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Study of Social Entrepreneurship and Innovation Ecosystems in the Latin American Pacific Alliance Countries

Case Study: Sistema Biobolsa, Mexico

Fundación Ecología y Desarrollo

Office of the Multilateral
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CASE STUDY

SISTEMA BIOBOLSA, MEXICO

Multilateral Investment Fund (IADB) ·
Fundación Ecología y Desarrollo

July 2016

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Esther Altorfer, Finance Director, Sistema Biobolsa
Jason Prapas, Chief Technology Officer, Factor(e) Ventures
Juan Barbed, Portfolio Manager for Central America, Caribbean and Mexico, Kiva

1. Introduction

Name: Sistema Biobolsa	
Description	Sistema Biobolsa manufactures, installs and facilitates finance for high quality, affordable biodigester technologies, empowering farmers with long term sustainable resource management solutions.
Founded	Buen Manejo del Campo. S.A. founded 2010 in Mexico D.F.
Legal format	Private limited company (*Sociedad Anónima de Capital Variable*).
Num. employees/volunteers	23 full-time staff in Mexico, 2 full time in Nicaragua.
Geographical reach	25 states in Mexico and Nicaragua.
Certifications/ awards	BiD Social Entrepreneur of the Year, Ashden Award Finalists (2010), Ashoka Fellow (2011), 2nd Place *Iniciativa Mexico* (2011), Echoing Green Finalists (2012), Buckminster Fuller Finalists (2014), B-Corporation (2015).
Social innovation variables	
1. Innovation type	A durable, lightweight, zero-waste, easily transportable and quick-assembly biodigester is the patented product innovation. Peer to peer validation, tailor-made financing, long term support and monitoring are innovations in the process.
2.Social impact	14,442 lives impacted through 2,440 installed systems. 150,000 tons of waste managed, 4,500 tons of biogas and 350,000 tons of organic fertilizer produced, 17,000 tons of CO_2 mitigated.
3. Financial sustainability	A blend of public subsidies and zero-interest loans provide farmers with a ROI in the first month of usage and exponential growth enabling the company to achieve profit margins of 18%.
4. Key Partners and Support ecosystem players	Public agricultural, environment and energy agents provide subsidies for farmers, private investors have supported the company since the start and international NGOs help build reputation for the founder and the company.
5. Scalability and Replicability	Expanding operations to Nicaragua (2016), 3 other Latin American countries (2017) and India and East Africa (2018).
References	www.sistemabiobolsa.com

2. Local Social Issue and the Challenge

Sistema Biobolsa addresses a set of integrated problems that threaten the livelihoods of rural farmers across the globe. These include poor waste management, soil degradation due to chemical fertilizers, increasing energy costs and the use of wood for fuel, exacerbating deforestation. In addition, each of these problems contributes to climate change. In Mexico 21% of the population live in rural areas, agriculture represents 3.5% of GDP and there are an estimated 4 million small-scale producers who face this set of challenges.

Lack of waste-to-resource culture

Organic waste is an under-used resource in rural Mexico and Central America where animal manure is often left in cattle pens or piled up in areas close to living spaces for up to a year, waiting to decompose into organic fertilizer. This attracts flies and as the manure often drains into shared irrigation systems and the drinking water supply, causing serious health problems. The challenge in Latin America is the lack of knowledge of the potential benefits of organic waste as a resource and the lack of access to the appropriate technologies to convert manure into a source of energy and organic fertilizer.

Costly farm inputs

Many farmers rely on imported chemical fertilizers to boost their production, the costs of which can become crippling for the farmer, especially as they are usually expensive one-off purchases in bulk. Persistent use of chemicals will deplete the soil of the nutrients essential for crop production and is also associated with health problems and diminishing yield in the long term. Another costly input is energy. Mexican farmers typically use fossil fuel-based LPG gas, which can be both costly and intermittent especially for more remote farms. Wood is also often used for cooking, with associated health risks from the smoke, time spent by women and children collecting the wood, as well as the deforestation it causes. Relying on costly external inputs can have a disempowering effect on farmers contributing to their sense of feeling "trapped" within a cycle of poverty.

Climate change

The effects of climate change are an additional threat for farmers, with Mexico already experiencing extended periods of drought, more intense rains and hurricanes, and frequent floods and mudslides.[1] The methane produced from animal manure, energy intensive chemical fertilizers and deforestation are all major contributors to climate change. Finally, there have been many attempts to install biodigesters in Latin American countries in the past, but most have failed to create lasting change in small farmers' lives, as the systems often fail over time due to inappropriate maintenance, lack of durability of materials and a lack of understanding of effective waste management technologies. Sistema Biobolsa aims to change this situation, by providing an integrated solution to the all of the above challenges.

[1] In addition, if climate change is not addressed, the Mexican economy is expected to decline by between 3.5% and 4% and suffer significant costs of up to 6.2% of GDP (WorldBank 2013).

3. Solution and Social Impact

"Sistema Biobolsa is a project with many benefits. Using organic waste that, through the fermentation process, produces biogas, and using this biogas in cooking stoves generates savings for families and helps us all protect the environment. So it is good for health, good for the economy and good to fight against poverty," Felipe Calderón Hinojosa, former president of Mexico. Sistema Biobolsa's vision is a sustainable, equitable, and empathetic world without waste and their mission is to create value from waste.

Anaerobic waste-to-nutrient biodigester

Sistema Biobolsa manufactures and installs high quality biodigesters for small and medium sized farms. The solution is facilitated by innovative microfinance mechanisms, education programs and ongoing technical support to ensure full technology adoption and long-term sustainable resource management at the farm level. The biodigester acts as an on-site waste-to-nutrient ecosystem that uses the millennial practice of anaerobic biodigestion (in an oxygen free environment) to convert animal manure and human waste into biogas and a liquid organic fertilizer. The reactor is made from advanced geo-membrane, durable and recycled materials and is sold as part of an integrated technology that includes all necessary connections and appliances such as a biogas cookstove. The solution is a multi-step process consisting of onsite diagnosis, tailored financing, installation, training and long-term accompaniment for appropriate waste management, biogas and fertilizer use. The biodigesters are available for farms of different sizes, ranging from 2 to 300 cows.

"*Better life in a box*"

The benefits for the farmer include less reliance on chemical fertilizers and soil remediation from the use of organic fertilizer; reduced energy costs and dependence on external energy supply and improved health conditions on the farm with effective sanitation and cleaner water supply as well as reduced risk of respiratory disease from wood smoke. Wider benefits include the reduction of greenhouse gases (in particular methane), reduced deforestation and the possibility for farmers to continue to be stewards of the land and not migrate to overpopulated cities. The system provides a unique combination of the knowledge and technology necessary to create a culture of sustainable resource management, improving rural livelihoods and empowering farmers to be more resilient.

