease or stop using their clean cookstoves (Carrión et al., 2020). Furthermore, women play a significant role in changing these social practices by using clean cookstoves (Dickinson et al., 2019; Jewitt et al., 2022; Menghwani et al., 2019). Therefore, it can save millions of lives a year, especially among women and children suffering from indoor air pollution, especially in the global south (Sovacool & Griffiths, 2020).

Another factor is that the energy must not be only accessible but affordable. However, the use of firewood for cooking or other uses is still more economical than other fuels (Mazzone et al., 2021). The same authors affirm that the supply of LPG in remote communities in the global south is particularly challenging because of its geography and the cost related to transportation (Mazzone et al., 2021).

Governments and civil society in the global south, along with international actors, promote both transition technologies that make solid fuels burn in a cleaner manner, such as "improved" cookstoves (ICS) as well as truly clean cooking solutions (CCS)- modern fuels, such as LPG, electricity, biogas, and ethanol, that critically contributes to human and economic development (Wang & Bailis, 2015; Kar & Zerriffi, 2018). However, efforts have not been entirely successful regarding the financial resources and the program's effectiveness (Schilmann et al., 2021).

Recently, researchers have proposed a solid-fuel suspension framework to understand the determinants of transitioning to exclusive clean fuel use (Carrión et al., 2020). Indeed, future scenarios have been developed that examine the GHG mitigation impacts of alternative ICS dissemination interventions. However, most of these efforts lack a spatial component. Their outcomes are presented in terms of aggregated national or regional data (Serrano-Medrano et al., 2018).

2.3 Transformative social innovation

The theme of social innovation has been widely studied by different areas of knowledge in recent years. This debate brings essential concepts regarding sociotechnical transition, such as innovative social transformation, which is understood as a process that encompasses different actors and results in the alteration or replacement of dominant institutions or organizations in a social context. Unlike Social Innovation (SI), which is related to "the fact that people do things differently due to this innovation, alone or together" (Franz et al., 2012, p. 5). Transformative Social Innovation (TSI) goes beyond changes in social practices. It challenges, alters, or replaces dominant institutions in the social context (Haxeltine et al., 2016), provoking a much deeper change.

It is a social innovation capable of transforming the scenario irreversibly from its perspective, values, and behaviours (Avelino et al., 2019). Therefore, we can characterize this process as co-evolutionary, as it interacts with other social innovations

and changes, affecting its transformative potential and enhancing its scale of impact. These changes will affect the social context in which they are inserted and result in profound impacts on society.
Furthermore, this process is divided and shared through "webs" or "networks" of social and material relationships (Pel et al., 2020) between different groups of people, institutions, companies, and actors in general, that contribute to its development. Additionally, from the arenas of development perspective, it results in a significant change in the actors that are part of the arena where this process takes place and consequently in the limits in which this arena develops.

2.4 Arenas of development

The arenas of development (AoD) theory enables an analysis of the cookstoves energy sector, the importance of the transition to clean cookstoves changing visions, and new practices in several global south countries. It is an alternative approach to transition analysis and is inspired by actor-network theory (Jørgensen & Sørensen, 1999; Jørgensen, 2012; Jørgensen et al., 2017; Heiskanen et al., 2018; Sillig, 2022). According to Jørgensen & Sørensen (1999), the arena is a cognitive space that holds together the settings and relations that comprise the context for a process that includes several elements such as actors, artifacts, and standards that populate the arena. Thus, action locations that generate knowledge and prospects change in this space. Furthermore, a set of translations have shaped and played out the stabilization and destabilization of relations and artifacts. Since the AoD objects of analysis are transitions (Valderrama Pineda & Jørgensen, 2016), it emphasizes its integrated socio-material relations. It responds to the need for an improved theory of transition processes that understand actors' navigations and performances(Jørgensen, 2012).
An actor-world is developed around a certain set of situations and is thereby limited to what we here call a location in the space of a development arena (Jørgensen & Sørensen, 1999). Therefore, involved actors view them as broad social and technological transformations. These transformations could change the fundamental constitution of our communities in the global south (Jørgensen, 2012; Valderrama Pineda & Jørgensen, 2016). In the perspective of arena framing actors' intervention, conflicting matters of concern are instrumental in setting the stage and framing the policy processes within an arena and the different choices of strategy and instruments that support the changes in institutions and technologies (Jørgensen et al., 2017). Thus, the AoD perspective is deemed particularly relevant in the cookstove energy sector when alternative practices and conflicting views and visions emerge that lead to controversies and dialogues among the actors and are open to changes in the sociotechnical configuration (Heiskanen et al., 2018).
Societies are composed of different changing arenas of development that can oppose, or complement, or interact, or overlap in different and contradictory ways (Valderrama Pineda & Jørgensen, 2016). The AoD approach to studying transitions applied in this

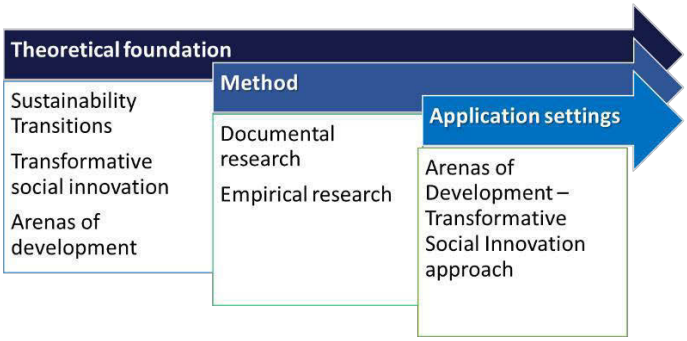
article cultivates sensitivity toward actors' engagement in the creation, operation, and governance of sociotechnical systems (Jørgensen et al., 2017). Furthermore, the approach offers a scalable tool for detailed studies of changes in sociotechnical systems as well as broader cross-sector and international changes, which are in the cookstove energy sector (Jørgensen et al., 2017; Sillig, 2022).

