

# Off-Grid Solar Pilot Program for Lighting the Villages Around Lake Bunyonyi in Southwestern Uganda



## The Global Livingston Institute

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**Table of Contents**

**Abstract ..... 3**

**Hypothesis:.....3**

**Background: .....3**

**Methods: .....3**

**Results:.....3**

**Conclusion: .....3**

**Introduction ..... 4**

**Goals & Objectives ..... 4**

**Methods..... 4**

**Partnership .....5**

        Product Details ..... 5

**Marketing—Initial Approaches .....6**

        Agent-Based Model..... 6

        Systemic Random Sampling Strategy (To be carried out) ..... 7

        Credit..... 8

**Financing Models.....8**

**Monitoring & Evaluation.....8**

**Results ..... 9**

**Financial Statement .....10**

**Conclusion .....11**

**Next Steps .....12**

**References.....12**

**Appendix: About the Global Livingston Institute .....13**

## Abstract

**Hypothesis:** Off-grid solar systems will provide affordable, reliable and sustainable energy to rural households, help residents reduce or cease the hazardous practice of indoor kerosene/paraffin/candle use, and promote social and economic development.

**Background:** Lake Bunyonyi lies in Southwestern Uganda, surrounded by verdant hills and adjacent to many villages and communities. These villages are isolated, with most residents identifying as small-scale farmers. Due to geographic isolation and affordability concerns, power grids generally do not connect to these villages. With an average household daily income of about \$2, community members lack options for safe and reliable electricity and lighting. Here, we test the hypothesis that off-grid household solar energy devices are safer than available alternative energy sources. We further hypothesize that these devices directly contribute to better health, education, income, and wellbeing of community members.

**Methods:** The Off-Grid Solar Pilot Program was launched by GLI to better accommodate the electricity needs of community members. The program began with an energy needs survey conducted with community members to understand their needs and experiences, as well as their preferred solutions or interventions. The marketing strategies used to engage more community members in the renewable energy practice are poster/flyer, word of mouth, and implementation of an agent-based model. Flexible financial options are introduced to ensure all households can acquire an off-grid energy system, which include options to pay upfront in cash, pay in installments, or rent the device. Lastly, GLI has introduced a monitoring and evaluation (M&E) framework to measure the short- and long-term impact of renewable solar energy in households, which measures changes in social, economic, and environmental conditions subsequent to the introduction of household solar energy devices.

**Results:** Analysis indicates that the amount of money households spend buying kerosene, paraffin, and candles can exceed the cost of a reliable off-grid energy system in the long term. Community members who participated in the early trial of the off-grid solar pilot program have confirmed improvements in various aspects of life including overall health, education, and relationships.

**Conclusion:** Through both field research and a needs-based survey administered with community members around Lake Bunyonyi, we conclude that off-grid solar energy is the best currently feasible option for providing these villages with safe, reliable, and affordable electricity.

**Keywords:** Off-grid Solar System, Social & Economic Development, Scalability, Monitoring & Evaluation

## Introduction

GLI administered an energy need survey in eight different villages surrounding Lake Bunyonyi. About 80 percent of the households in these villages use kerosene/paraffin lamps or candles as a primary light source. Some of the major drawbacks of using kerosene, paraffin gas and candles for lighting sources are that these energy and light sources are as follows.

- Hazardous to personal health – These light sources especially endanger the health of children and women working late at night. They also produce black stains on the ceiling of households and can be fire hazards (SolarAid, 2020).
- Bad for the environment – Kerosene and paraffin can pollute the lake and the environment around the home.
- Economically unfeasible – Kerosene, paraffin, and candles are very expensive to buy and “families often spend 10 – 15% of their household income on kerosene” (SolarAid, 2020). Further, the usage of these sources hinders economic vitality by making it unbearable to work in the home due to direct exposure and inhalation of fumes (World Health Organization, 2018).
- Inadequate for modern household energy needs – These resources do not provide critical services in a modern economy (i.e. phone charging or adequate light). They can inhibit social interaction with family members and neighbors at night.

To combat the practice of using harmful lighting sources, the alternative solution must be effective and affordable and must meet a household’s lifestyle needs. The electricity generation from traditional power grid and microgrid are not infrastructurally or economically feasible due to geographic barriers. Hence, GLI launched the off-grid solar pilot program to make renewable energy accessible to community members in order to alleviate the aforementioned drawbacks. The program allows community members to acquire an off-grid solar system at an affordable price. Ten households participated in the initial trial testing the effectiveness of the project, with future plans for scalability in place.

