Sustainable diffusion of sustainable technologies? An entrepreneur-led initiative to promote improved cookstoves in rural western Kenya

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This article presents the accomplishments and challenges of a rural sustainable development initiative in Nyanza Province, Kenya. Our focus is on the sale and financing of a simple technology—an improved cookstove—by a local entrepreneur. The theoretical basis of the research is innovation systems and (social) entrepreneurship. We first define the major challenges of the diffusion process encountered throughout the initiative’s early years, with special concentration on maintaining the working capital to sell and finance additional innovations. We next present the measures to address the challenge, including detailed written contracts, a modest fee for late payments, a contract-signing witness, and money-transfer options by mobile telephone. We subsequently present repayment rates for up to one year after implementing the changes, which show a general pattern of improvement. Finally, we discuss the sustainability of the technology, repayment rates, innovation systems, and entrepreneurship in sub-Saharan Africa. The main message of the research is that the major challenge is not creating more sustainable technologies, but overcoming difficulties in diffusion processes.

KEYWORDS: innovations, small businesses, socioeconomic aspects, technology, financing, rural areas

Introduction

There have been over the years many efforts to improve the dire conditions that African smallholders face.¹ Development aid initiatives have been one form of assistance, driven primarily by nongovernmental bi- and multi-lateral aid programs, as well as by donations from individuals and businesses. However, the challenges related to conventional, top-down, technology-transfer programs to transform the lives of people in sub-Saharan Africa have prompted alternative efforts that attempt to more effectively fuse broader sustainable development goals with the unique conditions, priorities, and competencies of the individuals that they target (Hägerstrand, 2001; Swallow, 2004; Malton, 2009; Röling, 2009; Jones, 2012; Sachs, 2012).

The innovation-systems approach represents a second form of assistance and has been promoted by the introduction of tangible technologies and/or improved practices and processes (Reij & Waters-Bayer 2002; Sanginga et al. 2009; Hounkonnou et al. 2012). A specific method within the innovation-systems realm is innovation diffusion through the efforts of an entrepreneur. Entrepreneurship has been actively encouraged and studied in a number of sectors and settings throughout the global South, especially in urban areas (Wellings & Sutcliffe, 1984; Rogerson, 2001; Urban, 2008). Despite this interest, there are still significant knowledge gaps in better understanding the efficacy of entrepreneurship in promoting rural sustainable development and poverty alleviation (Malton, 2009; Röling, 2009; van Rijn et al. 2012). For example, we lack sufficient understanding about how to build and maintain rural entrepreneurship initiatives that seek to promote the diffusion of more sustainable technologies in the countries of the global South. Furthermore, the specific strategies and tools to help sustain the economic viability of these efforts require further examination.

The research reported here contributes to the literature on sustainability and entrepreneurship in the global South. The intention is not to comprehensively assess the sustainability of individual technologies, for which there is already ample research (cf. Westhoff & Germann, 1995; Lee et al. 2013). The aim is rather to provide insights into the practical challenges of maintaining an initiative that targets smallholders in sub-Saharan Africa. In particular, the emphasis is on the main impediments that entrepre-
neurs face selling improved cookstoves and the adaptive measures that they can take to address the greatest obstacle to sustainable operations, namely, loan repayment by customers. The study area is in rural Nyanza Province in western Kenya.

The article is structured as follows. We begin with background on the initiative. We then describe the technology and present its accomplishments and major challenges from 2009 until 2014, focusing on issues of trust, competition among aid organizations, transportation and infrastructural development, and the inadequacy of loan-repayment rates. We next highlight the measures taken to improve repayment rates and the initial results after their implementation. The article concludes with a brief discussion about the technology, repayment rates, innovation systems, and (social) entrepreneurship.

**Background**

To provide a more complete picture of the initiative, we first offer some background. This section covers the theoretical bases of activities—including both innovation-systems and entrepreneurship approaches—to afford deeper understanding of the terms and how they have evolved to better encapsulate the social and environmental aspects of development in the global South. To create a more detailed portrayal of the impetus for this work, we next present the history of our activities in the region, including the prior research we have carried out, the actors that have been involved in the initiative, and the respective roles they play. We then present the methods that we employed to study the evolution of the activities over the first five years of the project to improve our understanding of the daily challenges smallholders face and related issues. Finally, to create a more robust depiction of the smallholders that were targeted, we describe the study area and provide an overall characterization of the groups in rural Nyanza.