In sum, the AoD approach first focuses on actor-network theory. Also, their change dynamics are tensions between actor-worlds resulting in changing alignments and boundaries. Moreover, their core framing configuration is actor-worlds that emphasize their frames of interpretation and conflicting perspectives. In fact, the role of actors as navigators, performing visions and socio-material practices. Furthermore, this approach included the researcher's position as another actor, though privileged. Finally, the researcher's challenge is to search for boundaries and stabilizing configurations.

3 Methodology approach

The methodologic approach involves three stages as follows. First, it will be characterized by the theoretical foundation of energy transitions in the cookstove, cleaner cookstoves, and the arenas of development (AoD) approach. Secondly, based on the documental research, we analyse the actors involved in the cookstoves energy sector. And finally, the founding principles and organization logic evidenced in the document collection related to the AoD approach for this research will be characterized, as shown in figure 1.

Figure 1 – Methodological Scheme



Source: Authors, 2022

Documental research may include "any written and non-written record which exists and may enhance the researcher's overall understanding of the situation under study" (Gay et al., 1996. p. 221). The documents identified come from several actors that help to transform the cookstove energy sector, such as Biolite, Doña Dora, USAID, and Clean Cooking Alliance were selected based on the previous relationship with the researcher. Additionally, the agenda 2030 of sustainable development goals 3, 4, 5, 7, and 13.

- Biolite is a social enterprise in New York that develops, manufactures, and distributes advanced clean energy technologies to off-grid households worldwide (https://global.bioliteenergy.com/, accessed: 21/04/2022).

- *Estufas Doña Dora* is another social enterprise located in Quetzaltenango, Guatemala, that sells customized stoves to Guatemalan families who depend on firewood as a source of energy for cooking.
- The United States Agency for International Development (USAID) is an international cooperation agency for administering civilian foreign aid and development assistance. USAID developed cookstove programs have the potential to improve the health, livelihoods, and environment of the three billion people who still rely on traditional stoves and solid fuels to feed their families (https://www.usaid.gov/energy/cookstoves, accessed: 21/04/2022).
- The Clean Cooking Alliance is a multilateral organization with the support of the United Nations Foundation to promote clean cooking technologies in lower and middle-income countries. Its mission is to work with a global network of partners to build an inclusive industry that can make clean cooking accessible to all (https://cleancooking.org/mission-impact/, accessed: 21/04/2022).

The documents analysed in this research were:

- Biolite Environmental Sustainability Report (2018). This report represents a potential mechanism to generate data and measure progress and the contribution of social enterprises toward global sustainable development objectives.
- Biolite 2018 Impact report: An article on an organization's accurate demonstration of the impact of an investment or program.
- Executive Summary Biolite: Overview document of the Social enterprise.
- Clean and efficient cooking technologies and fuels, USAID, 2017: The toolkit provides an overview of how the cookstove sector is evolving, best practices, and key challenges.
- *Alianza Global para Estufas Limpias*, Global Alliance for Clean Cookstoves, 2013: *Análisis del Mercado de Estufas y Combustibles de Guatemala.*
- *Estufas mejoradas de leña en Centroamerica: Detonando mercados, 2013*: Report of market of cookstoves in central America
- *I Seminario Taller Latinoamericano De Cocinas / Estufas Limpias,* Global Alliance for Clean Cookstoves, 2014: Report of Latin American Workshop on Clean Cooking: Promoting Adoption and Sustained Use at Scale.
- Agenda 2030: Sustainable development goals: 3 – Good Health and Well-Being; 4 – Quality education; 5 – Gender Equality; 7 – Clean and Affordable Energy; 13 – Action Against Global Climate Change.

To analyse these documents, we applied the AoD steps presented below (Jørgensen, 2012).

- Define the scenario to be analysed. We were starting from the point where we understand AoD as spaces where we can organize processes and interactions between different actors. The first step is to identify the arena, where we will look,

what will be the theme in focus during the analysis, and start the other identifications based on that.

