

Complexities and challenges in the emerging cookstove carbon market in India



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ABSTRACT

"Improved" cooking technologies have been generally understood to be a "win-win" development intervention creating both environmental and development benefits. Yet dissemination of improved cooking technologies has faced many challenges. Carbon finance provides an opportunity to address some of the financial barriers in dissemination initiatives. However, the impacts of carbon finance on cookstove activities are not fully understood. Using India as a case study, this research examines how carbon financing is impacting cookstove dissemination efforts. Specifically this study identifies which actors in the Indian cookstove arena are engaged in carbon financed initiatives and how this is changing their business models and for those not applying for carbon finance, what their rational for this choice is. Results based on 19 semi-structured interviews provide an overview of different organizational approaches employed, perceptions around carbon financing, and identification of the opportunities, challenges and unknowns surrounding the use of carbon finance for cookstove dissemination.

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Introduction

The use of inefficient, polluting cookstoves located mostly in developing countries has resulted in large-scale impacts on social welfare (e.g., global health), local environments and climate change. Three billion people worldwide still rely on some form of solid fuels (i.e., traditional biomass and coal) to meet their cooking and heating needs (Legros et al., 2009). This results in approximately four million annual premature deaths attributed to the effects of household air pollution (including both indoor and outdoor emissions from cookstove use) (Lim et al., 2012) with 53% global woody biomass harvested used for wood fuel (FAOSTAT, 2013). Furthermore, cookstoves are significant emitters of black carbon, a climate forcing species recently recognized to be second only to carbon dioxide. Up to 80% of black carbon emissions in Africa and Asia are the result of residential solid fuel use (Bond et al., 2013). Switching from less efficient stoves to cleaner burning, more efficient stoves therefore has great potential to create both environmental and social benefits. This recognition has resulted in many initiatives to disseminate various forms of improved stoves globally.

Despite many efforts implemented through different dissemination channels over the last 40 or more years, more than 40% of the global population still uses solid fuels. Of those, more than two thirds do not use an improved stove (Legros et al., 2009). The failure to achieve wide-spread dissemination of such technologies has been attributed

to many different barriers of diffusion including failure to meet users' needs (Barnes et al., 1993), challenges with distribution supply chains, and high technology and distribution costs relative to the low-income households who could benefit from such technologies the most (Zerriffi, 2011; Shrimali et al., 2011; Rehfuess et al., 2013). Carbon financing has been proposed to address one of the existing diffusion barriers, generating the additional financing needed to provide stoves at affordable, subsidized costs for targeted end users while allowing for sustainable business models. Based upon these potential benefits, applying for carbon finance has become increasingly popular for cookstove projects (Blunck et al., 2011; Shrimali et al., 2011; Peters-Stanley and Yin, 2013). Furthermore, the perceived development value of cookstoves has resulted in these projects earning the highest average price per credit per project type in the voluntary market both in 2011 (Peters-Stanley and Hamilton, 2012) and 2012 (Peters-Stanley and Yin, 2013). However, there is still much uncertainty around credit prices with an average 15% price decrease observed between the two years (Peters-Stanley and Yin, 2013).

Overall such a model has yet to prove its long-term sustainability as the first cookstove project was registered in 2007 (Peters-Stanley and Yin, 2013), with the crediting period usually lasting over a period of seven-ten years¹ (Blunck et al., 2011; The Gold Standard, 2008). There is also limited research around the impacts of carbon financing on the cookstove business models themselves, this being the focus of this

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¹ Both the CDM and GS follow the allowable standard UNFCCC crediting period. This allows for projects to be designed around fixed or renewable time periods. A seven-year renewable project period can be chosen and renewed up to two times resulting in a maximum of 21 years. Or a 10-year fixed project time line can be used with the project being terminating at the end of the 10 years (UNFCCC, 2013a; The Gold Standard, 2008).

study. A few studies have looked at tradeoffs between different benefits of carbon financed cookstove projects and their potential implications (Simon et al., 2012; Freeman, 2012; Freeman and Zerriffi, 2012; Freeman and Zerriffi, accepted for publication), with others focusing on commercialization efforts and business models for cookstove dissemination (Shrimali et al., 2011; Zerriffi, 2011; Bailis et al., 2009). Yet there hasn't been any peer-reviewed published works comprehensively examining the way carbon financing is changing approaches for cookstove dissemination for multiple types of organizations at the country scale. To better understand its potential role in dissemination models, this study examines how carbon financing is changing the cookstove industry. India was chosen as a study location because 1) it demonstrates extensive potential to benefit from such improved technologies and 2) it is home to a number of past and present cookstove dissemination efforts. This study specifically aims to identify what kind of organizations are choosing to apply for carbon finance for cookstove projects, what their main motivations are and how this is changing the way they are doing business. Similarly for cookstove organizations choosing not to apply for carbon financing, the rationale for this choice, effectiveness of their current business models and their perceptions of carbon finance were explored. Specifically this study addresses the following research questions:

1. What are the perceptions around the benefit and barriers of carbon finance for organizations disseminating cookstoves?
2. How is carbon financing changing the way of doing business or operating as an organization?
3. What are other strategies cookstove organizations are taking to promote cookstove dissemination in addition to carbon finance?

The results of this research outlines a general picture of how carbon finance is being applied within a range of different organizations in India and provides insight into the potential benefits, challenges and uncertainties surrounding the use of carbon finance as a tool for cookstove dissemination.

Background

Challenges in dissemination

Cookstoves can provide a range of benefits including improved health conditions resulting from the reduction of household air pollution (Bruce et al., 2000; Smith and Mehta, 2003; Rehfuess, 2006), reduced demand for fuel sources (often woody biomass) (Barnes et al., 1993; Rehfuess, 2006), reduction of climate warming species emitted (Bond et al., 2004; Smith and Haigler, 2008; Grieshop et al., 2011), empowerment of women (Rehfuess, 2006; Parikh, 2011) and savings in time and/or money dependent upon whether the fuel is collected or purchased (Barnes et al., 1993; Hutton et al., 2006; Rehfuess, 2006). Based upon the many potential benefits and relative low cost of the intervention (Rehfuess, 2006), many initiatives to disseminate different improved cookstove models, mostly in developing countries, have occurred globally. Still such efforts have been challenged in generating long-term, wide-scale uptake (Zerriffi, 2011).