Social and environmental impact

Sistema Biobolsa has been described as "*potentially the most impactful way to empower farmers to take an active role in escaping the cycle of rural poverty and improving the quality of their own lives*, (Jason Prapas, Factor(e) Ventures). To date 2,440 systems have been installed, creating a positive impact on 14,442 lives. A total of 150,000 tons of waste has been managed, 4,500 tons of biogas produced, 17,000 tons of CO_2 mitigated and 350,000 tons of "biol" (organic fertilizer) produced. The company has also been a key player in developing the small-scale biodigester market in the region, leading the creation of the Latin American Biodigester Network with a current membership of 500 organizations. In 2016 operations started in Nicaragua.

4. The Social Entrepreneur

Alex Eaton´s connection with sustainable agriculture goes back to his childhood, growing up on an organic farm in the US. After studying natural sciences in Kenya and motivated to learn about other cultures he later graduated with a degree in journalism and communication in Colorado. His interest in nature fueled an early career in environmental journalism, and his passion for the outdoors later took him to Alaska where he worked for several years as a wilderness guide and training search-and-rescue teams. After an alarming avalanche rescue experience, and newfound respect for the fragility of life he decided to change tack and moved to Latin America.

Alex´ first experience in the region was in Nicaragua where he helped a local organization install photovoltaic and solar cooking and drying systems, which inspired a new passion; for rural technology. There, he also first came into contact with a biodigester on a small rural farm and was struck by the effectiveness of the system, both to deal with animal manure in a safe and hygienic way as well as produce biogas and liquid fertilizer. However he was also struck by the inefficient, rudimentary nature of the technology and set out to work on improving it. Alex later relocated to Mexico where he spent a year holding biogas courses with a local organization, and installing different types of biodigester systems with local farmers. He then returned to the US to study and graduated with a Masters in international development and engineering from Humboldt State University in California where he focused on the impact that scaling small-scale biodigesters could have in Mexico.

After graduating Alex began as an independent consultant on larger renewable energy and biodigester projects and set out to create effective solutions for small-scale farmers. He built the Mexico Biogas Program, hosted by the International Renewable Resources Institute (IRRI) as a non-profit organization from where he continued to develop and improve the technology. He went on to co-create the Latin American Biodigester Network (Redbiolac) to help create greater exposure for the technology. In the process of refining the biodigester design, fabrication process and patent registration, in 2009, Alex met his future business partner, Camilo Pages.

Camilo, co-founder, and current COO of Sistema Biobolsa has a background in industrial engineering and at the time of meeting Alex, he was marketing eco-friendly technologies in Mexico. Inspired by Alex´ passion for biodigestion to alleviate rural poverty Camilo joined the team and together they set up the company in 2010. Alex has been recognized internationally for his contribution to sustainable rural development. In 2011 he was selected as an Ashoka Fellow, and has since received several awards. While he still likes to get involved hands on with the work on the ground his role as CEO of a fast growing social enterprise, he is increasingly focused on the strategic direction of the company and international expansion.

5. Business Model

Sistema Biobolsa's business model has been carefully designed to meet the needs of rural families and farmers that previous biodigester programs have failed to meet. This includes technical aspects, such as material durability and ease of installation, an appropriate financing model and the long-term behavioral aspects required to produce long-lasting results.

There have been many previous attempts supported by governments and private organizations to create small-scale biodigesters in Latin America, India and East Africa however very few have been successful in the long term. Many have used inappropriate technology, often low quality or defective systems that fail over time; others have failed to put in place sufficient training and long term follow-up needed to ensure that farmers incorporate the biodigester system into their daily farming practices. Other programs have been too expensive and out of the reach of many farmers. This track record of failed biodigester attempts has in turn created a lack of trust in the technology Sistema Biobolsa's innovative business model has strived to overcome these barriers.

a. Characteristics

Sistema Biobolsa provides high-quality, affordable biodigesters for small to medium sized farms. Through a relatively easy-to-use technology, farmers can transform their animal waste into an odorless gas usable for cooking or heating water and into an organic fertilizer, for use in further crop production. 15 sizes of biodigester are available for different capacity needs for farms with just 2 cows to larger scale livestock operations up to 300 cows, or 1,000 pigs.

The Biobolsa

The Biobolsa is mainly composed of a reactor that can be compared to a large, resistant and high quality bag (*bolsa* in Spanish) made with resistant, synthetic plastic that is placed in a trench dug outside the farmer's house that connects to a source of human or animal waste and water. The reactor is closed to enable the anaerobic process that allows the bacteria in the manure to flourish and convert the organic waste into biogas and organic liquid fertilizer. A tube connects with another bag that collects the biogas and issues it through a pipe that leads either into the home to a cooker in the kitchen and/or bathroom and/or to another appliance, such as a generator. Another tube funnels a liquid organic fertilizer (described as biol), from the Biobolsa to an exterior tank. The system takes approximately 30 days to reach its full productive capacity, after which time the Biobolsa produces biogas and fertilizer on a daily basis with a constant supply of manure and water.

Characteristics of the Biobolsa: (For a small scale operation with 6 pigs or 2 cows)

- Includes a cooking stove or other appliance for use of the gas
- Installation takes half a day and within 15-60 days biogas is produced
- 30kg of animal manure is processed per day
- 80 liters of liquid organic fertilizer "Biol" produced per day

- 1m^3 of biogas (2kwH equivalent) produced per day (30kg per month), i.e. 2 to 4 cooking hours per day
- Durable materials lasting for 50 years (resisting strong sunlight for 20 years)
- Average savings of 480 USD per family per year
- Lightweight, easily transportable, flat-pack system (10 packs fit in one truck)
- Modular options available for connection to latrines to process human waste
- Small scale biogas generators and other accessories available for larger systems
- Mitigates the equivalent of 3 tons of CO_2 per year

"*The biodigester is not an end in itself, but rather the means to change rural farmers' energy use and their perception of their own conditions*," Alex Eaton, co-founder of Sistema Biobolsa.

Seven steps to satisfied clients

Table 1 outlines the different steps taken to ensure that this high quality technology is an effective means of improving the living conditions of farmers in Mexico. Currently the systems are manufactured in Toluca, the head office is in Mexico City and there are three regional offices, with operations carried out in 25 states of Mexico and one office in Managua, Nicaragua.