## Goals & Objectives

The ultimate goal of this pilot program is to provide a proof of concept for an economically sustainable model for providing rural Ugandans in the Lake Bunyonyi region with affordable, reliable, and clean electricity. This directly contributes to improved outcomes in terms of health, education, income generation, and overall well-being of the participating households.

## Methods

For a community development project to be successful, it is important to first understand the community’s perceptions and experiences of the issue to be addressed. The best way to do this is by involving the community in the project from the start. GLI conducted a needs analysis, or vulnerability assessment, to learn about the energy needs of the community members. This was done by interviewing and surveying households from different villages and conducting group meetings with community members. This helped GLI better understand the problems associated with the lack of affordable, clean energy in the villages, as well as the factors—educational, social, and economic—in play as households

make energy-related choices. With this baseline analysis complete, GLI moved to find a product and program model that would respond to community needs and conditions.




**Partnership**

With many off-grid solar options available in the market, it is important to identify a product and a partner that can be relied upon. After exploring available options from the standpoints of functionality, reliability, serviceability, and cost, we formed a partnership with a solar enterprise called Greenlight Planet to offer household solar devices to interested community members. Greenlight Planet is a for-profit solar energy business enterprise that designs and distributes off-grid solar products to underserved populations around the world that lack access to electricity. It has sold and distributed more than 9 million solar products across 4.5 million homes in over 40 countries (Greenlight Planet, 2017). The prices of the devices range from \$5 to \$400. They have won numerous awards for their reliable, cost-effective and sustainable design, including the MIT Design Award.

**Product Details**





One benefit of Greenlight Planets offerings is the availability of a spectrum of off-grid solar options to choose from, depending on the energy needs and economic situation of each household. GLI offers home systems and solar lamps that come in various models, and we help customers choose the appropriate model to meet their specific needs. Based on the preliminary analysis described above, GLI learned that between three and four light bulbs and a phone charging port are essentials, which makes the Home 60 and Home 120 models the most convenient package for average-income households in the region. The solar lamps are an equally popular choice, as they are portable and easy to carry around. All models come with two years of factory warranty and five years of battery life. The specifications of available off-grid solar devices are given in the charts below.

**Home Systems**

 <p style="text-align: center;"><b>Home 60</b></p>	 <p style="text-align: center;"><b>Home 120</b></p>	 <p style="text-align: center;"><b>Home 400</b></p>
6 Watt	12 Watt	40 Watt
24 hrs run time in full charge	24 hrs run time in full charge	8 hrs run time in full charge
100 lumens on each hanging lamp. Total output 30X brighter than kerosene lamp	200 lumens on each hanging lamp. Total output 60X brighter than kerosene lamp	TV- 6 hrs of night viewing Overhead lamps- 40X brighter than kerosene Tube lamps- 80X brighter than kerosene lamp

1 USB port, 3 hanging lamps with switches	1 USB port, 3 hanging lamps with switches	19-inch digital TV, 2 tubes lights, 2 overhead lights, 1 motion sensor security light, 1 radio
Wholesale Price: \$ 68.26 MSRP: \$ 90.00 Margin: \$21.74 (32%)	Wholesale Price: \$83.14 MSRP: \$ 116.00 Margin: \$32.86 (40%)	Wholesale Price: \$327.00 MSRP: \$ 440.00 Margin: \$113.00 (35%)

### Solar lamps

 <b>PICO PLUS</b>	 <b>PRO 200</b>	 <b>PRO 300</b>	 <b>PRO 400</b>
0.35 watt, integrated polycrystalline solar panel	2.35 watt, comes with 5V USB power output	5.5 watt, comes with 5V USB power output	5.5 Watt, comes with 5V USB power output
Up to 72 hours of run time	Up to 72 hours of run time	Up to 100 hours of run time	Up to 100 hours of run time
50 lumens total flux, 5X brighter than kerosene lamp	220 lumens total flux, 20X brighter than kerosene lamp	330 lumens total flux, 30X brighter than kerosene lamp	440 lumens total flux, 40X brighter than kerosene lamp
Wholesale Price: \$5.34 MSRP: \$8.00 Margin: \$2.66 (50%)	Wholesale Price: \$14.72 MSRP: \$21.00 Margin: \$6.28 (43%)	Wholesale Price: \$24.59 MSRP: \$34.00 Margin: \$9.41 (38%)	Wholesale Price: \$25.14 MSRP: \$ 36.00 Margin: \$10.86 (43%)