In the 1970s improved cookstove projects started to gain international traction with concerns about energy scarcity and pressures on wood fuel resources (Barnes et al., 1993). Since then many different cookstove related programs and initiatives have occurred with a shift in focus of such programs to address sustainable development through the creation of both environmental and social benefits (Bailis et al., 2005; Hutton et al., 2006; Smith and Haigler, 2008; Simon et al., 2012). Most efforts thus far have been implemented through non-governmental organization (NGO) and governmental channels. With the exception of the Chinese national program neither have been successful at achieving wide-scale lasting uptake of improved cooking technologies (Shrimali et al., 2011). Only 838 million people worldwide, two thirds of whom are in China, have access to some form of improved

cookstove compared to the 3 billion still using some form of solid fuels to meet their cooking and heating needs (Legros et al., 2009). Dissemination through NGOs has been restricted in scale due to limited human and resource capacities (Edwards and Hulme, 1992; Uvin et al., 2000; Shrimali et al., 2011). Though some governmental programs have achieved significant scale of dissemination it often has not resulted in long-term uptake of the technology as in the case of the Indian National Program for Improved Chulas² (NPIC; Kishore and Ramana, 2002; Hanbar and Karve, 2002). Dissemination challenges for NGOs were related to inappropriate choice of technology which did not fit users' needs, limits in scale and funding, lack of infrastructure to provide after-sale services such as maintenance and replacement options, and neglect to create the necessary awareness to generate end user value for the new technologies (Bansal et al., 2013). Furthermore the promised benefits of such new and "improved" technologies, in practice often fell short. There were a number of instances where the stoves did not in fact reduce emissions and/or fuel (Kshirsagar and Kalamkar, 2014). In part, this was due to performance in the field being vastly different from the lab as well as stove durability being limited in many cases (Kshirsagar and Kalamkar, 2014).

Due to the disappointing outcomes of such initiatives, a number of different market-based approaches have recently been emerging. Though many are fairly young, challenges in achieving both widespread dissemination and financial sustainability have been identified (Shrimali et al., 2011; Kowsari, 2013; Zerriffi, 2011). Much of the challenge lies in targeting low to lower-income consumers in tandem with the need to create a new commercial market (Zerriffi, 2011; Shrimali et al., 2011; Kowsari, 2013). Though different companies have different stove models targeting different consumers, including the middle-income bracket, in general, cookstoves are a commodity with lower than normal profit margins requiring large scales to generate significant returns. Commercial entities face additional challenges including needing to create a market for a commodity which in its traditional forms is usually available at a fraction of the cost, limits to available start-up financing with many financial institutions wary of providing loans to a company with a product generating such low margins of return, and creating functioning cost-effective distribution channels for both sales and after-sale services (Kowsari, 2013; Zerriffi, 2011; Rehfuess et al., 2013).

A new tool: carbon finance

The financial gap between the cost of improved cooking options and the willingness or ability to pay of lower income households, combined with the climate effects of inefficient burning of solid fuels, provides an opportunity to use carbon finance to bridge that gap. There are two ways cookstoves have climate impacts. First is based upon reducing their direct emissions (including short-lived particles of incomplete combustion, i.e., black carbon) through increased combustion efficiency³ and second through the reduced consumption of non-renewably sourced fuel (e.g., woody biomass harvested at a rate exceeding the rate of regeneration). In principle, reducing climate impacts either way should generate carbon credits that can be used to offset emissions being emitted elsewhere. In practice, most of the carbon credits calculated are through the latter source with many direct emissions either not included in calculations at all or accounting for only a limited set of climate forcing species (Freeman and Zerriffi, accepted for publication).

Carbon finance is generated through registering emission-offsetting projects. Improved cookstove projects, which are defined as either energy efficiency or renewable energy projects, can qualify to become registered as an offset project generating carbon credits that can be sold in the carbon markets to buyers wishing to offset some form of emissions. These projects can be certified under either the regulated or voluntary markets. The regulated markets generate credits to be sold to buyers

² Chula is analogous to cookstove.

³ See supplementary material in Jetter et al. (2012).

Table 1

Estimated market size in number of households for different market segments in India. Taken from Shrimali et al. (2011) with original sources cited in the table.

Market definition	Market size estimates (households)
"Bottom of the pyramid" rural households (spend less than \$75 a month)	114 million ^a
"Bottom of the pyramid" rural houses that purchase firewood	30 million ^a
Rural households that use LPG	3.5 million ^b
Rural households in top two energy consumption tiers (>30 W per capita)	60 million ^b

^a Data from CDF-WRI (2010).

^b Calculated by taking Pachauri and Spreng (2004) data for five-member households in India (constituting 20% of all households) and assuming that households of all sizes follow the same pattern as these five-member households.

with commitments to meet specific emission quotas (e.g., Kyoto Protocol). Under the Kyoto Protocol, countries with emission commitments can purchase carbon credits generated by offset projects in non-Annex I countries to help meet emission targets by offsetting some of their emissions (UN, 1998; UNFCCC, 2011a). Within this framework, cookstove projects are registered under the Clean Development Mechanism (CDM) (UNFCCC, 2011b) generating certified emission reduction (CER) credits.⁴

The Kyoto Protocol was agreed upon in 1997 and put into effect in 2005 with the first commitment period lasting until 2012 (UNFCCC, 2011c). Leading up to the Conference of Parties (COP) 17 Durban summit climate negotiations there was uncertainty about the future of the Kyoto Protocol and subsequently the continued existence of the regulated carbon market. The conclusion of the summit instated a second commitment period from 2013 to 2020, but included some amendments. With the new commitment period focusing on projects in least developed countries (LDCs), India, not being a LDC, is no longer qualified to register CDM projects under the new commitment period. In the new commitment period the only option for continued registration of projects in India is through the Programmes of Activities (PoA) (UNFCCC, 2013b), which must be registered before the end of the first commitment period. The PoA was created to reduce barriers for registering CDM projects by allowing many projects to be registered under one umbrella application. The PoA can cover a geographical area from a municipality to multiple countries (UNFCCC, 2013c). Under a PoA, individual projects are registered as component project activities (CPAs) with at least one CPA required to be registered in the initial PoA application. An unlimited number of subsequent CPA applications can be made afterwards. The initial crediting period for a CPA is for 7 years which can be renewed up to three times (CDM Rulebook, 2013). Therefore if a PoA application was successfully registered by the end of 2012, CDM cookstove projects could continue to be implemented and credited up until 2031.

Voluntary credits in contrast are sold to buyers who want to voluntarily offset some of their emission related activities (e.g., travel by airplane, emission impacts related to events such as conferences or as a corporate social responsibility initiative). For voluntary cookstove carbon financed projects the main methodology used is the Gold Standard (GS) methodology, which aims to specifically promote sustainable development alongside emission reductions by limiting the scope of acceptable project types and requiring extra steps in the registration process (e.g., holding stakeholder consultations) (GS, 2011a). Under the GS methodology it is possible to apply both for voluntary credits (voluntary emission reductions; VER) and CER credits. In the latter case, the extra GS certification

ensures the CER credits result in higher level of sustainable development outcomes than CER credits alone.