**Innovation-Diffusion Systems**

Innovation research has been conducted for more than a half century (Rogers, 1995). In the context of this work, an innovation is defined as an idea, practice, or object that is perceived as new by an individual. Diffusion is the process through which the innovation is communicated and implemented via channels of the members of a group, equating to a type of social change (Nypan, 1970; Rogers, 1995). Innovation-systems research, and more specifically the literature on diffusion of innovations, focuses on several areas including education and training (Spielman et al. 2008), innovation leadership (Vlok, 2012), policy processes to promote innovation (Foxon & Pearson, 2008), and sustainable technology-diffusion processes in industrialized countries (Jacobsson & Johnson, 2000; Jacobsson & Lauber, 2006). Innovation diffusion in Africa, in particular, with a focus on smallholders, has also become commonplace in recent decades (Reij & Waters-Bayer, 2002; Sanginga et al. 2009; Batino et al. 2011; Tittonell et al. 2012; van Rijn et al. 2012).

Existing work concentrates on, for example, social capital and agricultural innovation (van Rijn et al. 2012), access and social marketing (Freeman et al. 2009), gendered norms and power (Bourey et al. 2012), acculturation (Martin & Novicevic, 2010), and multi-stakeholder perspectives (Carlisle et al. 2013). The work presented here unites a number of the above areas and concentrates on the more practical impediments in diffusing innovations via an entrepreneur.

**Entrepreneurship**

Interest in entrepreneurship and the specific traits that the entrepreneur should possess have increased in recent years (Kobia & Sikalieh, 2010). Definitions of entrepreneurship and the role of the entrepreneur have evolved from seventeenth- and eighteenth-century interpretations of innovators as the drivers of capitalistic creative destruction processes (Dees, 1998) to today’s more diverse and sometimes contested discussions. Understandings of the entrepreneur run the spectrum from strict for-profit ventures to models where the creation of capital wealth is ancillary. The concept of entrepreneurship also extends from strict commodity-production models to novel decision-making approaches that focus on stimulating societal change (Wallace, 1999; Ruvio et al. 2010). An entrepreneur can drive change from outside or can facilitate change from within an organization, for instance as an interentrepreneur (Kistruck & Beamish, 2010). Entrepreneurs can be defined by the personal traits they possess, their innovative behaviors and strategic management practices, and their ability to identify opportunities (Kobia & Sikalieh, 2010). According to Schumpeter (1934), the entrepreneur should be innovative, creative, and able to take risk. Skilled entrepreneurs should also be able to explore an environment and discover and exploit opportunities (Barringer & Bluedorn, 1999).

The added aspect of stimulating social and environmental change has become more commonplace. There are numerous labels for individuals seeking to drive these changes, including social entrepreneurs (Dees, 1998; Thompson, 2002; Seelos & Mair, 2005; 2007; Weerawardena, 2006), sustainable entrepreneurs (Schaltegger & Wagner, 2007; Tilley & Young, 2009; Spence et al. 2011), and ecopreneurs, (Keogh & Polonsky, 1998; Dixon & Clifford, 2007).
Social entrepreneurs typically concentrate on innovating, facilitating, and sustaining positive changes with respect to a certain social problem (or problems). Santos (2012) differentiates social entrepreneurship from commercial entrepreneurship, with the former focused on value creation (i.e., creating value for society) and the latter concentrating on value capture (i.e., revenue generation and profit, progress implementing foreign assistance programs). Efforts focused on pressing social and environmental challenges have gained academic stature through an expanding literature on both social entrepreneurship and innovation as well as in the popular media through the sponsorship of organizations like the Skoll Foundation and the Bill and Melinda Gates Foundation. The effort presented here is an amalgamation of the different forms of entrepreneurship to promote solutions for those individuals most vulnerable to negative social and environmental change.