### Marketing—Initial Approaches

There are various marketing strategies that were initially considered; primarily 1) word-of-mouth and 2) posters. Because of the remote village setting, the word-of-mouth method would be less efficient. We created awareness posters with advertisements of off-grid solar to put in different high-visibility locations in targeted villages. Most farmers don't speak English, and many cannot read their native language of Rukiga. Therefore, the poster method also yielded implementation issues. Consequently, it was necessary to look at other methods that require a more verbal and relationship-based approach to marketing. These methods are explained below.

### Agent-Based Model

The agent-based model is implemented by one "mobile agent" and multiple "immobile agents". As these terms indicate, an immobile agent remains in one place/office and is responsible for training mobile agents (meeting with them weekly), bookkeeping (tracking and recording sales) and accounting. Mobile agents visit different villages to promote the awareness of clean energy and to reach more end-users. They target important areas in the villages where people come together for different events to promote

awareness of clean energy. Agents are autonomous, active, and adaptive. They interact and engage with consumers in ways they find comfortable and effective. We hire “mobile agents” from different villages so they are more comfortable reaching out to households from their respective villages. Agents bring customers into the program and receive a commission of five to 10 percent on their sales, which incentivizes them to be more proactive and reach more customers. The steps of the agent-based model are illustrated in the chart below:

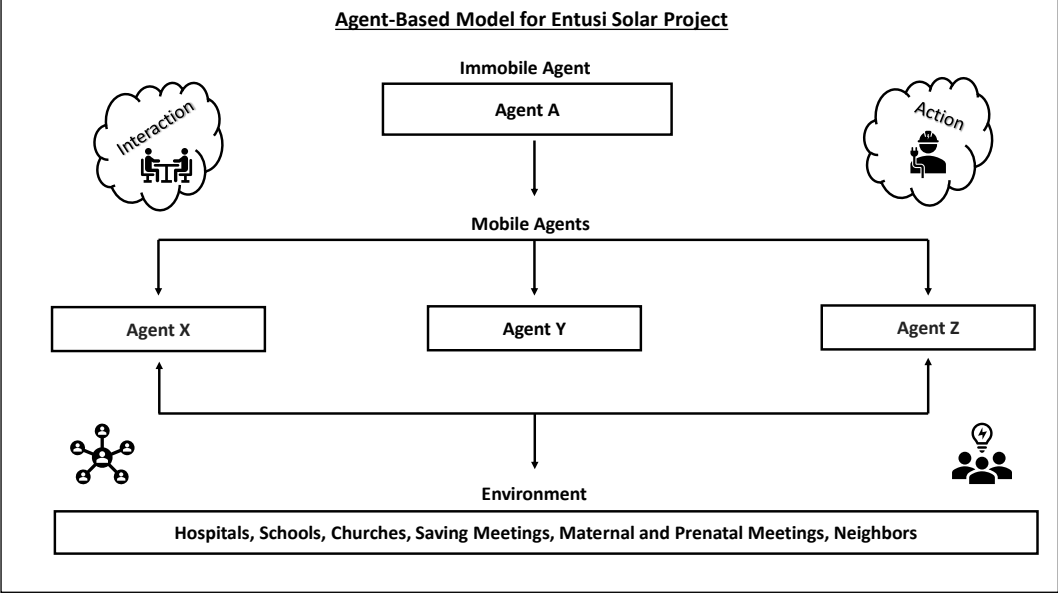


Table 1. This table presents the basic building blocks of the Agent-Based Model.

**Systemic Random Sampling Strategy (To be carried out)**

It is not an easy task to change a custom that has been in practice for decades in a given community. That is the case with convincing community members to eliminate the usage of familiar light and energy sources—kerosene, paraffin, and candles—in favor of an “unknown quantity” like off-grid solar. Community members justifiably have many questions in terms of cost and reliability. They also must consider the very different economic model requiring a large one-time investment at outset, in relation to the advantages and disadvantages of solar energy. In order to gain trust and demonstrate this project’s value proposition, we will use a randomized control trial (RCT) to illustrate the difference of using solar lamps relative to using kerosene lamps.