- Identify the main actors involved; after identifying the scenario, we analyse the key actors who represent the arena, such as markets, academia, and third sector, culture, technology, policy, and industry.
- Check which connections exist between the actors. It is important to understand the connections to analyse the influences in the environment in which they are inserted. AoD uses the idea of partial connections and multiple stories. Therefore, the actors' connections are fundamental to understanding how the arena behaves.
- Understand how the actors' performance influences the stabilization and definition of arena boundaries. At the beginning of the approach, the constellations of actors were identified, and their interactions and collective creative activities were perceived, which will define the limits of AoD, that is, how far it extends. AoD will go no further than the performance and collective interactions of actors allow. Therefore, understand the possibilities of AoD due to the constant changes between the actors and their performances. Additionally, the boundaries of the arena are constantly changing.
- Identify the heterogeneous sets of entities within the arenas that form the actors-network. The actors-network comprises a heterogeneous set of entities within an arena, including humans, technologies, institutions, visions, and practices endowed with their specific meaning, position, and identity through their interconnection in network relationships. They are, therefore, entities that within an Arena are organized and stabilized through their interconnections.
- Identify which actors-world are generated from the structuring and stabilization of actors-network. From the previous stage, where the actors-network is organized and stabilized, the actors-world appears. They are semiotic networks that produce in parallel the focus, limits, and dynamics of the arenas through the relationships and internal tensions created between them and the actors' performance that constitute the actor-network frontier.
- Monitor the tensions and misalignments within the actor-world and the ongoing restructuring and readjustment processes generated. The importance of monitoring tensions and misalignments in the actors-world starts from the idea that these aspects, within an actor-world, result in continuous processes of restructuring and readjustments. The spatial dimension of the arenas provides an analytical view of these crucial dynamics for the transformations that re-signify and reshape socio-material relationships. It is worth mentioning that actors can have multiple identities and commitments. Therefore, they can be enrolled in more than one actor-world set simultaneously.
- Analyse changes in arena boundaries based on actors' performances. The arenas are restructured, and their limits can expand or shrink depending on the actor's performances when trying to stabilize, transform or even destabilize the actor-worlds

in the arena. The performance dimension focuses on discursive, organizational, or material events. What counts as performance are, therefore, different types of practices that operate through interactions, demonstrations, and other ways of creating a presence concerning other actors, comprising a variety of acts that range from visions and narratives of meaning to materialized interventions.

- Describe the policies and interventions of actors in innovation processes for a better understanding based on the analyses carried out. From the analyses developed, describe which policies and interventions of the actors had effects on innovation processes, thus highlighting their relevance within the concepts of social innovation.

4 Results

The starting point of this research emerged from analysing a macro scenario, considering sustainable transition initiatives that aim for clean cookstoves, from the perspective of AoD. First, we identified the actors-world that works in this area. Then, by reading the documents and material available on their website, we analysed their performance contrasting with the SDGs as parameters, with the specialized literature, and from reports investigated. This analysis validated the low-income communities, local government, social enterprises, multilateral agencies, international cooperation agencies, and the research as actors within the cookstove sector arena. Furthermore, the actions carried out by these actors moved the scenario, reaching other actors that happened to be new actors who are part of this transition process. The data analysis is summarised in table 1.

Table 1 - Approach to AoD in the cookstove energy sector

Define the scenario to be analysed	**The cookstove energy sector in global south countries**
Identify the main actors involved	Low-income communities Social entrepreneur (Biolite and *Estufas Doña Dora*) Local government Multilateral agency (Clean Cooking Alliance) International cooperation agency (USAID) Research institution
Check which connections exist between the actors	see fig 7
Understand how the actors' performance influences the stabilization and definition of arena boundaries	see fig 7
Identify the heterogeneous sets of entities within the arenas that form the actors-network	Clean cooking alliance - USAID Clean cooking alliance - USAID - Biolite Clean cooking alliance - USAID - Doña Dora Researcher - Biolite - Doña Dora
Identify which actors-world are generated from the structuring and stabilization of actors-network	see fig 7

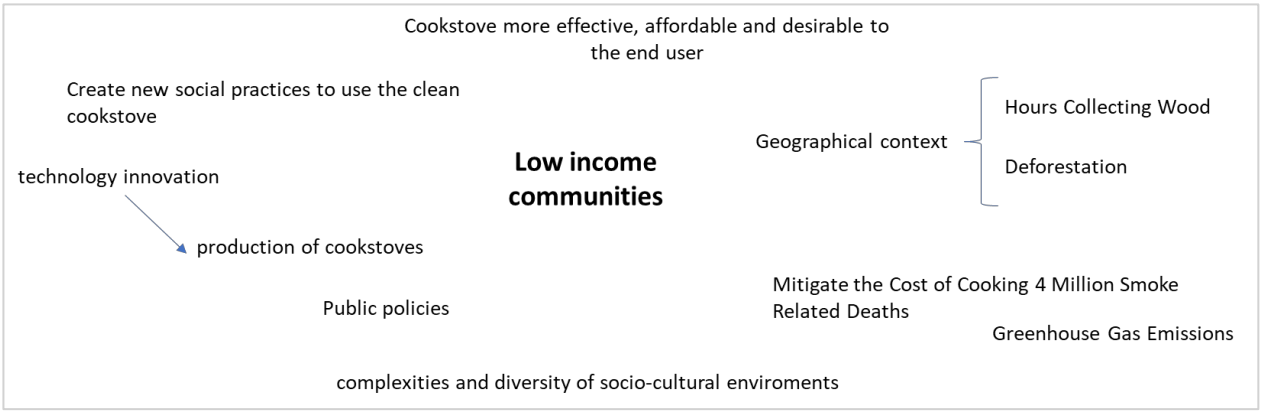
Monitor the tensions and misalignments within the actors-world and the ongoing restructuring and readjustment processes generated	see fig 7
Analyse changes in arena boundaries based on actors' performances	Low-income communities: Buying, promoting, and using the clean cook stove. Financial institutions: Microloans to buy the cooking stoves. Local government: Policies to regulate the microloans and promote better health conditions. Social entrepreneur: Develop new products, sustainable practices, and social innovation. Multilateral agencies: Agenda setting, promoting SDGs, reports. International cooperation agency: Economic and technical cooperation, official development aid. Research institutions: Democratize knowledge and knowledge production.
Describe the policies and interventions of actors in innovation processes for a better understanding, based on the analyses carried out	Provide policies that generate health benefits relative to polluting options. Promote important incremental steps towards to cleaner option. It can help achieve interim air quality targets on the path toward reaching guideline levels.

