# INTRODUCTION

## *CITE SUSTAINABILITY*

Though technology evaluation is inherently product-centric, the product itself is embedded in a larger innovation ecosystem that influences how it is used and the extent to which it spreads. A host of interdependent contextual factors, from the micro- to the mega-level as shown in Figure 1, determine whether or not an innovation is adopted and its diffusion spreads over time.

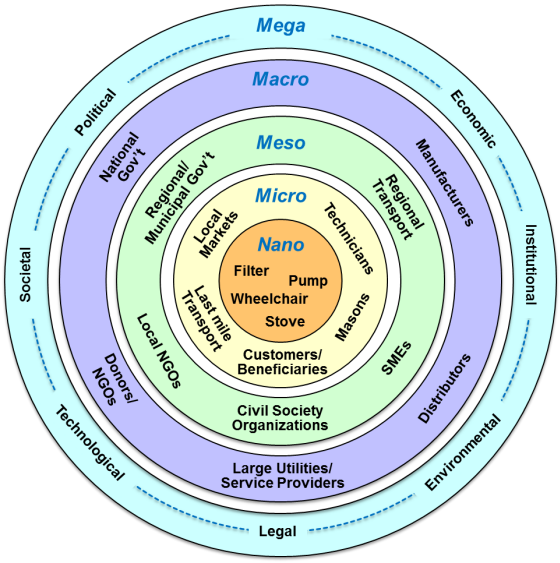


**FIGURE 1: SUSTAINABLE INNOVATION ECOSYSTEM**

Understanding the complex processes by which innovations diffuse is at the heart of the Sustainability Team's research effort. Specifically, our research program comprises three separate but interconnected efforts: 1) product assessment using a weighted criteria matrix, which will be incorporated into CITE Technical Evaluation Reports (TERs); 2) "deep dive" studies on specific elements of the Sustainability assessment that require further assessment; and 3) simulation models and decision support tools that focus on how social, economic, environmental and technical factors lead to varying diffusion and adoption outcomes over time.

In consultation with USAID and its Development Innovation Ventures (DIV) initiatives, we chose to focus on Uganda to investigate a hybrid/social enterprise diffusion strategy for our first pilot evaluation. We partnered with Solar Sister, an organization that distributes solar lanterns in Uganda through a network of women entrepreneurs. Over 4 weeks, we interviewed 80 entrepreneurs throughout Uganda to learn about their experiences selling lanterns and the sustainability of the organization's diffusion strategy.

Below, we present our main findings. First, we provide a brief overview of the Ugandan context and Solar Sister. We then offer an analysis of the hybrid model along social and economic dimensions. We end with a brief summary and the vision for our future work.

# SETTING THE CONTEXT

## *UGANDA*

Uganda is a land-locked country of 35 million people on the northern shore of Lake Victoria in Eastern Africa. Most people (85%) live in rural areas, where access to power infrastructure is limited and unreliable. Uganda's official electrification rate hovers at around 10% (5% in rural areas), low even relative to other Sub-Saharan African nations. Despite the Rural Electrification Agency's (REA) Rural Electrification and Strategy Plan (RESP) 2013-2022, which aims to achieve universal electrification by 2040 and the elimination of all kerosene lighting by 2030, low electrical coverage will likely persist. High capital costs, rapid population growth and a geographically diffuse populace have resulted in inadequate investment, evidenced in aging infrastructure with low generation, transmission, and distribution capacity. And despite a tiered tariff scheme, the cost of electrical services often remains well above many households' ability to pay.

Because the solar lantern sector is only five to six years old and has yet to penetrate fully into local markets, knowledge about off-grid, household solar lighting remains low. This is despite the low prevalence of electrification and the need for alternatives to kerosene lamps, which, according to the 2002 Ugandan census, are used by 75% of households.

The implication of low electrification and high poverty rates is clear: better, cheaper, and less-polluting energy solutions are required. Though the potential market for non-grid energy solutions may be considerable—as high as 90% of the population—demand is tempered by cost, lack of product awareness, and availability of products.