Table 1. Sistema Biobolsa in 7 steps

Steps	**Details**	**Innovation**
1. Promotion and technology dissemination	Explain to future users how the systems work in the farms of existing clients.	Peer to peer validation, existing farmers promote the product.
2. Onsite diagnosis and financing plans	Visit the farm to recommend appropriate system and develop financing plan	Tailor-made financing plan ensuring net savings made in month 1.
3. Manufacturing	100% manufactured in Mexico.	High quality, durable materials in part from recycled PET.
4. Installation	Installation on site.	Fast service, in 2-5 hours!
5. Maintenance and impact monitoring	Client visits 30, 90 and 180 days after installation to measure impact, reinforce training and provide maintenance.	Detailed measurement of energy use, fertilizer production and reduction in energy costs.
6. Capacity building	Ongoing technical assistance through free phone	Creative, educational workshops to train all the family on use and

	assistance.	maintenance.
7. Satisfied clients	Clients save money by displacing fossil fuels and chemical fertilizers.	"Better livelihood in a box" improved productivity and families' wellbeing.

Table 1 highlights some of the keys to the success of the model, the peer to peer validation, end-user financing and comprehensive and long-term follow up process are three factors that differentiate this model from previous attempts at successful distribution of biodigesters in rural farming communities. "*With this peer-to-peer validation we can make concrete economic, social and environmental arguments for the technology, showing payback times, improved efficiencies and reduced health impacts*," Alex Eaton.

Future innovations

Sistema Biobolsa´s main product to date is the biodigestor system, which includes a gas cooker as this serves a basic need for families. However, the company has also developed additional accessories such as generators and small scale motors to meet different needs of farmers and producers. Although the biogas sector in Mexico is growing the culture of using this fuel for productive activities in the agricultural sector is still limited. Farmers do not tend to use biogas for productive activities due to the lack of suitable biogas motors available on the market in Latin America to convert biogas into electrical or mechanical energy. To overcome this barrier Sistema Biobolsa has developed a series of small scale gasoline motors to run on biogas which could be used for running milking parlors, water pumps, grain mills or to produce electricity. These new systems are currently being trialed on several farms in Mexico.

Fee structure and finance model

Another essential ingredient for the success of Sistema Biobolsa is the affordability of the system achieved through an innovative combination of public finance and micro-lending. Prices range from 975 USD per system for the smallest size to 14,000 USD for the largest. Farmers are usually able to secure at least 30% of the cost of the system through agricultural subsidies from their local municipality. For the remainder of the cost around one third of clients pay up front. However the remaining two thirds of farmers pay via a loan agreement with Sistema Biobolsa.

The loan is carefully tailored to the farmer's individual circumstances, and is based upon a calculation of the farmer's current energy and fertilizer expenditure as part of the initial diagnosis. This enables Sistema Biobolsa to design a payback scheme whereby monthly payments are designed to be less than the monthly savings generated by the biodigester (through displaced energy and fertilizer expenses) so the farmers can benefit from net savings from the first month. This immediate ROI for the farmer is a key incentive to motivate farmers and their families to undertake the necessary changes in their daily farming practice required for the system to be successful.

Sistema Biobolsa works with KIVA, the micro-lending site to facilitate the loans to farmers. For each loan required Sistema Biobolsa uploads a lending petition on KIVA's platform. Once the loan has been secured through KIVA's international community of lenders, the money is transferred to Sistema Biobolsa who then administers a simple repayment plan wherein payments are collected during the regularly scheduled follow-up and monitoring activities. Once the loan has been paid off Sistema Biobolsa manages the repayment to Kiva. This zero interest rate financing facility is key to removing the cost barriers usually associated with rural technologies. In addition, the company offers special financing programs for ¨micro-regions¨ when there are five or more farmers in one region who can collaborate and generate cost-savings in terms of installation and maintenance. Sistema Biobolsa's financing model includes the sale of carbon credits, which would finance the extensive follow-up and monitoring plan.

The use of the biodigester's organic products will pay back in full the cost of the system in a span of 8 to 18 months, depending on the farmers' baseline conditions and variations in the size of the system that has been installed. Once the Biobolsa is fully paid off, what traditionally would be regular energy and fertilizer expenses contribute to increased disposable income or savings for the farm.

Target beneficiaries

The motivation from Alex Eaton, Camilo Pages and their team is to inspire a sense of dignity among small-scale poor farming communities in Mexico, Central America and beyond. The system has been designed both to be easily transportable and to resist intense weather conditions making it a viable technology for small farmers around the world.

4 million farmers in Mexico

In Mexico the target beneficiaries of the company are the estimated 4 million small scale farmers in the country, with 95% of the company's clients living in poverty. To reach this target Sistema Biobolsa develops solutions for the smallest family farms, which may have just one or two heads of livestock as well as medium sized operations of up to 1,000 pigs or 300 cows. For the smaller operations the biogas produced ($1m^3$ daily) is suitable for cooking needs for one family, giving between 2 and 4 hours of biogas per day. For the larger operations the biogas can be used for production activities, (producing up to $240m^3$ daily) and has for example been used to heat 10,000 square feet of greenhouse tomatoes. As the design is modular the Biobolsa can be easily adapted to different needs of the farmer.

In all cases the company`s mission is to empower farmers to manage their own resources in order to build a better future for themselves and their families. This goal is achieved not only through the well-designed technology behind the Biobolsa but also through the comprehensive process of raising awareness around the benefits of the system. Given the low levels of knowledge around the opportunities for waste-to-resource systems and skepticism around an unknown technology, a meticulous strategy has been devised to win over farmer's confidence. The teams of technicians come from rural communities themselves, and most of

them own their own Sistema Biobolsa. They begin this process of raising awareness by holding a demonstration event to show the community an existing system in action. The team will emphasize that the biodigester makes their work easier and increases their production while drastically reducing energy costs.

Efforts are continuously being made by the team to maximize the effectiveness of this part of the work, and in 2015 the company began working with artists to complement the raising awareness activities. Demonstrations now include a puppet theatre to help build a deep understanding in all members of the community of the intrinsic relationships between waste management, energy and resource use, climate change, health and the family's economy. Once interested families are identified, the technicians train them to use a biodigester and the first farm to install the system becomes the prototype for the rest of the community. After a six-month adaptation period with regular visits from the technicians the family is "certified" as biodigester users and "local experts" and given the opportunity to participate in the ongoing peer-to-peer validation and exchange as well as speak at future events and demonstrations. According to Jason Prapas from Factor(e) Ventures, "*There is a great channel of communication between customer and Sistema Biobolsa, it takes open ears from a company level to maintain this*."