Source: Authors, 2012

The interaction between energy and poverty has been identified as critical to achieving a sustainable energy transition in global south countries. Indeed, several impacts in low-income communities exist. First, no effective public policies contribute to designing and planning long-term policies, programs, and incentives in the energy, environmental, forestry, and educational areas. Besides, there is no information platform and the generation of knowledge of successful experiences to be replicated in these local contexts. Furthermore, the cost of clean cookstoves, mass production, and commercialization is difficult since they cannot generate economies of scale.

Additionally, the geographical location in distant rural areas and the complex and diverse socio-cultural environments make implementing this type of stove challenging. Despite this, reducing the negative impacts on users' health is key to the energy transition. Exposure to smoke, the low efficiency of traditional stoves, particularly in infants and women (Sovacool & Griffiths, 2020), includes acute respiratory infections caused by inhalation of accumulated smoke in homes, burns, arthritis, and muscle pain. That means extraordinary expenses in the limited family income due to medical care and medicines. The capacity to assess the energy-efficient profile of the cookstoves because the demand and its dynamics are complex due to factors such as cultural diversity, the customs of cooking food, availability of construction materials at the local level, and limited technical capacity to ensure adequate construction quality, lack of maintenance, among other aspects. Finally, the massive use of firewood causes an increase in the deforestation of protected natural forests. In addition, the absence of community programs to replace forest resources is evident, as shown in figure 2.

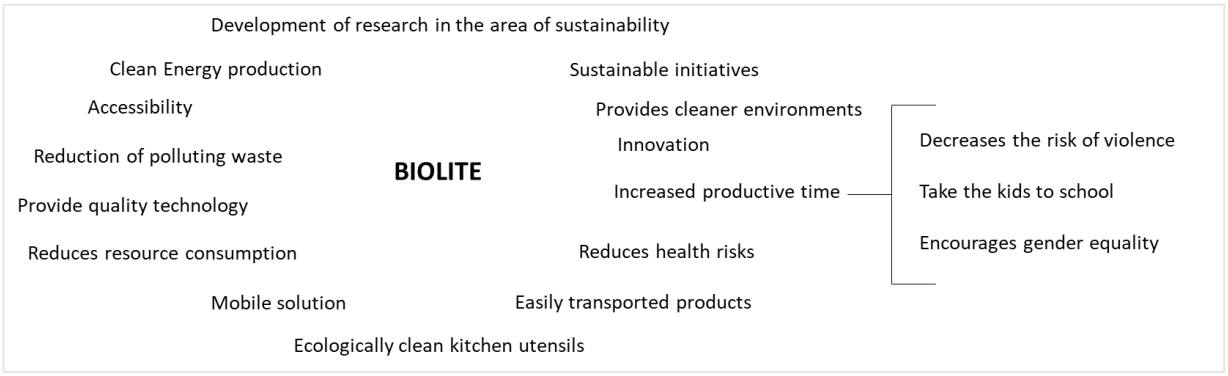
Figure 2 – Impacts/Performance Low-income communities



Source: Authors, 2022

The developed technology by Biolite considerably reduces the production of pollutants that helps mitigate the impacts of climate change. It also has an impact on the health and well-being of cookers as well as a social action that promotes gender equity if we start from the idea that women will no longer have as much work to cook, which will allow them to develop other activities. Likewise, it reduces the work previously carried out by children (of fetching fuel for cooking), allowing them to concentrate on their studies. Further, we can frame this social enterprise from SDGs 3, 4, 5, and 13, as shown in figure 3.