The Initiative and the Actors
The scheme reported here has been part of broader outreach and action efforts by researchers at the Lund University Centre for Sustainability Studies to contribute to sustainable development while simultaneously studying these processes (Stringer, 2007; Jerneck & Olsson, 2011; 2012). Our project has been a small internally funded effort that grew from earlier research by others at the organization concentrating primarily on the climate vulnerability of smallholders in the region (Jerneck & Olsson, 2011; Gabrielsson et al. 2013). The initiative consists of a small network of actors and at its core is an entrepreneur that Lund researchers met during prior research visits to the region. For the sake of convenience, we refer to him here by his first name, Benson. We recruited Benson because of his knowledge of the region and networking skills. He drives the majority of his activities from Kisumu, the largest city in the province. Benson’s initial task was to gain a more comprehensive understanding of the various organizational structures within different villages in the region, as well as a more detailed account of the daily routines, challenges, and needs of the villagers. With these in mind, the aim was then to develop and introduce technologies that address current social challenges, so time and/or money could be devoted to alternative activities such as agricultural education, basket weaving, and rope making. To the greatest extent possible, Benson developed the technologies in collaboration with end-users, craftspeople (potters, tinsmiths), local retailers, and with additional oversight and development assistance from Lund researchers.

Additional tasks that Benson performed include the sale, delivery, and installation of the technologies to establish and maintain contact with households and village leaders and to conduct follow-up visits to collect payment on units sold, to make additional sales, and to engage in discussion on product improvement. The technologies are simple, established, and, in theory, affordable to end-users with the help of financing mechanisms. The initial technology we introduced to the region was the smoke-free stove. Benson earned a modest commission on each system that he installed. An additional characteristic of the initiative, and job of the entrepreneur, has been to offer payment plans to customers. Researchers in Lund provided initial financial capital with the aim of establishing a revolving loan system to finance additional technologies with the profits from previously installed systems and to support Benson during the start-up phase. The payback period was usually six months. Initially, the entrepreneur required no down-payment. This changed to 50% of the purchase price in 2012 to increase the commitment of cookstove purchasers. For systems that are financed, there has been a modest interest charge built into the final price. Contacts with leaders in the villages have also played an important role in the initiative through their actions as technology demonstrators, resources for technology-improvement suggestions, and more recently, collectors of monthly installments.

Researcher Roles and Study Methods
Our role in the project was twofold. In the first instance, we studied the initiative’s successes and challenges and, second, we were a resource for Benson (both activities common in action-research initiatives) (Stringer, 2007). More specifically, we worked with him to suggest technology improvements, new technologies, marketing approaches, loan-payback systems, and general business administration. We also sought to better understand the initiative in terms of its wider sustainability and innovation-diffusion contexts, including comprehending the larger institutional impediments to expand the initiative. Finally, we were responsible for the production of knowledge-dissemination mediums to diverse audiences through, for example, films and publications about different aspects of the initiative.

3 More recently, Benson introduced a more expensive rooftop-water harvesting and storage system in addition to the cookstoves. He has sold seven systems and now offers financing through a community micro-finance organization. The water systems are not assessed in this research due to the use of a separate financing system.

We used multiple methods to gain both a broad appreciation of the challenges that households in Nyanza Province faced in earning incomes and fulfilling their basic needs and a more detailed understanding of the project’s obstacles. We selected this particular study area because of our familiarity with the region through other current research in the vicinity surrounding Lake Victoria. Most of the information we acquired about the initiative as it progressed was through ongoing dialogue with Benson via approximately monthly emails and/or telephone conversations that took the form of “mini-status reports” and through direct conversations during field visits. The information included general sales levels and Benson’s financial situation, new areas/villages to target, technology modifications, and details about the sales approach. We supplemented this feedback with electronic spreadsheets (emailed generally on a quarterly basis) that contained detailed information on both cookstove sales and repayment status. This information enabled us to provide Benson with suggestions on how to improve this initiative.

To augment the above interventions, we made three visits to the region between 2010 and 2012, including stopovers at several villages to conduct interviews with households on a variety of topics. The interviews initially concentrated on household size, income sources, and time spent for fuel-wood and water collection. Once the cookstoves were being sold, we expanded our survey questions to include benefits and deficiencies, such as savings derived from new appliances, changes in cooking patterns, and reasons for non-repayment. We conducted between 15–20 semi-structured interviews with households during each trip to the region, based on methods detailed by Bryman (2004) and Yin (2009). The interviews typically lasted for between 30 and 60 minutes depending on the topics covered and how much detail respondents provided. In most cases, the questions were posed in English and translated to Luo, the region’s native language. Prior to the 2012 field visit, the entrepreneur also distributed 35 surveys to cookstove customers, with questions focused on the specific reasons for non-repayment. We collected twenty completed surveys from the households and sent these data to researchers in Sweden for initial analysis. The responses were subsequently used to drive changes to the sales and repayment system.