2 billion farmers worldwide

From the outset Alex and Camilo have made conscious efforts to design a product that could easily reach farmers in all parts of the world, given that the large majority have unsustainable waste management practices, particularly in African countries, India and Latin America. In China the technology is already fairly well established.

"*According to the Food and Agriculture Organization of the United Nations, in 2014, there were more than 500 million small farms on the planet, but only 10 million biodigesters,*¨ (Swhartz, 2015).[2]

Sistema Biobolsa has already shipped biodigesters to Ghana, Nigeria, Madagascar, Haiti, Cuba, Nicaragua, Peru and the UK. While this currently represents less than 1% of sales the company's long-term vision is to help farmers on an international scale.

[2] http://qz.com/571295/smells-like-opportunity-mexican-farmers-are-turning-cow-poop-into-proverbial-gold/

6. Social and Financial Performance

6.1 Social Impact Performance

Since the company was founded in 2010 Sistema Biobolsa has installed a total of 2,440 systems, most of which have been in Mexico and has calculated a direct impact on 14.442 lives.

6.1.1 Social impact achieved

Table 2 below shows the steady increase in installations as well as the number of beneficiaries over the last five years. On average 75% of the systems sold are very small, 15% medium sized and 10% at the larger end of the scale.

Table 2. Evolution of systems installed since 2011.

	2011	**2012**	**2013**	**2014**	**2015**	**Total**
Systems installed	184	395	531	774	556	2,440
Beneficiaries	1,104	2,370	2,988	4,644	3,336	14,442
% in Mexico	100%	99.5%	98%	98%	99.5%	

The company aims create a culture of sustainable resource management, one farmer at a time and a clear signal of progress towards this mission is the increasing number of systems installed.

"*We try to create change with small farmers by reconstructing their perceptions around waste as a resource. Apart from the impact of our technology on the livelihoods of small farmers, we hope it also acts as a catalyst for further positive change as they increase their awareness of other sustainable resource management opportunities*," Alex Eaton.[3]

6.1.2 Social impact measurement

Once a farm has decided to go ahead with an installation, a detailed initial baseline assessment is taken by the technician on his/her smartphone, including the number of animals on the farm, number of family members, current expenditure on fertilizer, LPG gas and other fuel, time spent collecting firewood and other key facts about the farm operations. Six months later the same measurements are taken and the situation is compared. This data is stored in Sistema Biobolsa's online CRM system and analyzed to help support the ongoing improvements to the system as well as inform the education program and awareness-raising program to encourage new farmers to participate in the system.

[3] http://www.forbes.com/sites/ashoka/2013/08/15/agricultural-innovation-in-reverse-qa-with-ashoka-fellow-alex-eaton/#2f2579456596

In terms of the environmental impact of Sistema Biobolsa´s work to date there has also been a steady evolution since measurements began in 2011. The original business model of Sistema Biobolsa included the sale of carbon credits on the international carbon market, and for this reason from the start a robust methodology to measure CO_2 reductions was put in place. However, since the carbon market crash in 2011, this scheme was paused until the market picks up or a voluntary carbon reduction partnership can be created.

Sistema Biobolsa´s Environmental impact 2011-2016

150,000 tons of waste managed
4,500 tons of biogas produced
17,000 tons of CO_2 mitigated
350,000 tons of biol (organic fertilizer) produced

In addition to the positive environmental impact that is continuously monitored Sistema Biobolsa has also taken care to capture qualitative feedback from users, and this is communicated extensively through social media with over 60 videos on the YouTube Channel,[4] over 11,000 likes on Facebook[5] and 600 followers on twitter.[6]

"*The fact that farmers are able to produce their own biogas and biol gives them the opportunity to grow their income and savings, which they later reinvest in the purchase of additional animals or farms improvements. This is the objective we seek to achieve by working with Sistema Biobolsa. We want the farmers to feel the benefits in their pocket*!" representative of Rural Development in Acatlán, Hidalgo

"I feel very lucky to have my Biobolsa, it is extraordinary and has changed my life. Since I use biogas to cook, my income has improved because now I save money instead of buying LP gas. I am fertilizing my garden with biol and can feed my children with the vegetables I harvest. I even sell the excess on the local market." Mrs. Susana, Hidalgo (Sistema Biobolsa client).

6.2 Financial Performance

Sistema Biobolsa has shown a steady increase in revenue from sales since 2010, reaching a break-even point and its first million USD in sales in 2014. The company has received external financial support with both grants and investment received from 2011 as shown in figure 2. In addition to the early investment Sistema Biobolsa attracted external investment of a total sum of 500,000 USD in 2015 and 395,000 USD in 2016. The investors in the company are a mix of private individuals and companies based in the US and Europe. One of the first companies to invest in Sistema Biobolsa was the multinational French based energy company ENGIE through their solidarity investment fund, ENGIE *Rassembleurs d'Energies*,[7] which

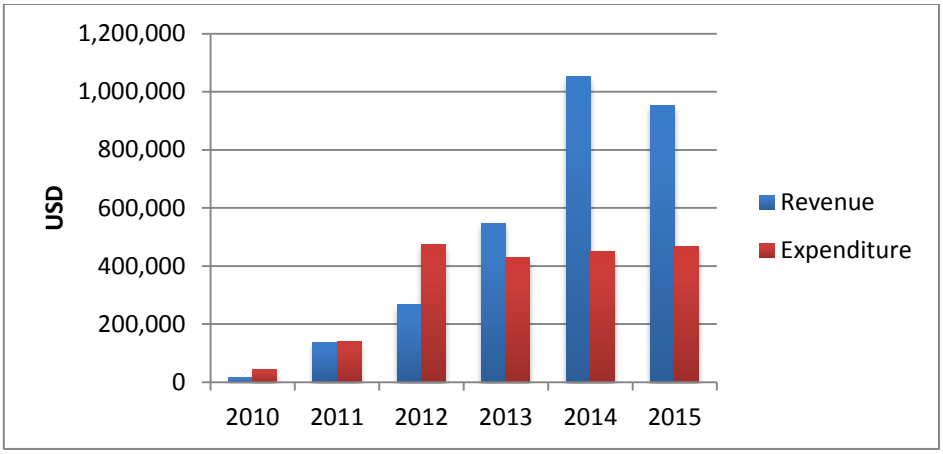
[4] https://www.youtube.com/sistemabiobolsa
[5] https://www.facebook.com/sistemabiobolsa
[6] @sistemabiobolsa
[7] http://www.engie.com/engagements/acces-energie-durable-pour-tous/initiative-rassembleurs-denergies/

supports social enterprises who combat energy poverty around the world. The most recent investor to join is Factor(e) Ventures,[8] a venture development firm that supports early stage entrepreneurs providing access to energy solutions through a blend of risk capital and technical resources.