## *SOLAR SISTER*

Solar Sister was founded in 2010 by Katherine Lucey, an American businesswoman with extensive experience working as an investment banker in the energy sector. Through her participation with a philanthropic organization working in rural Uganda to provide access to solar renewable energy, she saw first-hand the lack of access to affordable, reliable, clean energy for many. Through this initial experience, Katherine realized that the need for energy far outweighed the resources available via philanthropy alone; hence, market forces had to be tapped and harnessed.

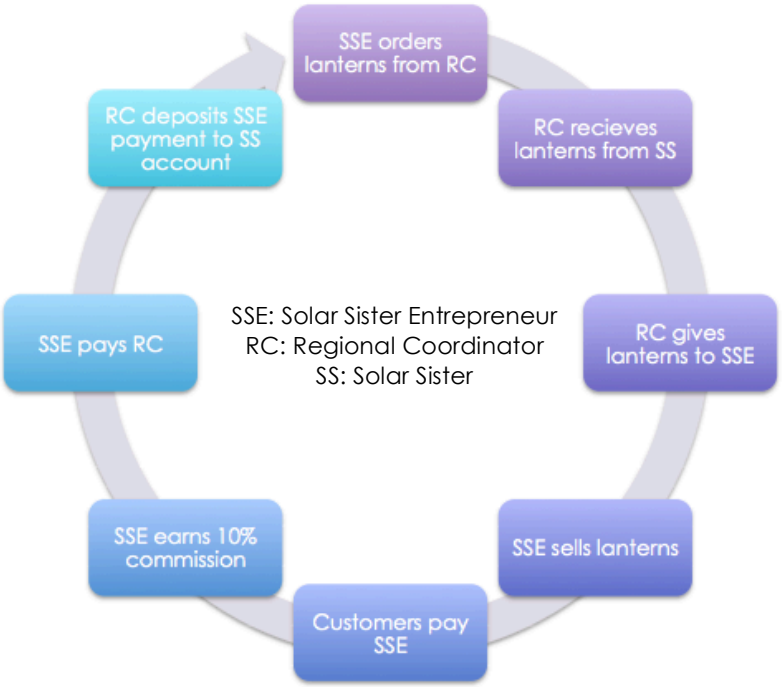


**FIGURE 2: THE SOLAR SISTER SALES CYCLE**

As a mission-driven organization, Solar Sister has a triple-bottom line. Its priority is to empower women through its network of Solar Sister Entrepreneurs (SSEs), who sell solar lanterns in their local communities. It also aims to provide access to clean energy, mostly in rural areas. Finally, it seeks to turn a profit from the sale of solar lanterns.

Though their business model has evolved over time, the core process has remained the same. Solar Sister provides an opportunity for each woman to own a micro-business by providing each SSE with training and start-up capital, a "business in a bag," which consists primarily of solar lanterns, but also includes marketing and other materials. SSEs are then sell the lanterns to friends, neighbors and colleagues, earning a commission with each sale. This augments household income while also bringing energy and light to areas that need it most. Since its inception three years ago, Solar Sister has grown rapidly, recruiting and training over 400 entrepreneurs in Uganda, about 275 of which have remained active. Beginning in 2013, the organization began to scale its operations, expanding into Tanzania and Nigeria, with plans to recruit an additional 3,000 entrepreneurs by 2015.