4 For a short film on the initiative, see https://www.youtube.com/user/LUCSUSLUMES.

Target Groups in Nyanza

Nyanza Province is located on the northeastern corner of Lake Victoria (Figure 1). The Luo, the third largest ethnic group in Kenya, constitute the dominant group in the province. Physical infrastructure throughout the area is poor, with very limited or no access to electricity, a limited water-pumping network, and no paved roads into the villages. Women head many of the households, in numerous cases either widowed or with a husband who lives and works in an urban center (KNBS, 2011). The vast majority of households have children to support. The women, often with the help of children, are responsible for most household activities, including cooking, agricultural production, water and fuel-wood collection, and washing. Household incomes, in addition to remittances from outside, are derived from activities such as basket weaving, rope and dressmaking, retail sales, and sale of agricultural commodities. Major family expenses include school and uniform fees, medical costs, and agricultural expenditures. Household-land sizes range from a quarter of an acre to ten acres and the main crops are maize and sorghum, supplemented with a variety of others products including peas, squash, bananas, onions, tomatoes, kale, papaya, green grams (mung beans), and sweet potatoes. Roughly half of the households sell crop surpluses at a local market. Intervention from Kenyan government bodies is inadequate, though 77% of inhabitants in Kenya have mobile-telephone service (CCK, 2014).

Formalized group structures, such as widows’ groups, exist in most of the villages. Various aid organizations have been active in many villages for periods ranging from less than a year to over ten years. These groups concentrate on different activities, including agriculture and agroforestry, assistance with school fees and uniforms, construction of pit latrines, and community empowerment.
The Technology

Many residents of Nyanza Province expend large portions of their income for basic needs such as water for drinking and hygiene, wood or charcoal for cooking, and food. This inhibits the ability for many of them to establish savings or to accumulate capital for investment, as well as limiting the time that can be devoted to other nominal activities. Moreover, when resources such as fuel-wood are collected, retrieval often requires the coverage of great distances, diminishing the time available for alternative income-generating activities. It is therefore important to develop and introduce technologies that are as resource efficient as possible to reduce or altogether eliminate long resource-collection times. Cooking is one area where there is room for substantial development.

Improved Stoves

Household cooking in rural Nyanza Province is usually performed indoors using the traditional three-stone technique, in which larger stones support a cooking pot that can be balanced over a fire. The use of fuel-wood mirrors trends in other low-income regions around the world where nearly three billion people rely on solid fuels like wood, charcoal, dung, and crop residues for cooking (World Bank, 2013), driving the use of approximately two million tons of biomass each day (Adkins et al. 2010). Solid fuels also contribute to environmental stress by exacerbating deforestation and global climate change (World Bank, 2013). In Kenya, 68% of all households use firewood as their source of cooking fuel, while in the country’s rural areas the incidence is over 80% (KNBS, 2011). The collection time for a bundle of wood ranges from one to five hours and the price is between 30 and 100 Kenyan schillings (KES) (US$0.35 to $1.17).

The World Health Organization (WHO) estimates that indoor air pollution is responsible for 2.7% of the global disease burden (WHO, 2007). This surpasses the WHO estimate of annual deaths from HIV/AIDS, tuberculosis, and malaria combined (Ezzati & Kammen, 2002; WHO, 2007). The smoke from burning biomass generates a variety of pollutants, including particulate matter, carbon monoxide, nitrogen dioxide, and sulfur oxides, as well as polycyclic organic matter and other carcinogens (Ezzati et al. 2000). In Kenya, only 6.5% of rural kitchens have chimneys (KNBS, 2011) and this situation contributes extensively to indoor pollution, harming women and children in particular (Ezzati & Kammen, 2002).

Because the aforementioned challenges are important in the lives of Nyanza Province’s rural residents, Benson, in conjunction with researchers, decided to create and distribute an improved cookstove. The specially designed and locally crafted clay stoves are simple in design, durable, and produced at a relatively low cost (Figure 2). They are designed to support a twelve-inch cooking pan, widely used by households in the region, and to fit a tin chimney that protrudes through the back of local dwellings. The units are also equipped with a metal plate, so a common nine-inch pan can also be used over the flame. A local potter and tinsmith manufacture the cookstoves.