6.2.1. Revenue and Expenses

Figure 1 shows details of revenue and expenditure since the company was founded, with a notable increase in sales between 2013 and 2014, during which time the company almost doubled its revenue.

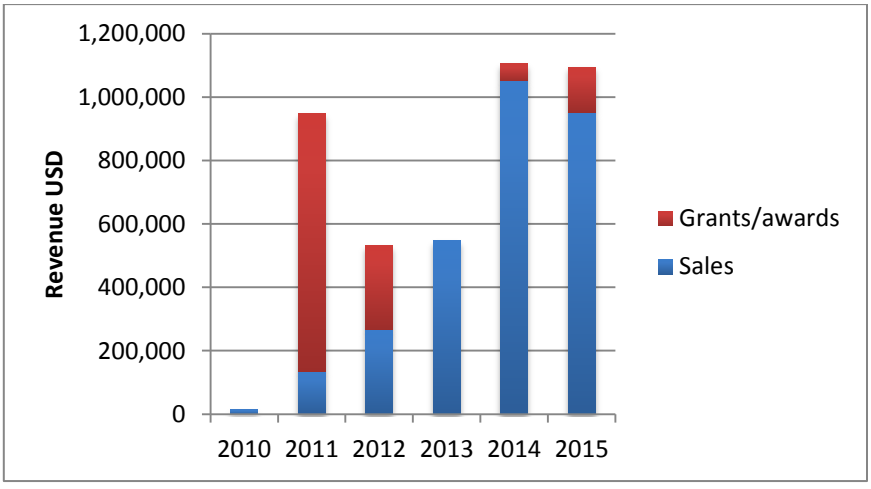
Figure 1 Sistema Biobolsa Sales revenue and expenditure (2010-2015)



6.2.2 Proportion of Income from Sales

During the first two years of operation 16% of total revenue was generated by sales, by the end of the third year (2012) this increased to 50% and by 2014 represented 95% of total revenue. In 2015 there was a slight drop to 87% as the second tranche of the 2014 grant with the Inter-American Development Bank was received in that year.

Figure 2 Sistema Biobolsa Revenue from sales vs. grants (2010-2015)



[8] http://www.factoreventures.org/

The sum of short-term zero-interest loans managed through the international lending platform KIVA has also shown steady growth, with loans managed for clients in 2013 for a total sum of 111,000 USD, 120,000 USD in 2014 and 122,000 USD in 2015.

7. Business Development and Ecosystem Evolution

Since 2005 Sistema Biobolsa has evolved from a non-profit institute specialized in renewable resources in Mexico to a profitable company with over a million USD annual turnover and operations about to start in Nicaragua. The process can be categorized into three stages.[9]

Table 3. Summary of Sistema Biobolsa´s business development milestones from 2010 to present

Stage	Year	Description
Start-up	2005	Alex Eaton and others register International Institute for Renewable Resources (IRRI) as a non-profit organization in Mexico.
	2007	IRRI begins to install and trial small scale biodigesters in Mexico. Alex is nominated Switzer Environmental Leadership Fellow.
	2009	Alex completes his Masters thesis on biodigesters and develops a business plan for Sistema Biobolsa. Installations and trials continue through IRRI.
	2010	Buen Manejo del Campo S.A. de C.V. registered in Mexico by Alex Eaton and Camilo Pages and the technology is patented.
Early	2010	Alex receives Global Social Entrepreneur of the Year award from BiD Network. Co-founders meet KIVA at the Latin America Impact Investment Forum, first 20 biodigesters purchased across Mexico.
	2011	Alex is nominated as Ashoka Fellow and company wins second place in "National Mexico Initiative" with national TV coverage. First angel investment received, machinery purchased and a team contracted.
	2012	Near breaking point as initial funds are exhausted, collaborations start with KIVA. Echoing Green finalists as top 10 Entrepreneurs of Latin America. Engagement starts with Opportunities for the Majority Program (IDB).
	2013	Technology improvements continue, sales increase and procedures systematized. First large public purchase by the Food Security program in the state of Tlaxcala for vulnerable communities. Press coverage increases.
Growth	2014	First profitable year (18% net margin) and 2,000 systems installed. Greater Impact Foundation funds 100 biodigesters across Mexico. Start to seek foreign investment and grant received from MIF (IDB). Alex and Camilo participate in the GSBI incubator at Santa Clara University.
	2015	First round of investment closed with two out of three investors. Biogas motor technology trialed across Mexico with support from Wisions of

[9] **Start-up stage:** a preparation period for setting up a business or an enterprise. An entrepreneur's team develops a business idea and a business model. In some cases, they have product/service prototypes which are not fully developed or tested. **Early stage:** A period from business initiation until business scale-up. An entrepreneur's team may first deliver its products/ services in a test market to examine its business model. Also, the team may file patents or obtain licenses, if necessary. Once the business model is consolidated, it starts its business. However, the business remains quite small due to lack of capacity and resources. It may reach a breakeven point at the end of this period. **Growth stage:** A period after scaling up the business. The business exceeds the breakeven point and increases its sales, number of beneficiaries, the market share etc. The team revises the business model in order to sustain and/or expand the business, if necessary. In some cases, the team starts to investigate new products/services.

		Sustainability. Second profitable year.
	2016	Signature of third agreement with Factor(e) Ventures for equity and technical support . 2 regional offices opened, Customer Relationship Management system created and 12 people trained in Nicaragua to start operations in June. First country manager hired and first international office with 2 local hires opened in Nicaragua in July.

7.1 Startup Stage (2005-2010)

7.1.1 Milestones

The following pages outline the key steps in the Startup stage of Sistema Biobolsa and key supporters in the process.

Step 1: register a non-profit

The first formal step in Sistema Biobolsa's history was the creation of the International Institute for Renewable Resources (IRRI), registered as a non-for profit organization in Mexico in 2005. IRRI was set up by Alex, Ilan Adler and other social entrepreneurs and engineers to promote sustainability in the rural communities of Mexico, Latin America and the Caribbean through research, training and development of appropriate technologies. The early small-scale biodigester prototypes of what would later become a patented technology were developed by IRRI.

By 2007 IRRI had started its biogas program, pioneered by co-founder Ilan Adler. The first prototypes were developed and installed in rural communities in Mexico and a process of trial and error began, with the systems financed as part of IRRIs broader work around rural development.