India as a case study

The context

India is home to the world's second largest population with 1.24 billion people. It has the third largest energy demand with projections for this demand to significantly increase (Ahn and Graczyk, 2012). 93% of the wood harvested in the country is wood fuel used for meeting cooking, heating and power energy demands (FAOSTAT, 2013). In 2005, 160 million out of 225 million households still relied on some form of solid fuels as their main cooking fuel resulting in an estimated 570,000 premature deaths from household air pollution creating 3.2% of the national burden of disease (Venkataraman et al., 2010). Despite this, in 2009, 72% of the population was still without access to clean cooking stoves or facilities (Ahn and Graczyk, 2012) and household air pollution from solid fuels was the highest risk factor in South Asia for attributable burdens of disease (Lim et al., 2012). These numbers demonstrate a great potential for the dissemination of improved cooking technologies within India. The majority of the potential user base resides in rural areas with 90% of the rural population primarily depending on some form of solid fuels for cooking, compared to only 31% in urban areas (Venkataraman et al., 2010). Although the government has encouraged the switch to cleaner fuels through the residential liquid petroleum gas (LPG) subsidy program, the characteristic low-income levels and disperse nature of many rural households do not provide the economies of scale for the establishment of LPG supply chains in these areas, leaving a large potential market for improved stoves (Table 1).

Recognizing this potential there have been many efforts to distribute stoves in India including the NPIC. This program was initiated in 1983 and closed in 2002 (Hanbar and Karve, 2002; Sinha, 2002; Kishore and Ramana, 2002). The program provided a minimum subsidy of 50% (Barnes et al., 1993) for fixed or portable stoves (Sinha, 2002) with an average cost of around \$10 (Barnes et al., 1993). Though it was successful in distributing approximately 32 million stoves (Kishore and Ramana, 2002; Sinha, 2002), the program suffered from corruption (Respondent D),⁵ inefficiencies of top down approaches (Barnes et al., 1993; Hanbar and Karve, 2002; Sinha, 2002), and poor design resulting in stoves either never being actually delivered (Respondent D), quickly falling into disuse (Sinha, 2002; Kishore and Ramana, 2002) or lacking capacity to be fixed or replaced when worn from use (Barnes et al., 1993; Respondent D).

Ongoing efforts through NGOs working with cookstoves have been occurring since the 1940s (Kishore and Ramana, 2002), but again these have been limited in scale and lacked the capacity to address the

⁴ It is important to note that after the time of this study the CDM market crashed in 2012 with prices per credit falling below 1 USD (Peters-Stanley and Yin, 2013). This was not the context during the time of the interviews. This sharp fall in the market price of CERs has likely changed a number of the organizations' operations/approaches included in this study who were pursuing CER credits. Voluntary credits also experienced a slight decrease in the average price per credit, but overall remained much more stable than the CER credits (Peters-Stanley and Yin, 2013) and continue to remain a viable source of carbon financing.

⁵ Each respondent to the interview protocol described below was coded with a letter or letter/number combination in order to be able to uniquely identify them in this paper while maintaining their anonymity. See below for more information about Respondent D.

Table 2

List and description of organizations included in this study and the type of stove or cooker being manufactured and/or disseminated where applicable or description of activities for networks and consultants. For some organizations, there were multiple associated organizations, e.g., partnerships between social enterprises with NGOs. Descriptions of the different counterparts and their relationship are included in the description section. Due to the integrated nature of the organizations one respondent or set of respondents were interviewed per letter organization unless otherwise noted, e.g., for J there was one respondent providing information about J.1, J.2 and J.3 which can be described as Respondent J.

Organization	Description	Type of stove	Location of activities
A	A.1: rural products company A.2: carbon consulting company A.1 and A.2 have the same founder and are working in partnership	Biomass forced draft gasifying rocket stove	National based with some international sales in East Asia
B	B.1: for-profit social enterprise which manufactures and sells stoves B.2: NGO which develops technologies with a social impact B.2 does the R&D for the stoves which B.1 pays royalties for	Different models of institutional stoves mostly for roadside eateries	National
C	C.1: cookstove company C.2: biomass briquette manufacturing company C.1 and C.2 have the same founder and are working in partnership	Industrial briquette stoves. Three sizes: 1) institutional stoves, 2) midday meal kitchens ^a , 3) starting to get into the roadside eateries	National
D ^c	D.1: for-profit social enterprise selling stoves, but shifting to become a sustainable lifestyle company with renewable energy products D.2: NGO, originally did the R&D for D.1's stoves, which D.1 paid royalties for. Now they are becoming more independent from each other.	Different models ranging from basic models of improved cookstoves to biomass gasifying stoves to biogas digester systems. Mostly residential stoves. D.2 is involved with building some institutional stoves.	Nationally based with limited international sales
E	E.1: national for-profit social enterprise stove company E.2: national NGO E.3: international NGO assisting with the application for carbon credits	Different models of biomass rocket residential stoves from basic models to more advanced designs. Also have other designs of stoves for other markets in other countries (e.g., charcoal stoves).	National and international based activities
F	US-based stove manufacturing company	Two stoves: 1) Residential gasifying, fan-powered stove. Generates its own electricity for the developing world. 2) Camping stove for the North American and European outdoors market.	Internationally based
G	National for-profit social enterprise operating internationally	Biomass and charcoal residential stoves and biomass and briquette institutional stove	Nationally based but almost exclusive international distribution activities
H	National solar cooker company	Large solar cookers for midday meal kitchens ^a	National
I	National stove and fuel company	Residential and institutional stove models. All stoves are top-loading gasifying stoves using biomass pellets as fuel produced and distributed by Organization I.	National
J	J.1: National NGO J.2: For-profit social enterprise manufacturing stoves registered as a charitable trust J.3: Community-based organization promoted and managed by J.1 J.1 and J.3 use J.2 stoves in their projects. J.2 also sells stoves to other parties.	Residential biomass rocket stove	National
K	National NGO working with tribal communities	Residential mud stove developed by an Indian research institution	National
L	National NGO	Using J.2 single pot portable stove	National
N	N.1: national company N.2: international company Both are carbon companies coordinating and implementing many different kinds of CDM projects	Have not yet decided, but are looking at two different biomass rocket stove models for their first cookstove project in India	National and international
O ^b	O.1: National research lab. Developed an efficient cooker technology. O.2: Manufacturer mostly manufactures automotive components, but have done some cookstoves originally for Organization I, but these activities have stopped due to lower than expected residential sales. Now are going to manufacture and distribute O.1 cooker technology	Efficient cooker technology which saves up to 70% of fuel compared to other cooking devices. Can be used with lpg or biomass stoves.	National
R	US-based for-profit social enterprise linking microfinance institutions to carbon markets with a focus on clean energy projects. Working with Organization Q to register both a CPA and PoA for cookstove projects.	Hadn't decided yet on stove model, looking at a range of different biomass models from rocket stoves to biomass gasifiers.	Internationally based
Q	Micro-financing institution with 165 branches nationwide. Provides cookstove specific loans in limited number of branches.	See R above	National
<i>Networks and consultants</i>			
Organization/respondent	Description	Activities	Location of activities
M	Indian network made up mostly of Indian NGOs with a tech team funded by a Dutch NGO over a three-year period	Tech team provided free consulting services to members to assist in the registration process in the first three years (2009–2012).	National with some international network members and support

Table 2 (continued)

Organization	Description	Type of stove	Location of activities
P ^c	Cooperative of development organizations (Mostly NGOs and social enterprises) focusing on scaling up members' activities through access to carbon finance	Provides peer-to-peer support through the network to reduce barriers to carbon finance for NGOs and social enterprises.	Internationally based
S	Independent household energy consultant working mostly in South and Southeast Asia, based in India.	Works on a range of different household energy development and research projects with specific knowledge about the history of Indian cookstove activities.	South and Southeast Asia

^a Midday meals are free lunches provided for primary and upper primary classes in public schools as part of a national government program.