This particular cookstove has a number of benefits over conventional systems. The enclosed design means increased fuel-wood efficiency in comparison to more typical arrangements. User-survey results show a fuel-wood savings in excess of 50% compared to the three-stone system, leading to, among other benefits, a decrease in fuel-wood expenses (as well as a decrease in the time needed for wood collection). The reduced fuel use is greater than the savings of roughly 25–40% reported by other studies with similar cookstoves (Bensch & Peters, 2013; Ochieng et al. 2013). Because the chimney releases the smoke outside of the kitchen, there is diminished coughing, burning eyes, and respiratory problems caused by indoor smoke, factors linked to increased medical expenses. Benson sold the cookstoves for 1,200 KES (US$14).

Technology Sales

Figure 3 shows the number of cookstoves sold annually since the start of the initiative in 2009. A total of 347 units were sold between January 2009 and January 2014. Only 30 cookstoves were installed
the first year because the majority of Benson’s time was devoted to stove development, establishing village contacts, and other administrative tasks. The number of units sold increased sharply in 2010 to a total of 148.

Cookstove sales stagnated after 2011, when Benson’s capital to finance additional units ran out. This downturn was followed by a modest capital infusion from us to Benson, after which sales again quickly increased. Sales then stopped again in 2012 due to a lack of operating capital, but picked up significantly in early 2013 (136 cookstoves) after new approaches to increase repayment rates were initiated (see subsequent sections).

Initiative Challenges

Despite initial accomplishments with the sale of the cookstoves, the initiative faced a number of impediments—both reported by Benson and that we observed—as discussed below.

Trust

The establishment of trust is an important aspect of entrepreneurship (Rothstein & Uslaner, 2005; Welter, 2012). Trust can be understood via a multi-level or hierarchical perspective: personal, community, and institutional trust (cf. Humphrey & Schmitz, 1998; Höhmann & Malieva, 2005; Sluss & Ashforth, 2008). First, at the micro-level is personal trust expressed through emotions, intentions, and goodwill among individuals. Second, at the meso-level is community trust via ethnic and organizational connections. Finally, macro-level trust is the institutional trust embedded in broader cultural, legal, and business infrastructural systems. Benson has described impediments at each level. There is a lack of institutional trust due to limited access to organizations to finance the cookstoves. This, in turn, is due to a general void of trust in government institutions. Another impediment is at the community level and arises from regional and ethnic divisions that make it difficult for Benson to sell beyond the Luo community living in Nyanza. Moreover, personal trust challenges exist due to his limited knowledge of customers’ character, intentions, and competencies. More concretely, in many cases, Benson had no direct experience with the targeted village groups. This meant initial reluctance by potential customers to provide an initial deposit because of concern that he would disappear without delivering the cookstove. In addition, customers had reservations about whether the cooking system was sufficiently durable and if the fuel savings and health benefits were as great as represented.

Benson faced similar trust issues with respect to whether buyers would repay the amounts financed, especially when the early repayment agreements were verbally communicated. Despite the oral agreements, Benson granted financing to customers.
**Links to Aid**

The large number of aid organizations working in Nyanza Province posed challenges for the initiative. Interview responses reveal that many households have over the years had contact with a variety of development groups working in the region. As noted above, there has been considerable variation in the specific organizations and the length of time that they have been engaged in a particular area, ranging from single visits to several years of support. Nevertheless, households employed a general strategy of procuring as many pre-offered goods as quickly as possible to take advantage of the *transitory* nature of many of the organizations. The presence of different groups working in the region, moreover, had created a culture among smallholders of expecting handouts, to the point where well-organized villagers proactively sought freely distributed goods and services.

The aid programs working in Nyanza created numerous immediate benefits for smallholders. But due to their prevalence in the region, we speculate that smallholders also regarded Benson’s initiative to sell cookstoves as another aid program. This perception was likely strengthened by the periodic visits to the villages by researchers from Lund to carry out interviews, which created confusion as to who was driving these activities. In addition, the longer-term experiences with the temporary nature of the aid organizations might have induced an understanding that if one deferred payments long enough the sponsoring group would cease operations in the region, an thus render the outstanding debt irrelevant.