# FINDINGS

## *SOCIAL*

**TABLE 1: SOLAR SISTER'S HYBRID MODEL – STRENGTHS AND CHALLENGES**

| Strengths | Challenges |
|---|---|
| • Trust, strong customer-service orientation<br>• Community embeddedness and "insider" knowledge of SSEs<br>• Large potential market<br>• Focus on last-mile (poor, rural) users | • Transport and distribution<br>• Consumer knowledge about lanterns<br>• Financing, credit and payback<br>• Balancing social and financial objectives<br>• Entrepreneur retention: quality v. quantity |

There are several benefits in joining Solar Sister. Increased social status and pride were prevalent, as family members and friends reacted positively to the decision. Trainings were another key positive feature of being a SSE, yielding the opportunity to learn new business skills (accounting, marketing techniques) and interact with other entrepreneurs. Many SSEs were able to integrate lantern sales into their daily lives: selling lanterns at work, when traveling, or at night when the lanterns can be easily demonstrated. SSEs also realized that sales tend to be seasonal, especially in rural areas: customers are likely to buy lanterns when they have more cash on hand, such as post-harvest. The additional household income generated was much needed. Monthly spending exceeded household income on average, and went primarily toward children's educational expenses, food and small household items.

Despite the many positive aspects of entrepreneurship, nearly all entrepreneurs interviewed faced a steep learning curve due to numerous difficulties, especially during their first few weeks. Lantern price, convincing potential customers of the product's merits, and transportation (including associated costs, which can cut into commission earnings) were consistently cited as the primary challenges SSEs confronted. An additional challenge was concern over growing competition—hawkers whose products are of poorer quality, which turn people off to the entire product family, but also private companies, such as Total, who have now begun to sell the same solar lanterns, often at lower prices. Another frustration commonly encountered was that consumers wanted to purchase the lanterns (especially ones with phone charging capability), but many could not afford them. Even when SSEs completed a sale, getting customers to pay the full price of the lantern proved challenging. While these difficulties challenge the model's sustainability, continued recruitment and the existence of successful SSEs signify the viability and attractiveness of selling solar lanterns through a network of women entrepreneurs.

Based on probability and regression analyses, we found evidence that successful SSEs possess at least one of three important factors: intrinsic (non-monetary) motivation,

good communication skills and ability and willingness to travel long distances to find potential customers. Trainings geared toward cultivating these factors may help with higher SSE retention and improved sales.

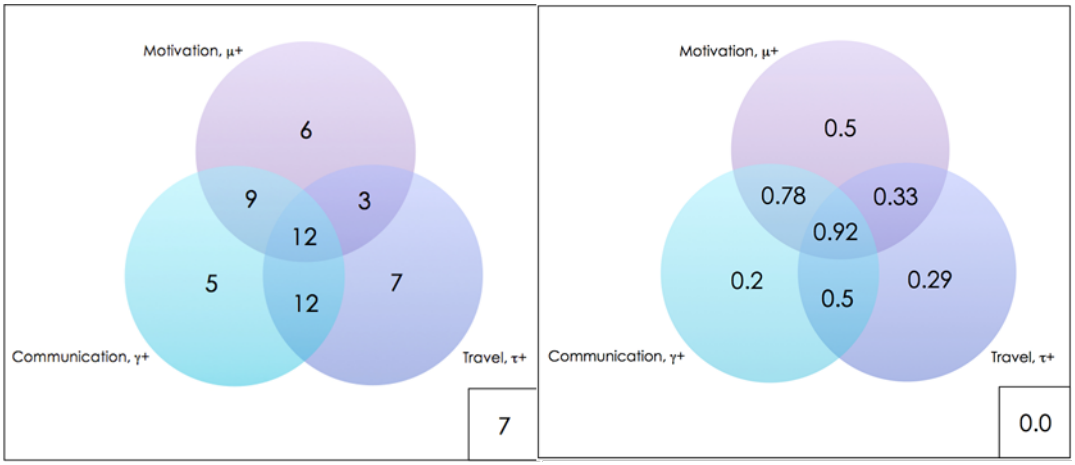


**FIGURE 3: SUCCESSFUL ENTREPRENEURS; TOTAL SSES (LEFT), RATIO OF SUCCESSFUL-TO-TOTAL SSES (RIGHT)**

## *ECONOMIC*

While Solar Sister has grown significantly, as shown in Figure 3, ratio metrics seem to have remained relatively constant since 2011. On an aggregate level, approximately 70% of lanterns purchased by Solar Sister from manufacturers were sold.[1] Lantern sales per entrepreneur have remained even over the last two years at around 19. Likewise, SSEs' average annual commission, $55 in 2013, has changed only marginally since 2011. Income from lantern sales, as a percentage of Solar Sister's expenses, has also remained relatively steady over the past two years.