^b O.1 and O.2 had two different sets of respondents each accounting for one of the 19 interviews.

^c The same respondent provided information for Organizations D and P as they were on the board of Organization P. Therefore information for both organizations was included in one interview. In the text the respondent is referenced as Respondent D.

large-scale need. Since the cessation of the NPIC, a number of commercial efforts have emerged with many of the initial ones supported in some way by international foundations, companies or other organizations, subsidizing their efforts to develop both new products and a new market. A review of commercial cookstove initiatives in India found none of them to have yet achieved overall commercial sustainability as defined by reaching significant dissemination scale and financial sustainability simultaneously (Shrimali et al., 2011).

Methods

Semi-structured interviews were conducted to determine why different organizations in India were and were not applying for carbon financing, how carbon financing was changing the way some were doing business and overall perceptions around carbon financing. Organizations distributing and/or manufacturing some kind of improved cookstove were identified and approached for interviews. In particular organizations known to be involved with carbon projects were targeted. During the interviews the snowball sampling method was used to further identify relevant respondents. The 19 respondents in this study span for-profit companies, manufacturers, NGOs, consultants, microfinance institutions and a research institute (Table 2). This inventory covered most major actors in the Indian cookstove industry at the time of the interviews, including most of the cookstove carbon projects in the pipeline (Fig. 1). It also includes three interviews related to cooker technologies, i.e., the cooking vessel and/or the cooking system, but differentiated from a stove (e.g., a solar cooking system). The owner, manager or director was chosen as a respondent when possible. The identities of the respondents and their organizations have been kept anonymous and instead organizations are referred to by reference letters (Table 2). The interviews took place between December 2011 and January 2012 either in person (respondents in Bangalore, Mumbai and Pune) or via Skype or telephone.

Respondents were asked questions about the role of carbon finance in their business model or organizational set-up. For the respondents applying for carbon financing, details about their applications were also collected from the public online registries (GS, 2011b; UNFCCC, 2013d). A few respondents also volunteered supplementary documents for reference during the time of the interview. An additional interview was conducted with one respondent due to their specialized knowledge of the past and future government cookstove programs (Respondent S). All interviews were recorded and transcribed. From this material trends were identified based on how different types of respondents were or were not engaging with carbon finance.

Overview of the organizations

The type of organization that was involved in the process of applying for carbon finance ranged widely from for-profit stove businesses (A, C, E), carbon companies engaging in carbon financed projects only (R, N), NGOs (J.1, J.3, K, L) and a micro-financing institution (Q) (Table 2). Of these ten organizations, A, C, E, Q and J.2 (stove manufacturer for J.1 and

J.3) were engaged in commercial activities outside of their carbon finance activities and five were involved in a PoA application (A, E, J.1, Q, R) (Table 4). All organizations interviewed that were not applying for carbon finance involved in stove/cooker manufacturing and/or distribution were for-profit entities (B, G, D, F, H, I, O). A limited number of organizations focused on institutional-scaled stoves/cookers (B, C, H, I), where the rest focused on residential models. Two organizations were networks, one nationally based (M) and one internationally based (P).

For the organizations that were involved in carbon financed projects, all of the organizations, with the exception of one (E), were targeting the BoP market group (Tables 3, 4). Organization E was applying for carbon financing retroactively for stoves already sold to low and middle income classes through commercial means. Additionality of the project was based on investment barriers to create distribution at scale. The carbon financing was needed to offset some of the distribution related costs including providing initial large-scale investment funds, creating awareness and developing an effective distribution network in rural areas.

Within the carbon financed projects, one was applying for GS VER credits (K), two for CDM CER credits only (A, N) and five for CDM-GS CER credits (CER with voluntary value-added; C, E, J.1, J.3, L) (Table 4). In general the compliance market (CDM) was perceived to give higher prices than the voluntary (GS), one reason many of the organizations chose CDM. Some of the organizations also saw the CDM certification to be more credible and was subject to less price fluctuations. A main motivation behind applying for both GS and CDM was based on wanting to more strongly demonstrate the sustainable development aspect of their project while also going for CER credits. Some also saw the additional GS certification as providing a premium price for their credits.

The financial structure of each organization was slightly different, with varying approaches to sourcing initial project financing, timelines projected for cost recovery and planned application of their carbon revenue. Carbon financing played an important role in initial project development with most organizations requiring upfront investment from buyers to be able to implement and monitor their projects. Some also required upfront investment to pay for the registration process.

Carbon financed project sizes for residential stoves ranged from 4000 stoves (K's VER project) to 200,000 (E with multiple PoAs). Most were between approximately 20,000–45,000 stoves. Carbon credits generated per residential stove ranged from 0.7 to 2.5 credits with an average of approximately 1.7. Expected prices per credit also ranged. At the time of the interviews the CDM CER market price was around 5.77–6.09 USD per CER (see footnote 4). Many organizations hoped to get a premium on these prices based on both the perceived win-win nature of cookstove projects and the extra GS certification most had. Price estimates ranged from 5 to 11 USD with one organization expressing that they couldn't go below 15.38 USD per credit in order to make their money back in the desired time frame, but didn't know what kind of price they would be able to secure. Lastly, total costs related to the certification process experienced by the organizations at the time of interviews were estimated to be between 21,500–150,000 USD,