**Transport Infrastructure**

Ensuring the safe and timely delivery of cookstoves, often over long distances, was also an important task for Benson. The underdeveloped condition of physical infrastructure, especially roads, in Nyanza hindered the success of this initiative. Paved roads throughout the region are often in poor condition and roads into the villages are usually unpaved and impassable by car. In most cases, a *matatu* (small van) was used to deliver the cookstoves from the potter to the main road closest to the village. Transportation, however, is expensive, and the units were susceptible to damage during shipment. Delivery by motorcycle was also possible, but a driver could only convey one stove at a time.

In addition to the expense of transporting cookstoves to buyers, significant costs were associated with collection of monthly installments. Due to high fuel prices and the considerable time to reach the different villages, it was not feasible for Benson to make monthly visits to each household to collect installments, contributing significantly to low repayment rates.

**Adaptive Measures**

Despite the challenges, a number of adaptive measures could place the sale of cookstoves on a more reliable footing and improve repayment rates. The main measures, presented below, arise from our ongoing dialog with Benson.

First, during the early stages of this initiative, financing was arranged via oral agreement between Benson and his customers and this transactional mode created unclear obligations for purchasers of the cookstoves. Along with Benson, we devised a system of written contracts to create a more legitimate and detailed account of the sales and the expectations of the customers. A completed contract listed the details, such as the parties involved in the transaction, the final price, as well as specifics pertaining to the financing plan (e.g., method of down payment, financing period, monthly installment amount, and payment dates). On the back of the contract was a small table for recording the amount and date of each payment and registering the remaining balance. Problems with implementation of this system due to illiteracy on the part of customers were not realized because most people had sufficient skills to understand the terms of the contract or had a household member who could do so.

Second, establishment of oversight of the contract-signing process by a village witness (e.g., group leader, village elder, or neighbor) proved an effective measure. The intention was to increase social pressure on customers to make monthly installments if they knew that another authority figure in the village was aware of the agreement. In addition, the contract had space for the authority figure to sign as a way to motivate both sides of the agreement to maintain their respective side of the contract.

Third, to improve repayment rates we recommended imposition of a small penalty fee for late installments. The fees were purposely kept low so as to not discourage repayment if a due date was missed, but large enough to motivate customers to take the repayment system seriously. The amount of the late fee was listed in the contract.

Fourth, an effective strategy to increase repayment rates entailed the use of mobile money-transfer systems (e.g., *M-Pesa*), widely available in Kenya, that take advantage of high rates of mobile telephone ownership. The system allows money to be transferred between accounts linked to different telephone numbers. There is a modest fee related to the transaction, which, in some cases, meant that one person in the village collected payments from other customers and made a single transfer to Benson. The details of the specific individuals responsible for the payments were then communicated either by text mes-
sage or telephone call. Benson envisioned the payment approach by a single individual to have the added effect of improving repayment rates through increased group pressure.

Finally, we also encouraged Benson to maintain more complete records after discovering that he had no detailed information on sales, outstanding payment balances, and working capital. Once the monthly reporting was implemented, both he and the researchers could better understand financial situation of the business.

Effects of the Adaptive Measures

The aforementioned changes were implemented throughout autumn 2012 to cookstove customers with outstanding balances. Figure 4 shows both unit sales and percentages of buyer repayment for approximately one year after implementation of the measures. Repayments are broken down to buyers who have paid for 0–50%, 51–75%, and 76–99% of the price of the cookstove and those who have paid it off completely. The bar on the left of the figure describes the repayment situation prior to the changes. No additional cookstoves were sold immediately following implementation of the measures, but Benson’s records show an increase in the number of stoves that were 76% to fully paid off, demonstrating that customers had returned to making their installment payments.

With working capital again available due to improvements in his accounts receivable, Benson was able to sell a number of additional cookstoves (third bar in Figure 4) in early 2013, where a majority of the units were sold with at least a 50% down payment (an additional sales strategy). Records show an increase in the number of stoves that were 76% to fully paid off, which included both installments made on units sold since autumn 2012 and installments made before the changes. No records were available for late summer 2013, but records for September 2013 again showed a rise in cookstove sales, with a particular increase in those that were 51–75% paid off. The final bar also shows the small number of units that were 0–50% paid off, revealing the customers who had not yet started to make installment payments despite the new measures, as well as new buyers who contributed 50% or less for a down payment.