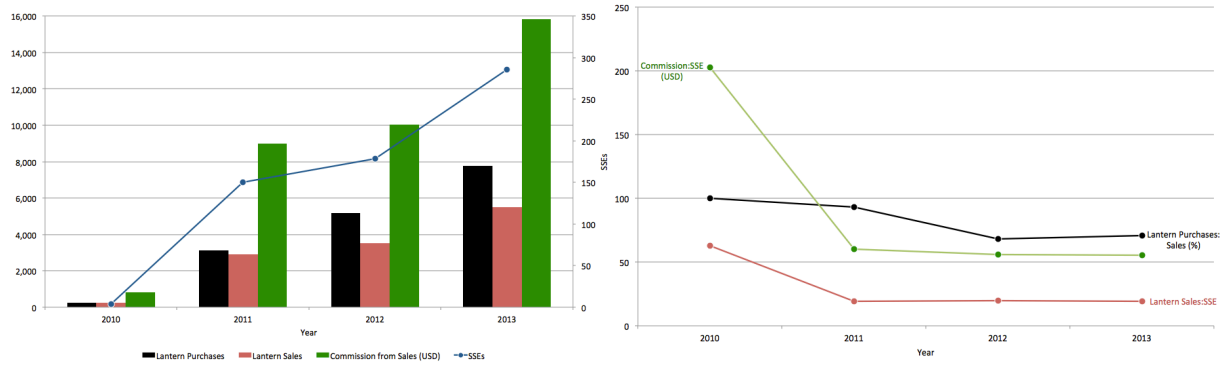


**FIGURE 4: SOLAR SISTER GROWTH (LEFT) AND RATIO (RIGHT) METRICS**

*Note: 2013 data are projected from January-February 2013 data. "Purchases" are lanterns sold to Solar Sister from manufacturers and distributors. "Sales" are lanterns sold and distributed to entrepreneurs from Solar Sister.*

[1] Sold is defined as lanterns distributed to SSEs, for which they are financially accountable.

Solar Sister's performance can also be measured by lantern model and regionally. Lantern sales have changed over time as Solar Sister strives to find the best products for its end users. D.Light's Kiran and Nova models were popular in 2010 and 2011: the Kiran was relatively cheap ($15), had a built-in solar panel, and diffused light well, while the Nova could charge phones and was durable. In 2012, Solar Sister began purchasing GreenLight Planet's SunKing Pro model—which could charge phones, had a bright light and multiple settings, and had a unique design that allowed users to point the light in any direction—and became its best seller in the early part of 2013 followed by the D.Light S1 model and the Firefly Mobile. Though the number of models has expanded considerably, the lanterns distributed to SSEs seem to have declined. In 2010, 100% of all lanterns purchased by Solar Sister were distributed to SSEs for sale. In 2013, this percentage had dropped to a range between 58% and 12%, depending on the model. This suggests that the amount of time a lantern is stored at the central warehouse before being sold to a SSE may be longer than desired. Decentralized, direct shipment of lanterns to each region might help improve the proportion of lanterns distributed to SSEs, and may be more scalable in the long-run, though this would incur additional logistical and warehousing costs.

In 2010, only the Soroti and Central regions were active; Gulu, Fort Portal, and Rukungiri were initiated in 2011; and Jinja joined in 2012. Between 2010 and 2013 the Central region has managed to distribute a larger proportion of purchased lanterns to their SSEs than the rest. Soroti follows Central, successfully distributing 87% of its purchased lanterns to its entrepreneurs from 2010-2013, with Gulu and Rukungiri not far behind at a cumulative sales ratio of 77% and 79% respectively. Fort Portal lags at 44%. From this, there appears to be somewhat of a correlation between the length of time that a region has been involved with Solar Sister and sales ratio, suggesting that – in time – this metric may improve for more recently-initiated regions such as Jinja and Fort Portal.