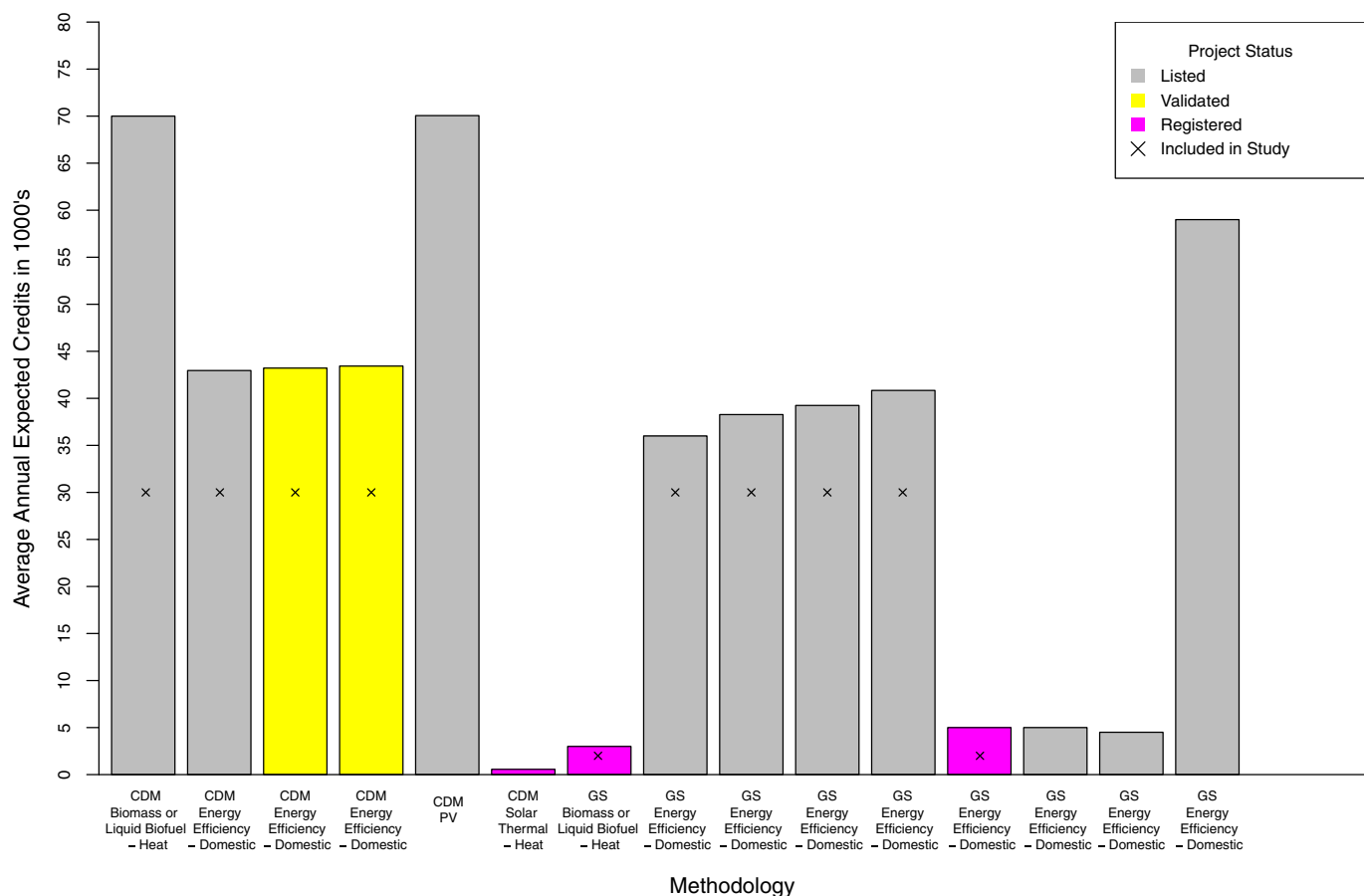


Fig. 1. Cookstove carbon financed projects in India. The listed, registered and validated cookstove projects in India at the time of interviews with the project type (methodology) and average annual expected credits generated per project. The interviews conducted in this study covered two thirds of these projects as indicated by the black x's. Projects are labeled by the project types they were categorized under at the time of the study. The CDM PV project was a solar photovoltaic lighting and improved cookstove project and the CDM Solar Thermal – Heat was a solar steam for cooking and other applications project.

with most in the range of 47,710–66,794 USD (or 2,500,000–3,500,000 INR).

Results and discussion

Perceptions of carbon finance: benefits and barriers

Benefits

All respondents recognized some level of potential benefits provided by carbon financing even if not actively applying for it. The most commonly mentioned benefit was the additional income that could be used to create a sustainable business model by offsetting operational and other costs as well as providing funding to subsidize the technology and access a larger consumer segment. This allowed distribution activities in most cases to reach a much larger scale than previous efforts. One respondent (J) saw this scaling potential as also providing access to the heart of the household, the kitchen, thereby creating an entry point to do additional development activities on a much larger scale. Most of the NGOs also expressed benefits relating to improving the quality of life in communities, with one (K) seeing carbon finance as a way to tap into a market that provided funds to pursue life improvement activities.

Organization N, a carbon company, saw carbon finance as providing a tool to increase corporate social responsibility (CSR)/corporate social investment (CSI) money thereby scaling these activities while also providing the first opportunity to track and measure CSR performance and impact. Similarly other respondents also recognized the carbon system to provide a way to maintain data about distribution activities through monitoring systems that had never been previously in place or

operational. Other kinds of capacity building benefits mentioned included changing work culture/habits, extending knowledge and creating awareness. In regards to overall carbon financing, cookstove projects were identified as actually generating sustainable development benefits compared to other project types. Organization N saw that making social benefits commodities provided a good business opportunity, yet at the same time recognized a danger in such commoditization, due to inherent defects in markets.

For the NGOs, carbon finance was seen as a way to support their other community development priorities. However, none had decided how the money would actually go back to the communities. Ideas for this included setting up a community fund that acted either as an insurance system for example for any sickness that may afflict certain community members (K), or as an investment fund. Respondent J saw creating such an investment fund as potentially bringing five to eight times more financial capital into the communities than through financial institutions. This capital could be available for microcredit, retailing or fund procurement and complimented by the establishment of community thrift schemes. Though promising, all of these options were in the brainstorming stage and far from actual operation at the time of the interviews, leaving room for many diverse potential outcomes.

Barriers

The most commonly cited challenge when applying for carbon finance was the large initial investment needed. This was especially challenging for small companies and NGOs without direct access to the amount of capital required. The second biggest challenge was the complex and tedious nature of the application process, which required

Table 3

Rough categorizations of consumer or end user household incomes and corresponding stove prices affordable to each consumer group based upon income groups described in the interviews. The gaps between the target consumers' household incomes are due to the categories being based purely on respondent descriptions, therefore these categories do not correspond to any official designations.

Target consumer	Household income/year ^b	Price of stove
"Bottom of the Pyramid" (BoP)	8,000–14,000 INR	Subsidized (free or minimal cost)
Low income	30,000–60,000 INR	500–1,000 INR ~ 10–20 USD ^a
Middle income	96,000–150,000 INR	1,150–2,600 INR ~ 22–50 USD ^a

^a USD values are reported based on an exchange rate of 52.4 INR to 1 USD. This was approximate exchange rate at the time of the interviews.