Discussion

The Technology

The installation of several hundred cookstoves in Nyanza Province in Kenya demonstrates an interest in the technology. Although total market penetration has been modest, the price of the stoves, in conjunction with the financing plans, made the appliances accessible to most households. Along with the cookstoves’ fuel efficiency and health benefits, this situation creates optimism for robust sales in the future. Closer re-examination of user habits with the appliances, however, reveals an unanticipated development with implications for both the health benefits
and the fuel-wood savings of the appliances. Our recent visits to the region have revealed that the three-stone cooking technique is still used in the kitchens of many households with the improved cookstove. The stove purchasers relate that they use the three-stone system at the same time as the improved stove, or in some cases, in place of the improved stove. This is apparently because users prefer the three-stone technique for certain dishes that do not require intense heat or when more than one cooking surface is needed to prepare food during family visits. This insight has prompted development of prototypes for a double stove by Benson and the researchers.

An additional concern raised by introduction of the improved cookstoves is whether they are truly a “sustainable” technology. Despite the immediate benefits of reduced indoor air pollution, fuel-wood savings, and the more indirect contributions of the appliance to decreased deforestation and reduced climate-change impacts, cooking with wood (or charcoal) stoves is not necessarily fully sustainable since they still rely on scarce resources and emit a small amount of smoke in the dwelling. This prompts the following questions. Could alternative technology options (e.g., household biogas, solar cookers, and kerosene burners) be introduced in place of the improved cookstoves? What are the advantages and disadvantages of each of these options and what more general transitions in household-cooking patterns are necessary to ensure their use? Further studies are warranted to examine potential diffusion of such alternatives.

**Adaptive Measure Effectiveness**

We propose a number of measures to improve the repayment rate for the cookstoves, which initial results show to be positive. However, we have not determined which corrective measure most effectively increases repayment rates. Because the written contracts, village witnesses, late fees, and mobile money-transfer services are closely related, and have a minimal cost, we have not deemed it a priority to examine which measure is most effective in enhancing repayment rates. Our interest instead has been on replenishing working capital so that our research efforts can be extended to new innovations (e.g., water tanks) and other areas.

A variety of additional measures are potentially available to improve repayment rates. Other strategies will likely be necessary, especially when more expensive technologies are added to the portfolio. We are currently discussing with Benson the option for customers to skip a payment (or two) when their incomes are especially low (e.g., preharvest, when school fees are due). In addition, we are also exploring the alternative of “outsourcing” the technology-financing arrangements to some of the micro-finance organizations that operate in the area.

**Innovation Systems and Entrepreneurship**

Observation and participation in the early phases of this initiative prompt several reflections on the broader process of innovation diffusion and entrepreneurship. Despite the challenges, initial successes help reaffirm that entrepreneurship, in its myriad forms, can be a valuable way to foster sustainable rural development and to alleviate poverty (van Rijn et al. 2012). However, an important lesson of this market-oriented project reveals that an entrepreneur must employ innovativeness as an agent of change on multiple fronts. The main obstacles have not been to identify opportunities and to develop affordable and more sustainable solutions for households as numerous existing technology options can be used—or modified—to fit the specific needs of end-users (Barringer & Bluedorn, 1999; Kobia & Sikalieh, 2010). The innovativeness must rather come through building and maintaining a financially viable enterprise so technologies can be disseminated throughout a target region. More concretely, strong emphasis must be placed on the entrepreneur to develop the basic proficiencies to nurture a small business, such as to foster her/his skills to establish and build personal trust with village groups and individual households in finding creative ways to work through community and institutional trust challenges (Höhmann & Malieva, 2005) and to develop competencies to closely manage cash flows to ensure the resilience of the financing system. Without such a capability, end-users are unlikely to adopt these simple technologies with multiple and significant benefits.

**Conclusion**

This article has described an entrepreneur-led initiative in rural western Kenya to sell and finance improved cookstoves, focusing on the major hurdles encountered by an entrepreneur and the measures to improve repayment rates by smallholders. More specifically, we have concentrated on the use of contracts, village witnesses, payment-penalty fees, and mobile telephone technologies to improve repayment rates. We envision that these measures are applicable in other parts of the global South where market-based initiatives are used for sustainable development purposes. As this initiative progresses, new lessons will undoubtedly be learned about financing the technologies and new challenges are certain to arise.
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References