Over time, Solar Sister's credit model has evolved as it learns and adapts from on-the-ground experiences. Initially, a 100% credit model was adopted, the logic being that Solar Sister wanted to keep the barrier to entry as low as possible. However, it became quickly apparent that this model was untenable: without any monetary stake in their success or failure selling lanterns, SSEs were not particularly motivated. To remedy this, they then moved to a 10% commitment fee, where SSEs are required to pay for 10% of the lanterns they order upfront. This was an improvement, but Solar Sister still continued to face challenges with timely payback. As a result, and because of their successful experiences in Nigeria and Tanzania, Solar Sister has now transitioned to a no-credit model, where SSEs must pay for 100% of their product upfront; it's too soon to say whether or not this shift is working in Uganda. This evolution speaks to the central importance of finding an appropriate financing mechanism to organizational success and the ability to get solar lanterns into the hands of as many end users as possible.

# SUMMARY AND FUTURE WORK

Solar Sister's distributed, direct sales hybrid/social enterprise model has grown significantly since 2010, and with it has come some growing pains. There have been challenges along the way, especially in balancing the dual goals of high desired social impact and financial viability. But these challenges have been acknowledged and Solar Sister has demonstrated flexibility and a willingness to learn and improve—important attributes for sustainability, especially during the start-up phase of an organization.

The use of social networks and the active promotion of new technology is a core strength of Solar Sister's hybrid model. SSEs, as community insiders, implicitly possess legitimacy, while taking the initiative to pursue customers serves to diffuse product knowledge more quickly than traditional commercial means, where a product sits on a shelf and the customer must "discover" it for herself.

These challenges, though frustrating when faced first-hand, speak to the importance of Solar Sister's work. For instance, customers cannot want something they do not know about. The fact that household solar lanterns are still not a well-known energy option means that Solar Sister is creating product awareness among consumers, a fundamental step in demand creation and therefore technology adoption. Additionally, convincing customers, while challenging, is best achieved through repetitive interaction. Because SSEs are community members and because they are actively seeking out customers, they are more easily able to interact with customers multiple times, increasing the likelihood of adoption.

While organizational factors and policies, such as finding the best credit policy and deciding which lantern models to include in the product catalog, prove important, the sustainability of Solar Sister's approach hinges on its ability to recruit, train, and maintain SSEs. Providing SSEs with the support and tools they need to be successful achieves all three of Solar Sister's goals: it empowers women through economic opportunity, it gets clean energy into the hands of end users, and it increases the proportion of operating costs covered by sales. Doing so cost-effectively and resource-efficiently will be a primary indicator of Solar Sister's sustainability as it scales.

For CITE Sustainability, our work with Solar Sister and solar lanterns was our pilot evaluation, and we learned a great deal. From this pilot, it has become evident that, if the ultimate goal of technology evaluation is to impact adoption in a positive way, understanding the complex socio-economic processes surrounding a technology is just as important as designing the "right" product. Moving forward, we plan to expand upon this type of research as discussed in the Introduction.

Specifically for 2014, we will complete as least two evaluations, with the first tentatively scheduled to begin in India in spring 2014. For the next evaluation, we hope to address the question of which household level water treatment options are the most sustain able. In addition, we will start at least one research study, although more may be conducted if MIT graduate students wish to pursue individual topics. Finally, we are working on the macro-level systems model using the commercially available AnyLogic program. This modeling platform will allow us to combine a variety of different modeling techniques to produce a decision support tool. This will also maintain synergy with other projects CITE Sustainability researchers are working on, which will allow us to leverage resources.