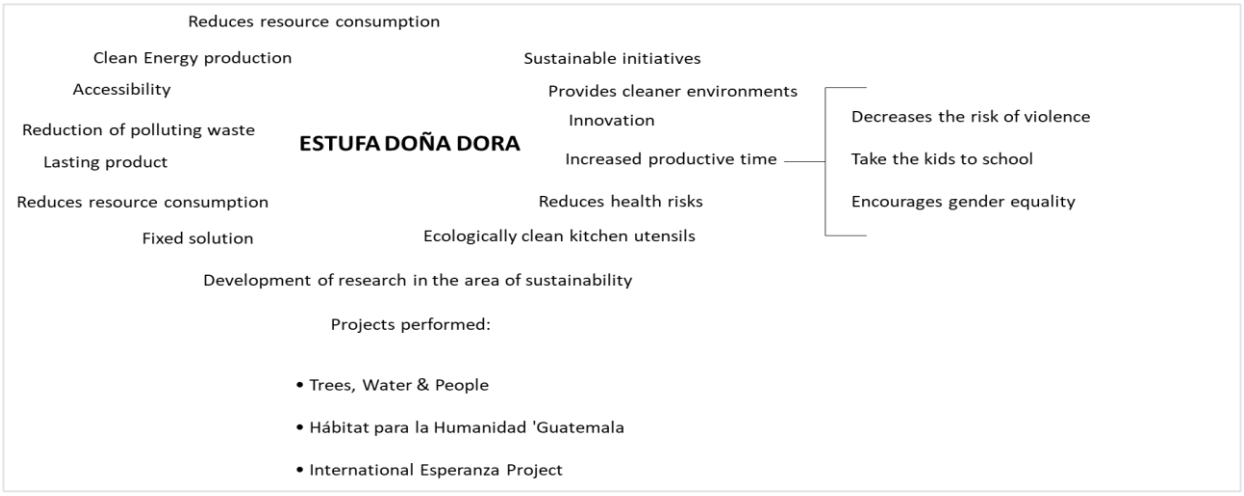
Figure 3 – Impacts/Performance Biolite



Source: Authors, 2022

Estufas Doña Dora is another social enterprise that operates in this sector, specifically in Quetzaltenango, Guatemala. Furthermore, we come from the same principles we used to analyse Biolite to consider as an actor in this arena. All information was also found on its website and supported evidence. Although, the low technology developed by Estufa Doña Dora is different from that developed by Biolite. They have similar impacts, and in this way, we can associate this social enterprise with SDGs 3, 4, 5, and 13, as shown in figure 4.

Figure 4 – Impacts/Performance Estufas Doña Dora

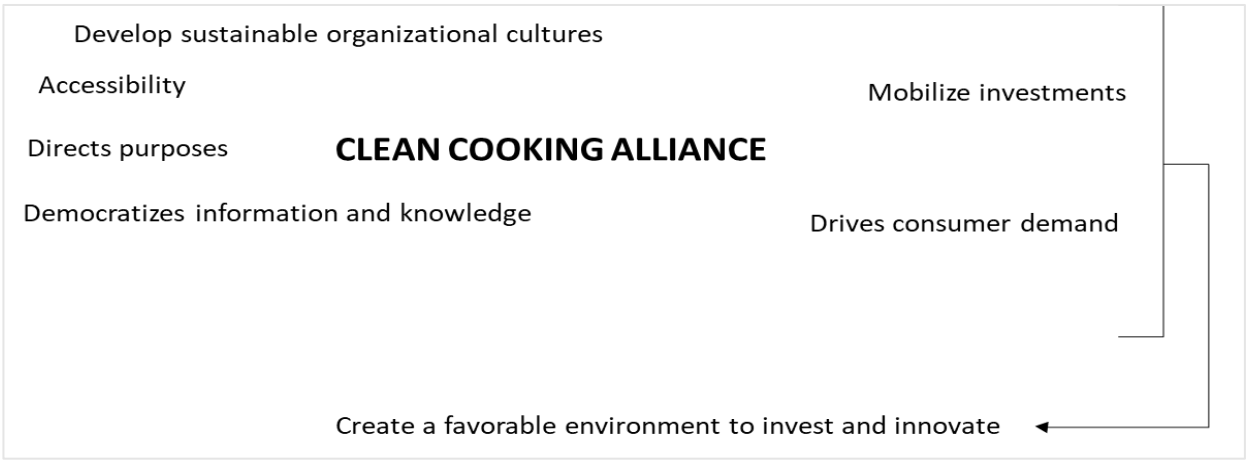


Source: Authors, 2022

As we were trying to understand some of the main actors and their roles, we found the Clean Cooking Alliance, which has a very important role due to its ability to fundraise and democratize knowledge about clean kitchens. We relate it to the SDGs based on its functions within the global scenario, as it is responsible for raising awareness of companies and people about the sustainable and social problems generated in an old-fashioned kitchen which can be linked to SDGs 3, 4, 5, 7, and 13.

The Clean Cooking Alliance also relates to all other actors, as it is one of the main references in relation to the cookstoves. Due to these issues, it is an important player that expands the horizons of this development arena, as shown in figure 5.