The plan is to randomly select 10 students from one school who are from different villages. We will then give them a solar lamp to take home in the evening after school and ask them to use it at night to study or for other work. Then the student will bring back the lamp to school the following morning. They will continue to receive a solar lamp every evening for a month for free. We will track the behavior and progress of these students in school and present this data to the school staff to compare with students who are not participating in the trial. We will also track any changes in behavior of the participants’ families. After a month, we will start to charge a small fee of about 250 Ugandan Shillings (UGX) per night for the solar lamp if they are interested in renting. This amount is equivalent to about 6.8 cents in USD. If

the model proves successful, it will make access to electricity for the households in more isolated areas much easier, as the students will be transporting the light to their homes for their families to use. The goal is to help participants see the tangible benefits of solar light and boost their confidence to invest in it. Ideally, this will subsequently influence their peers to also make the change to solar energy.

### Credit

A simple type of credit-based solar rental method was strategically designed by *JiroVe*, an enterprise in Madagascar, and is widely and successfully used in different parts of that country. Their model functions by establishing a franchise that charges a certain number of LED lights during the daytime using solar energy and distributing the lights to households in the evening to use for lighting at night (“Lighting up Madagascar,” n.d.). Then, in the morning the franchise collects the lights, along with a small fee from the users, and the cycle continues (“Lighting up Madagascar,” n.d.).

### Financing Models

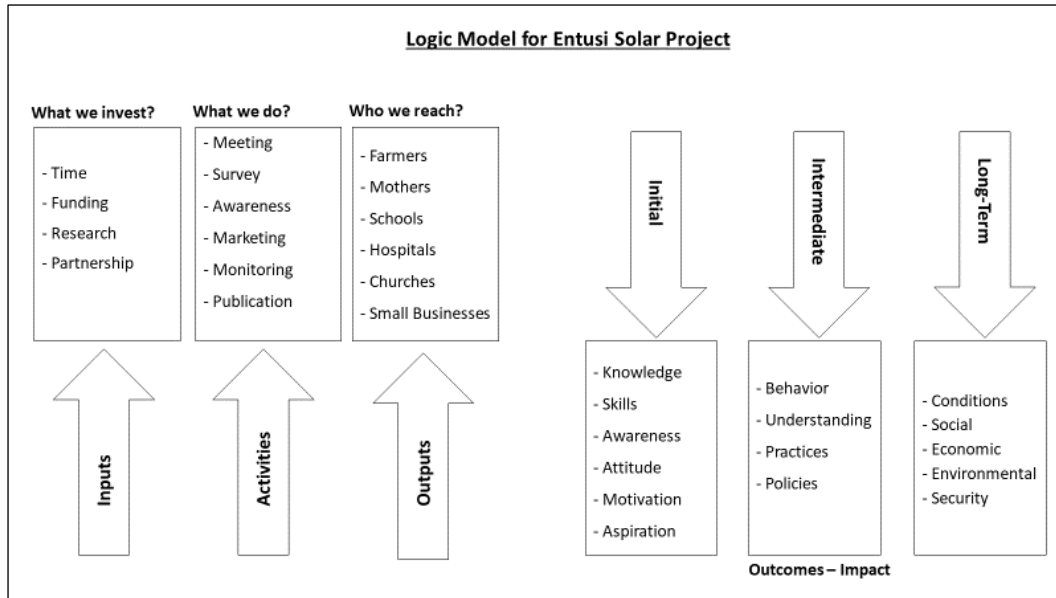
Upfront Cash	Flexible Loan	Smart Lending (To be carried out)
If the cost of the device is within the savings of the costumers, we encourage them to pay upfront in cash rather than paying monthly installments. If the customers pay the total price of solar devise, they own it outright.	We provide flexible loans for those who need the device but are not able pay upfront. We ask for a 30 percent down payment, with the remaining cost paid in installments for three months at zero interest.	A user can rent a solar lamp in the evening to use it at night at a small fee and return it back the next morning. This method gives flexibility to users and enables them to acquire the light in emergencies or specific occasions when they need it.

### Monitoring & Evaluation

We divided the process of monitoring into three different phases for effective data and feedback collection inspired by the United Way outcome evaluation model (United Way, 2015).