^b While the respondents saw significant variation among income classes they could potentially serve, it should be recognized that the market remains one dominated by those at the lower end of the income scale overall. India's recent poverty line definition would correspond to a rural income of roughly INR 48,000 per household per year (a poverty line that has been criticized as being too low) (GolPC, 2013). The first two groupings would correspond roughly to what Ablett et al. (2007) has characterized as "deprived", while the upper group would be in their "aspiring" low income group with "middle income" not occurring until INR 200,000 (a definition that is roughly consistent with other definitions of middle class in India) (Ablett et al., 2007; Meyers and Birdsall, 2012).

significant technical expertise and a long time period. The assistance of Organization M (further described in the section on *The emergence of new actors*) helped to significantly reduce this barrier for the NGOs. For those without this subsidized technical assistance, determining the fraction of non-renewable biomass value (a key factor in estimating the number of carbon credits) was particularly challenging as organizations did not know where to easily source this information. The allowance of a countrywide or conservative default factor was recommended to help reduce this technical barrier.

Suggestions to improve the accrediting process included making it more efficient by making it faster, cheaper and simpler. To address the barrier of initial investment one respondent suggested the creation of a revolving carbon fund providing loans to get projects off the ground, which would be paid back into after generating revenues (F). This would also help reduce the initial risk, especially for smaller organizations.

Respondents were specifically asked about the potential negative impacts of obtaining carbon financing for the projects. A number of them raised concerns related to uncertainty about the longevity of both the projects and the carbon markets. It was recognized that there was a potential such projects may not survive if the bottom dropped out of the carbon market (F) or if significant challenges emerged relating to monitoring and long-term usage of the stoves (E). This would particularly have negative impacts on business models dependent on carbon subsidies. Additionally, creating a market with subsidized priced stoves may undermine other efforts to sell stoves at full commercial value as consumers/end users perceptions may be skewed to expect stoves at subsidized prices (one impact of the late NPIC that commercial efforts have been trying to address) (D, F). Other concerns expressed included losing sight of the whole purpose of cookstove projects if focusing too much on or becoming dependent on carbon financing (I, L). One NGO explicitly made efforts to frame the benefits of the project to the community around the development benefits of cookstoves and did not focus on the economic benefits due to this concern (L). Along this line respondents were also concerned about where the benefits of the carbon credits went. A number thought they should be going towards sustainable development projects, providing direct community benefits, not just being an opportunity for foreign investment or to benefit corporate entities (J, H, K, L). Lastly, at a global scale some respondents did not think it was good to give Western countries an excuse to pollute (G, K). Overall, many, including those not applying for carbon finance, qualified their concerns expressing that overall the benefits of carbon finance outweighed the downsides.

How is carbon finance changing the way of doing business?

Carbon financing presents a new stream of financing for cookstove projects, not previously available. This has resulted in many changes in distribution efforts and the cookstove industry as a whole. Most notably this has allowed for entrance of new players into the cookstove arena, creation of networks, changes in the way previous actors in the cookstove industry are operating, access to new market segments and scaling-up of activities.

Table 4

Organizations were categorized by whether or not they were applying for carbon finance. If they were, the certification type chosen, whether or not they were involved in a PoA application and their target market is listed. For those with commercial activities outside of the carbon financing scheme, the target market under their commercial model is also listed.

Organization	Carbon finance	Certification type	PoA	Target market without carbon financing	Target market with carbon financing
A	Yes	CDM	Yes	Low income ^b	BoP
C	Yes	CDM GS	No	Sm-med and large institutions; roadside eateries	
E	Yes	CDM GS	Yes	Low and middle income	Low and middle income
J.1	Yes	CDM GS	Yes ^a	Middle income ^b	BoP
J.3	Yes	CDM GS	No	Middle income ^b	BoP
Q	Yes (with R)	N/A ^c	Yes (with R)	Middle income ^{b,d}	N/A ^c
K	Yes	GS micro-scale	No	N/A	BoP
L	Yes	CDM GS	No	N/A	BoP
N	Yes	CDM	Yes	N/A	BoP
R	Yes (with Q)	N/A ^c	Yes (with Q)	N/A	N/A ^c
B	Maybe	GS for kitchen regimes	No	Middle income ^b	Low income
G	Maybe	Don't know	No	Middle income ^b	N/A
D	Maybe for non-stove product	N/A	N/A	Low and middle income with one institutional model	N/A
F	No	N/A	N/A	Middle income ^{b,e}	N/A
H	No	N/A	N/A	Large institutions	N/A
I	No	N/A	N/A	Middle income ^b	N/A
O	No (interested in looking into it)	N/A	N/A	Sm-med institutions	N/A

^a Working with Ministry of New and Renewable Energies (MNRE) in partnership with GIZ – J.1 will be first CPA in the PoA.

^b Stove priced at specified target market based upon categories in Table 3, but the target market may not have been specifically indicated by respondent.

^c This information was not provided during the interview, but they expressed the stove was going to be subsidized to be provided at a lower cost in addition to the microfinance.

^d Based on the stove price of the stove being distributed, but the stove type was subject to change as they were in the process of exploring other options at the time of the interview.

^e Did not have a specific target market, but thought all consumer levels could be reached with right combination of financing tools.

The emergence of new actors

A number of new actors have entered into the cookstove industry based on the opportunity of carbon finance for cookstove projects including companies, social enterprises and networks. For example, Organization A developed out of the opportunity to apply for carbon financing to support their rural products' markets. Their improved biomass stove was only one of many products they were manufacturing or developing at the time of the interview. They had started off trying out other cookstove models, but found none of them adequately met their users' needs. Based upon this, they decided to develop their own stove, with a business model based upon manufacturing stoves. This deviated from their original model focusing on the development of carbon financed projects only.

Organizations N and R on the other hand were not manufacturing stoves and were instead only involved in carbon financed cookstove projects. Organization N was engaged with a range of different CDM projects both nationally and globally, whereas Organization R, was working directly with microfinancing institutions linking them with clean energy carbon projects, one of which was Organization Q.

Two networks had also been created/formed based on carbon projects (Organizations M and P). Organization M was set up to support pro-poor grassroots activities specifically through carbon projects. Initially sponsored by a Dutch NGO, the tech team of Organization M provided consulting services free of cost for network members meeting a set of criteria within a three-year period (2009–2012). In 2012, the funding from the Dutch NGO was scheduled to end after which point Organization M would have to start charging for their services. Organization P on the other hand was made up of NGOs and social enterprises with the aim to provide peer-to-peer support, hoping to develop an "insurance" fund of credits in case any problems arose within one of the member's project activities. With Organization M working only in India, their direct benefits were acutely observed during the interview process as they enabled a number of NGOs to develop carbon financed projects, which would have either been more challenging or not possible without their support. For Organization P this organization was not yet as established and operating globally, making its potential impact wider geographically, but perhaps less transformative for multiple actors in any one country.