Figure 5 – Impacts/Performance Clean Cooking Alliance

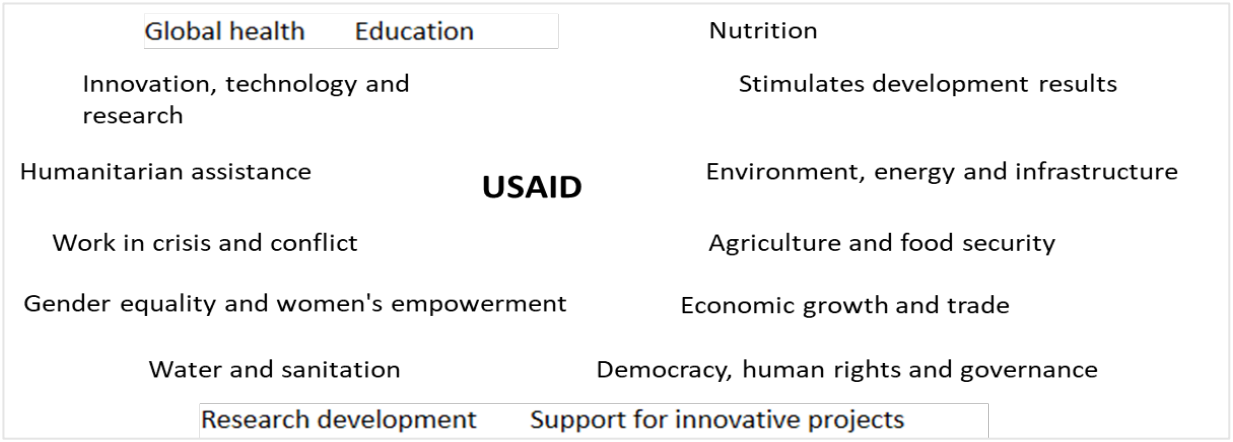


Source: Authors, 2022

Another actor is USAID which supports projects in various areas of the SDGs, including working with projects in the sector of clean cookstoves. Furthermore, we consider USAID as one of the actors which supports the 2030 agenda in other projects related to inequality reduction. Besides, the agency provides financial support due to its size and number of resources and has the potential to make a difference in this scenario.

Therefore, due to its nature, we believe it can become one of BioLite's stakeholders, promoting its transformative and sustainable projects, as shown in figure 6.

Figure 6 - Impacts/Performance USAID



Source: Authors, 2022

The SDGs 3 – Good Health and Well-Being; 4 – Quality education; 5 – Gender Equality; 7 – Clean and Affordable Energy; and 13 – Action Against Global Climate Change are the basis that guides the research parameters, together with the AoD perspective. Through them, we can categorize and validate the initiatives developed by the other actors. Therefore, AoD has a fundamental role, along with the other actors. Also, it helps to expand the limits of the arena in the cookstove energy sector. Furthermore, Because of its role and what it represents, all other actors related to it, even if indirectly, play a central role in our research.

Finally, the researchers, despite not being directly linked to transformative initiatives, have some of the most important roles, such as gathering information, analysing data, democratizing data, and, based on their conclusions, expanding the limits of this arena. Since these conclusions generate new conceptions on the subject and shape the limits of the arena, they have a broad view of events and understand them to create connections and generate meaning. Moreover, they are linked to the other actors as they analyse them, as shown in figure 7.

Figure 7 - Impacts/Performance Researchers

Source: Authors, 2022

As shown in figure 8, these actors involved can communicate and interact, expanding the boundaries of the arena of the cookstove energy sector. This relationship and

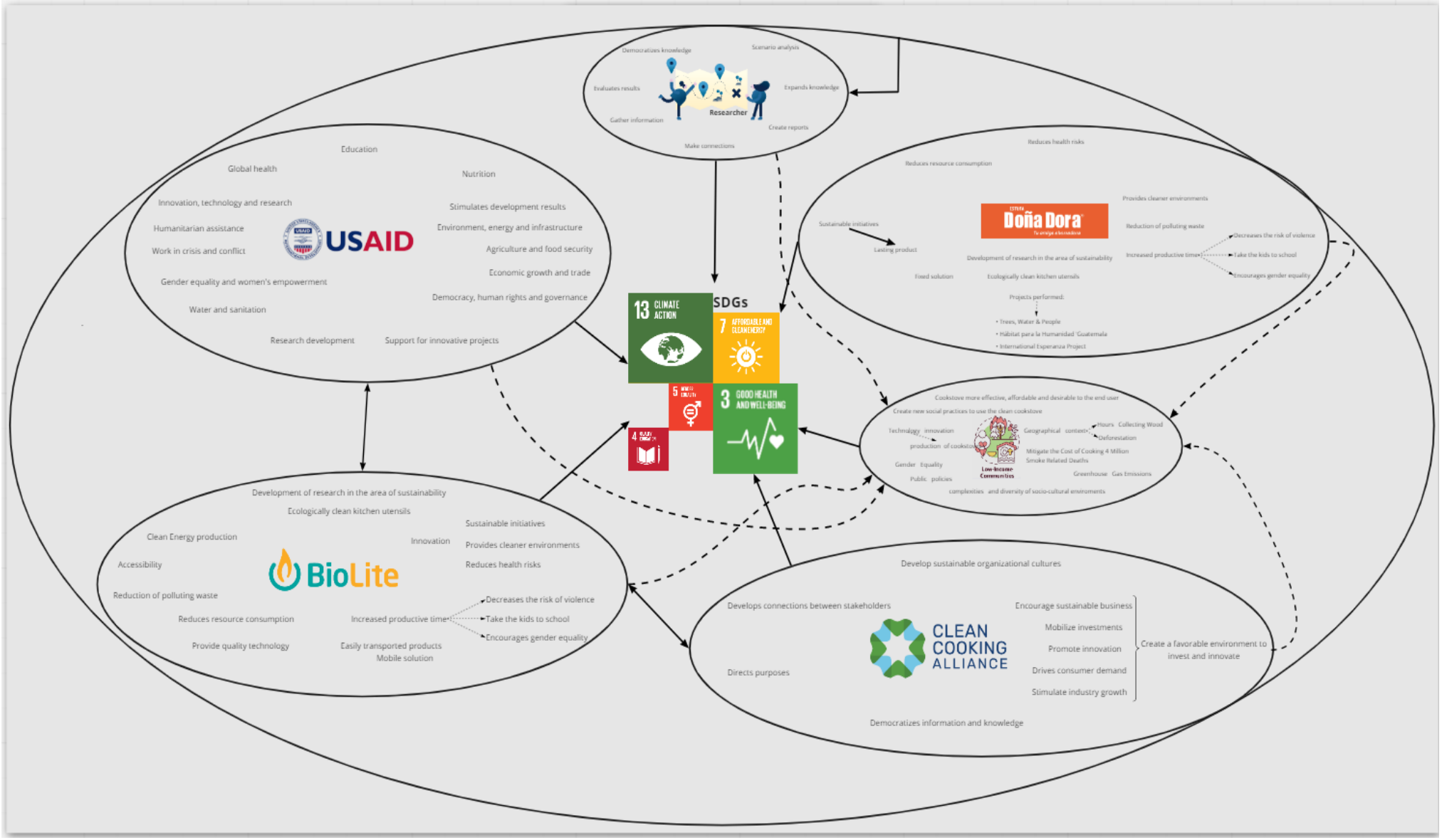
sociotechnical stabilization give rise to an actor-world that relates to other actors to continue changing, restructuring, and fostering transition processes. Beyond the mentioned actors, it is possible to imagine others still involved in this transition process. In practice, any entity, idea, or event related to the transition from "polluting cookstoves" to "clean cookstoves" can be considered an actor, as long as it is possible to measure its relevance and validate its performance in order to contribute to the transition.