Step 2: develop the technology

Conscious of the need to improve the technology for more effective small scale biodigesters Alex decides to return to study and undertakes a Masters program at Humboldt State University in international development and engineering. He completes his thesis on small-scale biodigester technologies and undertakes considerable research into the most appropriate materials for a successful system that would overcome the barriers previous attempts at small-scale biodigesters have faced. Material durability, ease of manufacture, assembly and transportation are all factors that were considered.

On completion of his studies Alex sets out to develop the business model for Sistema Biobolsa. Motivated by a business plan competition for Social Entrepreneur of the Year led by the Netherlands based BiD Network he visits leading institutions such as Harvard University to refine the business model. At this stage a key part of the model was based around carbon credits, whereby the company would measure the $C0_2$ reductions achieved through the biodigesters at farm level and sell these as carbon credits on the global market, which, at the time was valued at 28 USD per ton. However this idea was later set aside as by the time the business was up and running the price had dropped to 0.6 cents per ton.

Step 3: set up the business

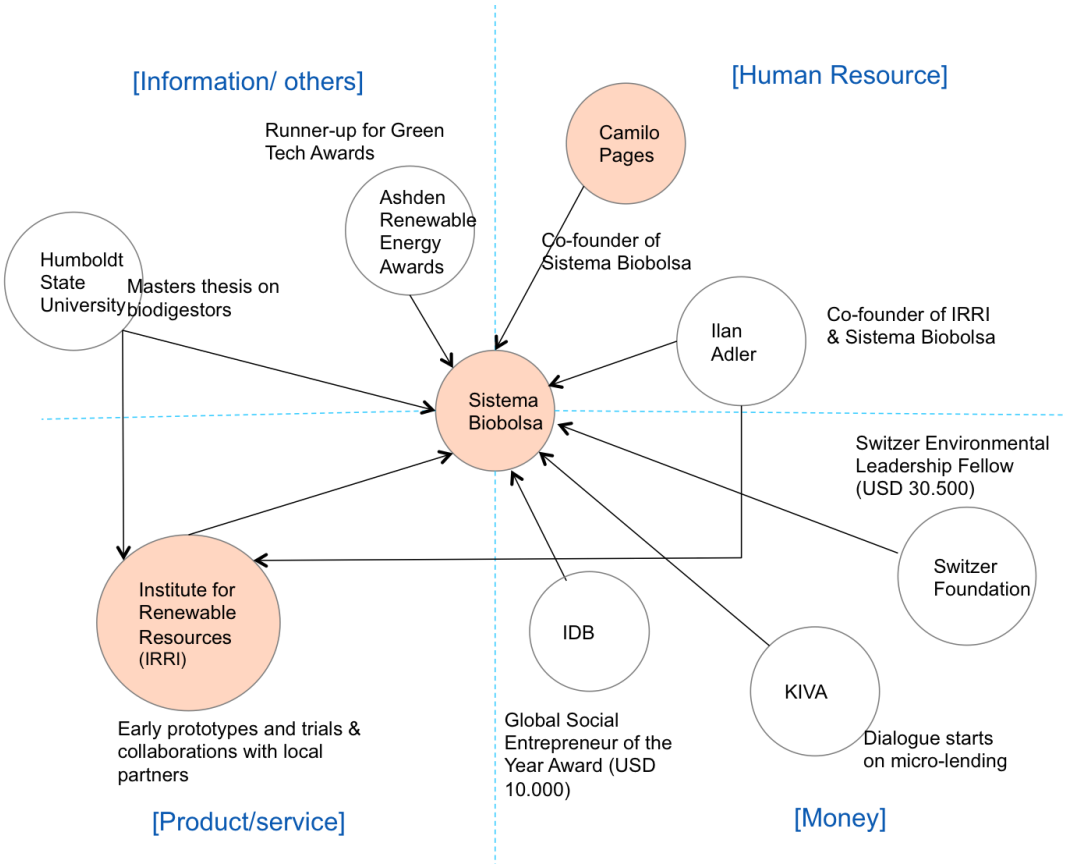
During this same year Alex met his future business partner Camilo Pages. Camilo was working at the time on the promotion of Mexican eco-friendly companies and joins Alex to create the new company.

"*Our business plan was developed by using the BiD Network framework and it was the competition that motivated us to put it together in a timely fashion. Secondly, winning the challenge was a huge motivation and confidence builder, validating our work and giving us hope that we could find investors. The prize money further helped us advance in pragmatic ways. Finally, as the winners of the BiD Network Challenge, we have additional validity on the world stage as we further develop our project*," Alex Eaton.

In 2010 Alex and Camilo separate themselves from IRRI and register a limited company, *Buen Manejo del Campo, S.A. de C.V.* and proceed to patent the newly developed biodigester system technology. In the same year they are also selected as finalists for the Green Tech Award for the Ashden Renewable Energy Awards. As part of the key early negotiations Alex and Camilo engage with the various public sector organizations that support agriculture, environmental and energy-related initiatives in Mexico. They start a process of negotiating support from state and municipal level to help finance the installation of biodigesters for poor, rural farmers. The pubic engagement translates initially into logistical support bringing together communities for demonstrations of the technology and later becomes financial aid in the form of subsidies for the farmers to cover up to 30% of the investment required for installation of the system. In 2010 Alex also meets another key player for the business, the team at Kiva, the micro-lending platform. The company later becomes Kiva's first non micro-finance institution field partner.

7.1.2 Key supporters

Figure 3 Key supporters of Sistema Biobolsa in the Startup Stage.



7.2 Early stage (2010-2014)

For the early stage of the business Alex, Camilo and their team start to create social capital on the ground in Mexico and also receive considerable support internationally, both resulting in a steady growth of the business.

7.2.1 Milestones

Building local social capital

Within the first two years of the business Sistema Biobolsa installs 100 biodigesters in 10 different states across Mexico, each representing a base from which to scale further. Systems are also installed in Nicaragua, Honduras, and Costa Rica. A two-pronged replication strategy is adopted during this phase. First, the company establishes a relationship with governments and rural cooperatives that can help install biodigesters in the communities where they work. Second, a "train-the-trainer" model is implemented that seeks to empower rural farmers as emissaries of the technology while also extending Sistema Biobolsa's reach. The most enthusiastic biodigester users receive training from the Sistema Biobolsa staff to spread the technology to other farmers around the area. These "ambassadors" form a local cooperative

that promotes, sells, and installs the biodigesters in neighboring communities, thus creating an additional income stream for farmers.