1. **Initial Outcome Evaluation:** Takes place 15 days after the household starts using the device. The agent or franchise conducts a survey of the household to examine whether they have acquired necessary skills to operate the device. The survey aims to examine awareness, attitude, and motivation of the family members.
2. **Intermediate Evaluation:** Takes place after three months to understand the behavioral change and changes in practices.
3. **Long-term Evaluation:** Takes place after one year to examine if the overall wellbeing of the family has improved and what role the solar device has played in the household.





*Table 2: The Logic Model table presents the overview of the project and discusses different phases of the outcome evaluation*

## Results

From the evaluation survey, it was learned that the average households spend a total of \$3.50 to buy kerosene, candles and paraffin, which typically last for a month. In addition, they spend \$0.50 per month to charge a phone in the market. Almost all the households in the villages own a simple mobile phone even if they don't have electricity at home. Cost-benefit analysis was done to compare the economics of three available alternatives: 1) Buying kerosene/paraffin/candles, 2) Buying an off-grid solar system and 3) Doing nothing. The result indicates that the off-grid solar option is inexpensive in comparison to kerosene, paraffin and candles, and it allows households to save more than 50% of the capital that would be spent on kerosene in five years. The following equation gives the total savings for community members over five years with solar:

$$\text{Total savings in five years} = (\text{cost of kerosene/paraffin/candles} + \text{cost of charging phone}) - \text{cost of solar}$$

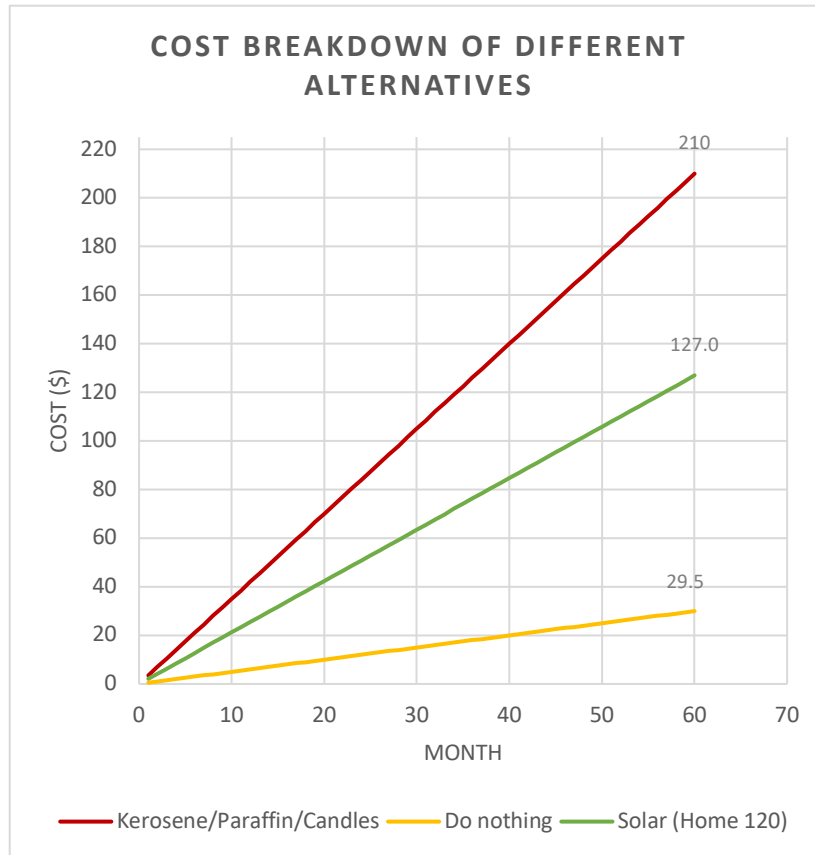


Figure 1. Cost analysis of different alternatives for five years period

### Financial Statement

Because our goal is sustainable community development, the responsible approach was to start small to determine the demand for this service—not to foist a new high-tech solution on a community that doesn’t want it. Thus, we made a modest initial investment in solar devices to test and troubleshoot the model. Of the initial customers who chose a financing option, the ‘on-time’ repayment rate has been around 85%. The profit margin on the initial batch of devices is approximately 36%. This is a good indicator that the pilot project is promising and potentially sustainable.

Qualitative results are based on the outcome evaluation methods explained previously. The first ten households to participate in the initial trail were evaluated using the ‘initial outcome evaluation’ fifteen days after they purchased the off-grid solar system. This initial evaluation gives an insight on change in behavior of family members within the first few weeks of experiencing the solar lights. We have collected few testimonials from households using the initial outcome evaluation survey. They are found below.