Taking this as a starting point, we identified other actors and thought of a scale to understand which would be the actors-world originated from these actors. For example, the beneficiary of the project (the one who will acquire the clean cookstove), if he/she is one of the targets to be reached, can be called an actor since his decisions, disposition, the financial and social condition will impact the success of the energy transition. In this way, we can also imagine the community where he/she lives as an actor-world, since it is the relationships between the actors that integrate him/her that will define the limits of this arena. The relationship between this world-actor and the world-actors identified earlier also forms part of the development arena, and their conflicts will move the energy transition forward.

This research allowed us to observe that the changing arena boundaries based on actors' performances in low-income communities in global south countries brought changes in their daily practice routines. For example, people could use efficient, clean cookstoves, promoting their use and making them accessible and affordable acquisition. For this to happen, local government developed policies to regulate microloans and promote better health conditions. The financial institutions promote microloans to buy cooking stoves. The social entrepreneurs develop new clean and efficient cookstoves, promoting new sustainable practices for use in these communities. According to the SDGs, the multilateral agencies formulated and promoted the agenda setting to mitigate the impacts on public health and social and economic development. Furthermore, these agencies generated reports to know the transformation of these communities and identified the lessons learned in these projects. Moreover, the international cooperation agency gave support with economic and technical cooperation and worked together with the multilateral agencies to formulate and promote the agenda setting.

As representatives of research institutions in this study, we aim to democratize, produce and share knowledge to generate new technologies, practices, measures, and more knowledge. Policies and interventions of actors in the cookstove energy sector provided new policies that generated health benefits relative to polluting options, especially for women in the global south. Therefore, new policies in these communities could promote necessary incremental steps toward the cleanest option in the cookstove energy sector to help achieve interim air quality targets toward reaching guideline levels.

Figure 8 – AoD Cookstove Energy Sector



Source: Authors, 2022

Based on the proposition for transformative social innovation of Pel et al. (2020), present social innovation to the involved communities to create more sustainable and healthier conditions to the prior situation, according to table 2.