Changes in approaches

Carbon credits were also changing the way some of the actors were engaging with cookstove activities. Organization E, a cookstove manufacturer and distribution company, had experimented with a number of different distribution models. They experienced a number of different challenges with each model and had concluded that carbon financing was now a necessary part of their business model to reach the desired scale of operations and achieve financial sustainability. For Organization Q this was an opportunity to earn additional income through another channel. Working with Organization R at the time on a PoA application, Organization Q was also in discussion with other cookstove organizations about engaging with additional carbon financed projects.

Two of the four NGOs, Organizations K and L, had been involved with cookstove projects before, one not having worked with stove projects in the past ten years due to lack of donor interest (L) and one being limited in scale, previously only able to reach up to 30 villages (K). The opportunity to apply for carbon financing allowed them to renew/expand their efforts in this area.

Lastly, carbon financing was changing how NGOs approached cookstove projects. As carbon financed projects generate revenue, introduction of such projects was presenting conflicting dynamics for the NGOs, as not-for-profit entities. To resolve this, social enterprise spin-offs were created to work in partnership with the NGOs and deal with the carbon project while the NGO could help with the distribution and relations with the communities and/or the research and development of the cookstove technology. This same model had previously been occurring in the NGOs that were experimenting with market-based approaches

for cookstove distribution such as Organizations D and B. The original models of both these organizations' NGO/social enterprise partnerships involved the NGO working on technology development with the social enterprise selling the technology and paying a royalty back to the NGO. Organization D has since departed from this model, and though the social enterprise still sold the stoves, they no longer paid the NGO the royalty. This arrangement also allowed the NGO in theory to sell their technology to other interested parties, which had not occurred at the time of the interview.

Developing new markets and achieving large-scale dissemination

One interesting outcome of obtaining carbon financing was the attempt to penetrate new, lower income, markets as part of the need to prove additionality. In order to register a carbon financed project, the additionality states that the project should not have been possible without the carbon finance. Therefore projects that are financially viable under normal market conditions do not qualify to be registered as carbon financed projects. The organizations additionally engaged in non-carbon financed cookstove activities had a specific target market (Table 4) and that target market was expanded to include lower income segments of the population when carbon financing was included. BoP end users could not pay otherwise, but by providing stoves at a subsidized price, it allowed organizations to access a market segment not previously reachable through commercial means. Applying for carbon financing also impacted the scale of organizational activities, requiring large-scale projects. For the NGOs in particular this was a significantly greater scale than they were able to previously operate at.

Potential enabling factors for carbon financing

Although presenting a significant financing opportunity many barriers remain prohibiting some organizations from applying for carbon financing. Enabling factors were identified during the study applicable both to India as well as to other countries engaging with cookstove projects.

Subsidized support for NGOs and social enterprises

One of the major enabling factors for NGOs to be able to participate in carbon financed projects was the free consulting assistance and support provided by Organization M for Organizations J.1, J.3, K and L. For the social enterprises, lacking this kind of subsidized support, and the international funding and specialized expertise other companies had, they faced a number of challenges. If subsidized consulting services such as those offered by Organization M, were provided for both NGOs and social enterprises this would enable increased access to the carbon markets. If such services are not provided, NGOs will likely still play a role in the carbon markets, but will act as the link between the project coordinator/implementer and the communities, as in general they have the strongest standing relationships with local communities. This could have a negative impact on the broader community benefits that might accrue with carbon financing. NGOs were the project implementers that felt the strongest about bringing some of the carbon revenue back into the communities. If, instead, they were limited to a facilitation role, it is likely that the types of projects certified will focus less on creating additional community benefits through the carbon financed gained.

Creating awareness

For stove companies, one general barrier for stove diffusion that came up was the need for intensive awareness building. This was largely the result of needing to create a market for a new product. Despite the long history of cookstove dissemination projects throughout India, there remains a lot of awareness raising needed to convince people they should purchase such products. The cost for such awareness creation was often not worked into the stove companies' business models nor was it covered by external support. For example Organization E saw one of the main reasons for not yet achieving financial sustainability being due to

the lack of funds to invest in awareness in order to generate the number of sales needed to become profitable. This was a challenge even with the support of an international foundation who specifically invested in some of their awareness raising activities. Organization A was experiencing similar challenges, though relatively new to the stove market. They did not have costs for awareness creation and marketing built into their pricing, but recognized it as being a necessary activity. Organization D used to get support from the same international foundation supporting Organization E to do weekly demonstrations in villages, but since the end of this support they could not afford to invest in many awareness activities. Organization Q took another approach partnering with NGOs who engaged with awareness creation and capacity building in communities, but again did not have this aspect built into their business model.

To support overall cookstove dissemination efforts in India, the Government of India could back general awareness campaigns about the benefits of improved cookstoves by framing these products as aspirational technologies. It is important these campaigns would generate appeal around these products, for example framing them as being "as good as LPG" instead of "better than your traditional stove" (see Smith and Dutta, 2011 for further discussion around this topic). At the same time due to the varying performances of improved cookstoves (Freeman, 2012; Grieshop et al., 2011; Freeman and Zerriffi, 2012; Freeman and Zerriffi, accepted for publication) it would also be important to implement some kind of evaluation system or certification scheme so that consumers could judge the relative performance of different stoves as suggested by Shrimali et al. (2011). This would allow consumers to discern potential tradeoffs of stove benefits, for example tradeoffs between health and fuel savings benefits for different stove models (Freeman, 2012; Grieshop et al., 2011; Freeman and Zerriffi, 2012). Thereby often neglected quantification of actual health benefits could be put under consideration by the consumer in addition to fuel savings at the point of sale. Within the global cookstove community there are current efforts working on this, but have not yet been fully developed (Respondent S; Chiang, 2012). Putting government funding towards this via subsidy schemes, could help to support the current commercial activities occurring within the country and perhaps give them the mass interest needed to achieve truly sustainable business models.

Other cookstove dissemination strategies

Alternative financing approaches in the residential market

Through past experiences with different business models (e.g., Shrimali et al., 2011) it appears there are limited opportunities in the current residential commercial stove market without subsidies. Purely commercial ventures will be restricted to mostly targeting the urban middle-income classes due to challenges in dissemination in rural areas and the low prices required for lower-income consumer brackets. Since carbon financing is one form of subsidy that requires targeting end users that would not be able to access the technology in the absence of a carbon project, it is biased towards servicing lower income brackets such as the BoP as evidenced by the market segment organizations applying for carbon certification were targeting (Table 4).