### **House #1: (Mercy)**

Mercy is a farmer and a mother of three and she is expecting another baby soon. She also has a small shop just outside her house. She used to buy candles to do household work at night and for her children to study. After learning about harmfulness of candle fume in children and herself (and her unborn baby), she bought a solar lamp on a loan. Now, her three children all study together in one lamp, and she takes turn to take the lamp to do other household work at night. She has taken that lamp to the shop a few times when it was available and opened the shop two more hours after dark, selling more products. She is saving to add more solar lights soon as both the family and business are growing.



### **House #2: (Remegio)**

Remegio is a father of five children. He used to buy one liter of kerosene per month at UGX 3,000, charge his phone three times per month at UGX 500 each time, and buy candles at UGX 4,000 per month. But, he hasn't spent a shilling on any of these things since he bought a solar device at UGX 331,000 and put lights in four rooms. During the five-year battery life of his solar device, he will save UGX 179,000 from not buying kerosene, candle and not charging phone outside. Already, his kerosene lamp sits unused in the corner, on its way to obsolescence.

Remegio said he bought solar because "I learned about the bad health effects of kerosene fume in my children and my family from the healthcare people in my village and that's when I decided to buy solar"

The intermediate and final evaluation take place after three and twelve months, respectively. These evaluations provide more specific result in terms of improvements in health, education, income, and overall wellbeing.



## **Conclusion**

For as long as members of these communities can remember, kerosene, candles, and paraffin have been used as light sources in people's homes. They are easily available, practical, and do not require big investment. Many community members are not aware of the detrimental effects of using these sources—and even if they are aware, other options are not always seen as accessible or affordable. The difficulty in changing this widespread practice is to break through the familiar practice of using harmful, inefficient light sources and introduce the concept of renewable energy in the villages. The ideal way to do this is to make the alternative energy option available for customers to try to see for themselves its utility and value. As demonstrated above, the off-grid solar option makes sense from the perspectives of health and

economics, and initial demand and reaction suggests that it is a viable alternative if we can continue to grow the model and make it more widely known, available, and affordable.

## Next Steps

The next step for GLI is to implement the smart lending method to make electricity accessible to all interested community members despite economic status or geographic isolation. We will start this by carrying out the school-based systemic random sampling trial described above to understand the impact and feasibility of this method. The resources needed to conduct this study are solar lamps from the Greenlight Planet, partnerships with schools and community leaders, and an effective research plan to help monitor and track the outcomes. We will first implement this method in Bwama Primary School in Lake Bunyonyi that has around 200 students. If the method proves promising, we expect about 80 percent of the students will use this service. We will then expand the rental service to other schools.

GLI's constant mantra and animating philosophy is Listen. Think. Act.® The organization firmly believes that any community development project should be structurally sound, culturally appropriate, community-driven, and financially sustainable. The off-grid solar pilot program was carried out only after initial fact-finding and determination that this project meets those core criteria. The methods used are data-driven and designed with focus on the human dimensions. Instead of taking the traditional philanthropic approach involving charitable "giveaways," GLI is taking a market-based approach to promote accountability, ensure community buy-in, and move the project toward self-sustainability. The profit allocated from the sales and services of the off-grid solar system will be reinvested in the project to expand its scope in the future.

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## Appendix: About the Global Livingston Institute

The Global Livingston Institute (GLI) is an education and research-based institute that works with students and community leaders to educate current and future changemakers, change the dialogue about sustainable development, and create empowering jobs. Since its founding in 2009, the GLI has recruited motivated students and leaders in East Africa to work together to reframe how we approach sustainable development and improve communities globally.

In addition to work on increasing health services in East Africa through free concerts and music festivals, GLI opened Entusi Resort and Retreat Center in 2013. Located in Kabale, Uganda, it serves as a meeting place for people of all backgrounds to come to together in order to discuss, and question the way we handle complex social issues from the local, national, and global perspective.

GLI's mantra and animating philosophy is "Listen. Think. Act." This is emblematic of the organization's goal to move away from the mentality that involves trying to "fix" communities and instead move toward a better understanding of and ability to listen to communities before proposing solutions. The mission of the GLI is to facilitate strategic and innovative approaches to international development while stimulating awareness, harnessing collaboration, and encouraging personal growth.

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