Table 2 – TSI in the Cookstove Energy Sector

TSI sets of (inter)relations (Pel et al., 2020)	Proposition	Actors
Relations within SI initiatives	Proposition 1. SI initiatives provide spaces in which new or alternative values can be promoted and aligned with new knowledge and practices—in the process of reflexive experimentation that supports both members' motivations and their moves towards collective 'success' and 'impact.'	Research institutions
	Proposition 2. Manifesting new/alternative interpersonal relations is one pivotal way SI actors can create the right conditions to challenge, alter, or replace dominant institutions.	Social entrepreneurs Low income communities
	Proposition 3. People are empowered to persist in their efforts towards institutional change to the extent that basic needs for relatedness, autonomy, and competence are satisfied while simultaneously experiencing an increased sense of impact, meaning, and resilience	Social entrepreneurs Low income communities (women empowerment)
Network formation processes	Proposition 4. The transformative impacts of SI initiatives depend greatly on the changing tensions within and stability of the action field(s) that they operate in.	Local governments
	Proposition 5. Trans-local networks are a key source of empowerment for local SI initiatives.	International cooperation agency Multilateral agency
	Proposition 6. Discourse formation and its mediation through communication infrastructures crucially enhances the reach of SI network formation.	Research institutions Local governments
Institutionalization processes	Proposition 7. SI initiatives need to find an institutional home in order to access vital resources; this often entails a balancing against the desire for independence from (critiqued) dominant institutions.	Local governments Low income communities
	Proposition 8. In order to bring about institutional change, SI initiatives need to combine different forms of institutional entrepreneurship, and proactively adapt these strategies in response to changing circumstances.	Social entrepreneurs Local governments Multilateral Agency
	Proposition 9. SI initiatives reconsider and reconfigure the broader institutional logics in which dominant institutions are embedded, by learning across different institutional logics and by reinventing, recombining and transposing specific elements from one institutional logic to another.	Local governments Low income communities Social Entrepreneurs
The shaping of TSI by the socio-material context	Proposition 10. The rise of SI initiatives and their particular transformative ambitions are strongly shaped by the historical development of the wider socio-material context.	Social Entrepreneurs
	Proposition 11. SI initiatives are only innovative against the background of an evolving socio-material context. Activities of innovating and inventing present but one historical appearance of SI, next to other less conspicuously innovative activities of re-invention, advocacy, and maintenance.	Social Entrepreneurs International cooperation agencies Multilateral agencies
	Proposition 12. Evolutionary diversity is an integral element of TSI processes, reflecting the historical diversity of the transformative ambitions of SI initiatives and the diverse motivations of the people involved in them.	Low income communities Social entrepreneurs Local governments

Source: Authors, 2022

As one can see, the relationship between social entrepreneurs and low-income communities creates social innovation initiatives that transform local cultures and practices, promoting new perspectives for low-income communities through policies, new products, and more accessible services.

5 Conclusion

This research focuses on how actors and locations engaged promote sustainability transitions in the cookstove energy sector. The analysis draws on the principal actors and how the transformation of these territories developed, specifically in global south countries. Arenas of development as an alternative approach to transition analysis in the cookstove energy sector take in the arenas in which actors operate in networks that involve institutions, policies, technologies, visions, and practices (Jørgensen, 2012). Thus, these actors-world cover a lot of different settings far beyond the scope of the cookstove energy sector in this case (Jørgensen & Sørensen, 1999).

In this documental research, the first actors analysed were the low-income communities. However, despite the transformations in the communities, many challenges also exist that need to be solved to contribute to change. For example, knowing the inefficiency, traditional biomass stoves solve many needs of the inhabitants, including cooking food, heating water, heating, drying clothes, and others. The smoke also provides waterproofing for roofs and repels insects in tropical areas. In addition, there are gastronomic traditions with solid cultural roots make it difficult to leave the kitchen quickly, especially in rural homes. Therefore, knowing the conditions is essential to mitigate the problems if it is not enough to insert a new technology to work with the culture and needs of the local environment.

The following actors in this arena, social entrepreneurs, aim to create a clean cookstove that is more efficient, sustainable, and healthy for communities. Besides, they mobilize and contribute to transforming these communities. Nevertheless, even though they affirm that they contribute to reducing inequalities, it does not happen effectively because there are not cultural transformations in terms of gender equity and other issues. Entities like USAID and the Clean Cooking Alliance offer technical and financial support to transform these communities. However, it is not enough to facilitate innovation in these territories as promoters and supporters of impact initiatives because it affects these communities' culture and financial condition to keep these changes in place. Cookstoves is straightforward, but not readily acceptable by the households (Urmee & Gyamfi, 2014). This connection with other actors also occurs through projects. The multilateral agency is a facilitator and promoter of the performance of other actors. It helps in the strategic, organizational, and financial vision of the other initiatives, accelerating this form or the process of transition itself.

According to the analysed documents, in the commercialization of clean cookstoves, the main clients have been international cooperation agencies, governments, and non-

governmental organizations that grant non-reimbursable funds. This condition limits many interventions to offer quality products since the end-user does not know how to operate and verify the technical specifications of the donated product. Thus, in the same documents analysed, the local government does not create conditions for developing effective public policies that can contribute to the design and planning of long-term public policies in the energy, environmental, forestry, and educational areas. Based on these findings, the most prominent and influential actors involved communicate and interact, expanding the limits of the arena in which they are involved. This relationship and stabilization of the origin of an actor-world that relates to others keeps changing, restructuring itself, and fostering transition processes. In addition, it is possible for the actors involved to imagine others still engaged in this transition process.

With this as a starting point, we identified other actors and thought in scale to understand the actors-world originating from these actors. For example, suppose he/she is one of the targets to be achieved. In that case, the beneficiary of the project (the one who will acquire the clean stove) can be called an actor since his/her decisions, disposition, financial and social condition will impact the success of the transition.

Finally, although this study demonstrated, through the documents analysed, advances for the communities involved and, in particular, women, we consider that this research also has limitations. For example, it is documentary research from the point of view of Biolite and Doña Dora entrepreneurs and USAID and Clean Cooking Alliance, both multilateral agencies which focus on financing policies associated with the SDGs of the 2030 world agenda. Given this, we consider that research conducted with people (particularly women) and their communities would be fundamental to understand better the effects of these technological strategies in relation to the expectations and needs of these communities. For example, ethnographic studies could provide a much broader understanding of this issue and the effects resulting from the insertion or sale of these technologies under analysis and other potential strategies for this and other problems related to the energy field.

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