Other forms of financing different organizations were engaging with included CSR/CSI funding. Stove specific microfinance loans, as a form of consumer finance, were being provided by Organization Q who was working with Organization R to apply for carbon certification of stoves distributed through this scheme. For CSR funding, Organization N was specifically using this as investment capital for carbon financed stove projects. Organization E on the other hand took a slightly different approach. They were using CSR funds for both carbon projects as well as for general distribution. They supplied a number of different industrial companies with their stoves and the companies sold them at a reduced cost or provided upfront, no-interest loans for their employees to purchase the stove as part of the companies' CSR activities.

For companies who were not applying for carbon financing at all, and those working with residential stoves, one was acting as a manufacturer only and operating internationally (F), one had switched its focus to institutional stoves due to challenges in distribution for residential households (I), one was operating globally with almost all of their activities outside of India (G), and one provided a range of different cooking technologies to all market segments, was one of the older actors in the Indian cookstove arena and was rebranding themselves as promoting sustainable lifestyles instead of just focusing on cooking technologies (D). An organization interviewed in the review of Shrimali et al. (2011) (in their paper Company F) was approached to participate in this study, but when contacted it was discovered that they had pulled out of the residential stove market in India due to many distribution challenges and were focusing their efforts in other places globally. All of these different approaches demonstrate the need for alternative funding schemes to create sustainable business models. As evidenced above, many different models are currently being experimented with, but still have yet to demonstrate long-term sustainability.

Institutional stoves: a new market

The respondents in this study were primarily focused on the residential market, but India also provides a unique case for institutional stoves (i.e., larger stoves for serving food in bulk, such as commercial and public establishments). There is a large market segment for kitchens cooking the midday meal as well as the community meals provided weekly by religious organizations country-wide. This has resulted in numerous very large-scale kitchens within India, some operating almost 24/7. In addition to hotels, restaurants and roadside eateries, this provides a significant market for institutional stoves. The institutional stove market is a completely different market than the residential one, with customers usually concentrated around urban areas. This requires a different kind of awareness building and distributional scheme, and by nature these kinds of projects avoid some of the challenges faced by residential projects.

Though previous cookstove efforts have mostly focused on residential stoves, there have been increased efforts in the institutional stove market. Organization C is the only business that was found to have made profits (though marginal) in a prior study of stove businesses (Shrimali et al., 2011). This organization targeted the institutional market by providing their biomass briquette stoves originally to schools and was one of the two organizations receiving carbon revenue at the time of the prior study (based upon their GS VER project). Organization I, who originally were targeting the residential market switched their emphasis to the institutional market, seeing this as a more profitable market segment due to more efficient stove and fuel delivery as most institutional customers were located in urban areas providing a denser consumer base. Both Organizations I and C replaced mostly LPG stoves with biomass pellets/briquettes. Economic savings based on relative fuel costs drove their business models, but such switches puts into question the relative health impacts with likely decreases in health conditions (Kowsari, 2013).

Organizations H, B and O were also targeting institutional customers, each with very different business models. Organization H was selling a large-scale solar cooker technology to an NGO with many midday meal kitchens across the country. Organization B was targeting roadside eateries with a range of different cooking technology models. And Organization O was about to start manufacturing and selling a cooker technology that reduced the amount of fuel needed to cook meals, targeting hostels and bulk kitchens.

Even though only one organization (C) was applying for carbon financing for an institutional stove project, such projects present an opportunity to earn credits in a more efficient way due to the much greater number of credits per stove in combination with the usually more dense nature of institutional stove locations. This, and the increasing recognition of the potential of the institutional stove market, will probably result in a significant rise in institutional stove activity in the near future.

Still if this results in users switching from LPG stoves to biomass stoves, it will probably also result in decreased health conditions (Kowsari, 2013). Therefore, again, some kind of stove certification or classification scheme could prove greatly beneficial.

Summary

A number of different strategies were being used by cookstove organizations to try and create sustainable business models. These included targeting both residential and institutional stove markets, utilizing different forms of financing (e.g., micro financing and CSR programs), changing distribution models, and shifting the focus of organizations away from only cookstoves to the promotion of sustainable livelihoods. Within this set of organizations, a number of them have included carbon finance as part of their business models. The organizations pursuing carbon finance varied widely, each with different approaches. This included differences in choice of certification, size of project and strategies for investment and sourcing buyers. Due to the need to prove additionality almost all organizations were targeting BoP end users in their carbon financed projects. Despite the potential of carbon finance to provide additional funding, there was still a lot of uncertainty around carbon prices. For each project, this affected the payback period needed to regain initial investments and to start generating carbon revenue as well as how much effort would be required to support monitoring and verification throughout the life of the project.

For-profit companies and NGOs had different motivations and focuses in their approaches to carbon finance; the former usually seeing it dominantly as a business and the latter seeing it as an opportunity to scale up development activities. Overall, carbon financing was viewed as a positive opportunity to increase cookstove dissemination efforts despite the uncertainty around it. Free consulting for NGOs and social enterprises through networks and generally increasing awareness about the benefits of cookstoves could be significant enabling factors for both carbon financed and commercial cookstove initiatives.

Overall many challenges remain to create sustainable business models requiring creativity and ingenuity. If targeting the BoP, carbon financing provides funding to help subsidize these costs. As one respondent put it, carbon finance may be the “catalytic” infusion of investment needed to make improved cookstoves financially viable, but has yet to be proven over time.

Conclusion

This study has shown that organizations involved with cookstove activities in India are still struggling to find sustainable business models with a number of different strategies currently being tested. Carbon finance appears to be a resource that can improve dissemination of cookstoves to the BoP in ways that are not possible through purely commercial channels and at much larger scales than previous NGO activities. Still there is a lot of uncertainty surrounding carbon markets and a number of unknowns amounting to carbon financed stove projects being a high-risk investment.

As the projects progress, challenges and successes will start to emerge. Carbon financing provides a good resource for reaching different market segments and perhaps can act as the infusion of capital needed to complement commercial efforts to obtain both financial sustainability and scale. Yet as it stands, there are so many uncertain variables it is challenging to speculate. At the same time if only commercially minded organizations are implementing carbon financed cookstove projects the benefits going back to the community beyond the stove itself, may not occur. Continued support of the donor-funded consulting services provided by Organization M for NGOs would be a significant enabling factor. For cookstove dissemination activities in general, awareness building is needed and could be one activity implemented nationwide by the Government.

As approaches for cookstove dissemination continue to evolve the hope is large-scale, long-lasting results can occur providing both development benefits and fuel savings to the communities while also contributing to climate change mitigation globally. More attention needs to be paid to the actual impact of the technologies disseminated, assessing them for efficiency (i.e., fuel savings), emission reductions and relative health benefits simultaneously, as tradeoffs between these benefits can exist. Further research into the outcomes of the initiatives covered in this study as well as others occurring worldwide will prove beneficial and further the understanding around the impacts of carbon financing on cookstove project dissemination and lessons around cookstove dissemination in general.

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