International validation

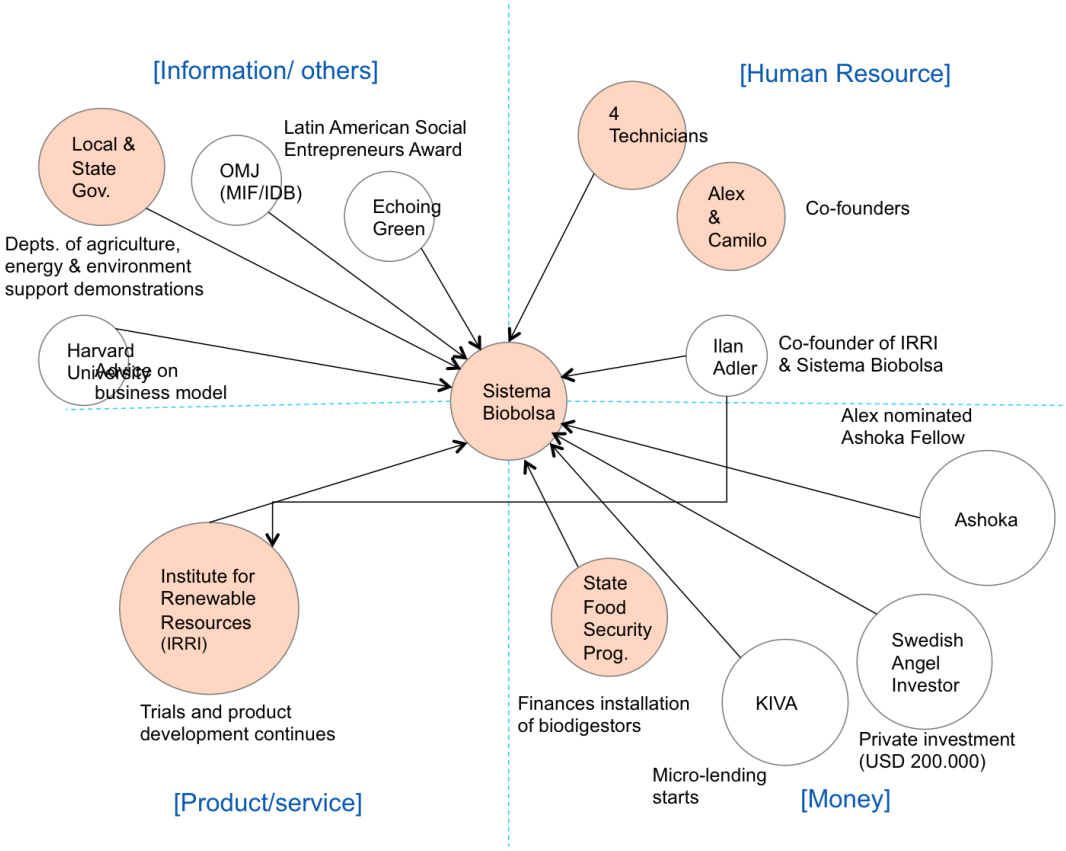
During this first year of the business Alex travels to Europe in search of an investor and receives his first support from a private individual in Sweden. The following year, in 2011 he is nominated as an Ashoka fellow, which marks a turning point in terms of both international and national support for the initiative. During this year the IDB department "Opportunities for the Majority" approaches the company and this engagement some time later evolves into a grant from MIF. Within the same year the company wins second place in a prestigious national award run by the Government secretariat for social development (SEDESOL) for which there were 57,000 applications. The prize known as "Mexico Initiative" (in Spanish *Iniciativa Mexico*) gave Sistema Biobolsa extensive coverage on national TV, with a soap opera made about the project as well as grant money. In 2012, Sistema Biobolsa is recognized by Echoing Green as one of the top 10 Entrepreneurs of Latin America and in the following year Alex participates in Ashoka Changemakers American Express Emerging Innovators Campaign and is nominated as a Buckminster Fuller Challenge Finalist. In 2013 Alex gives his first TedX talk at Valle de Bravo, Mexico and by this stage the company has received considerable press from CNN, Forbes and other several national media organizations.

Consolidation in Mexico

With the first injection of capital in 2011 the team starts to build the manufacturing plant in Toluca, Mexico. Four technicians are employed and the first 10 biodigesters are manufactured and sold. The team works on improving the technology and in 2013 receive their first significant public contract to install 100 biodigestors in poor households as part of the State of Tlaxcala's food security program.

7.2.2 Key supporters

Figure 4 Key supporters of Sistema Biobolsa in the Early Stage.



7.3 Growth stage (2014-2016)

In 2014 Sistema Biobolsa reaches break-even and revenue is doubled from the previous year reaching a net profit of 18% and one million USD in sales. This marks a significant step as the company prepares itself for international growth.

7.3.1 Milestones

MIF and GIF: donations from international organizations

By 2014 the company has installed 2,000 biodigesters and starts to seek further investment to scale up operations. In 2014 the MIF (IDB) provides Sistema Biobolsa with a grant of 250,000 USD to support a process of systematization of internal processes to help with the company's consolidation, which by 2016 has evolved into integrated Customer Relationship Management systems available on the technicians smartphones and tablets. In 2014 the Greater Impact Foundation also provided funding for 100 biodigestors, which set out to improve the lives of 442 families, and in 2015 the company gained certification as a B Corporation.

Factor(e) Ventures: strategic investment partner

Factor(e) Ventures, a US based venture capital company discovered Sistema Biobolsa in 2014 through their relationship with the IDB. Factor(e) specializes in access to energy technologies,

is housed within one of the worlds largest energy research institutes at Colorado State University and aims to work with companies that have the potential to affect 10 million lives.

Factor(e)'s technical staff were already very familiar with the technology of anaerobic digestion however up until this point had struggled to find a scalable business model, despite many attempts across the world in the last 50 years. Factor(e) had identified a series of barriers to biodigesters as described in Table 4 and discovered that Sistema Biobolsa's model appeared to overcome all of these. In 2015 Factor(e) visited the company in Mexico and was shown both the smallest system with just 2 cows and gas piped to the kitchen as well as the largest, and longest running system. Jason Prapas from Factor(e) described the system as "*a beautiful demonstration of the livelihood improvements from just one package*."

To support the investment negotiations with Factor(e) Sistema Biobolsa sought expert advice on an appropriate investment vehicle from SVX, Mexican based impact investment consultancy firm. After a thorough due diligence process the investment committee approved investment in 2015 complemented by considerable in-kind technical support to help develop technologies and above all provide support at the critical junctures for international scale. In addition Factor(e) works with downstream funders, who they hope will be interested in investing in the company further down the line once the international model has been proven.

Table 4. Barriers to scale for small scale biodigester projects

Barrier to Scale	Additional Notes	References
Poor ROI to end consumers	Some cheap systems exist, but have extremely short lifetimes (eg. PVC bags)	https://www.globalmethane.org/documents/GMI%20Benefits%20Report.pdf, http://journal.frontiersin.org/article/10.3389/fenrg.2014.00010/full
Wide variation in feedstocks	Many systems are not designed for the resulting feedstock mix	http://www.sciencedirect.com/science/article/pii/S0973082611000780
Installation Cost and Complexity	The popular brick and mortar dome systems require several highly trained masons, fully dug out pit. Last mile distribution in rural areas.	http://www.fao.org/docrep/t0541e/T0541E0j.htm#Chapter thirteen: Biogas programs in developing countries
Sporadic biogas production	Based on several factors, but temperature is a major one	http://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Anaerobic_Digestion/biowaste.pdf
Low biogas quality	H2S and CO2 content	http://www.sciencedirect.com/science/article/pii/S0960148104003830
Lack of finance options	Many programs have relied on donation or heavy subsidy	http://www.scirp.org/journal/PaperDownload.aspx?paperID=38454
Appliances not widely available	Gas is a platform, not a wholistic solution in itself	http://www.businessdailyafrica.com/Corporate-News/Programme-seeks-to-boost-biogas-adoption/-/539550/2110624/-/su8owwz/-/index.html
Consumer awareness and education	First informing potential customers that the solution exists, then how to operate properly.	https://www.abdn.ac.uk/sustainable-international-development/documents/Final_Report_-_Potential_of_Small-Scale_Biogas_Digesters_in_Sub-Saharan_Africa%5B1%5D.pdf

Source: Factor(e) Ventures

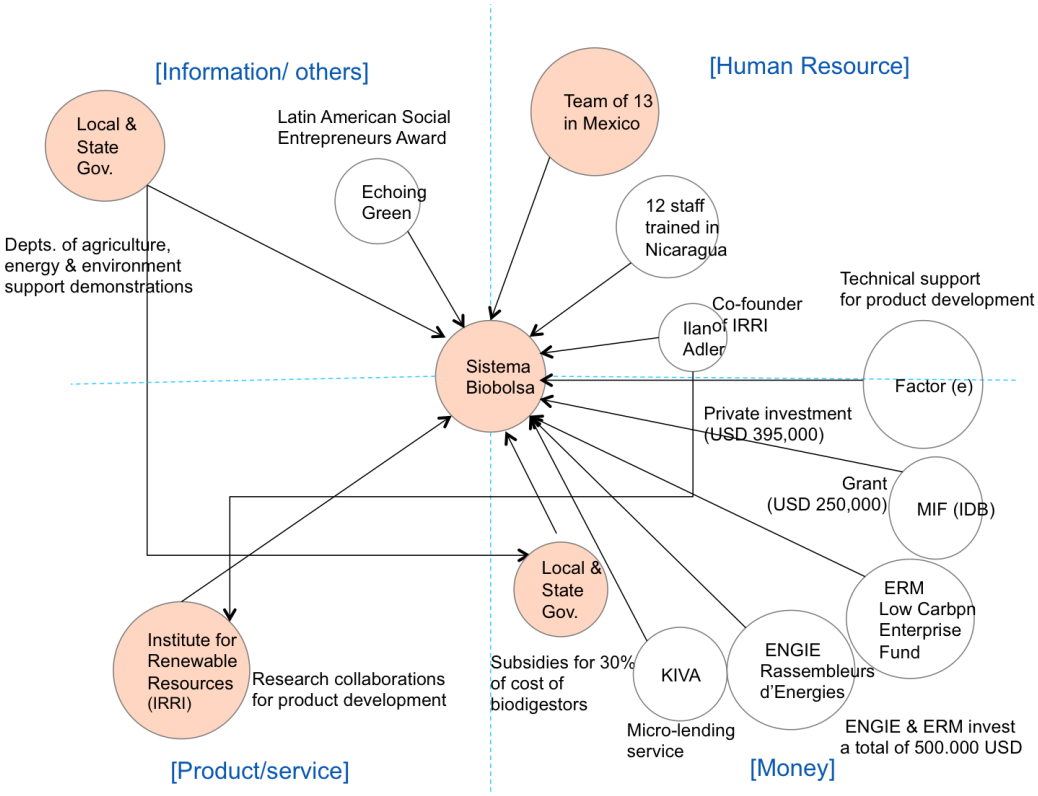
Product diversification

Sistema Biobolsa's long-term strategy for creating lasting social impact is to expand internationally but also to diversify the product base, and in this sense the company has started to develop additional accessories for the Biobolsa. Firstly a water treatment system using aquatic plants has been developed to further treat the effluent wastewater from the biodigester. Secondly, a small generator that can run on the biogas produced by the biodigester has been developed and is currently on trial in several farms in Mexico. This generator can be used to pump water, heat water, grind corn or generate electricity (between 5 and 10KW) for other uses on the farm. Through a collaboration between Wisions of Sustainability, IRRI and Sistema Biobolsa[10] a total of 20 gas motors have been installed in Mexico and four productive biogas and water treatment systems are also being trialed. The installations were partly funded by Wisions and the remainder funded through KIVA loans facilitated by Sistema Biobolsa. In addition to trialing and monitoring the technology this project has a training component to develop local capacity to convert, install, service and maintain the systems. In all cases a return of investment of less than three years is estimated for the farmers who purchase the systems.

[10] http://www.wisions.net/projects/removing-barriers-to-greenhouse-gas-mitigation-in-medium-scale-agricultural

7.2.2 Key supporters

Figure 5. Key supporters of Sistema Biobolsa in the Growth Stage.



8. Scalability and Replicability

Sistema Biobolsa currently has 2,500 biodigesters of varying sizes installed in 25 states of Mexico with field offices in Puebla, Jalisco and Yucatan as well as Managua, Nicaragua and several pilot installations in Central America, Haiti and East Africa. The company recently started operations in Nicaragua and has plans to be present in three additional Latin American countries in 2017, with installations in East Africa and India by 2018. Alex has had international ambitions for Sistema Biobolsa from the outset, however different strategies to achieve this have evolved over time as described below.

Piggyback other distribution channels

The first attempt at replicating the model internationally was to work with a solar energy equipment distributor in Nicaragua (Tecnosol), by including biodigesters in their existing distribution channels. Several biodigesters were sold by Tecnosol, however given the solar company did not have a follow-up maintenance program the process was not successful. A key factor in Sistema Biobolsa's model is the ongoing relationship with the client, to solve any technical issues as well as build a culture around sustainable waste management, which takes time and investment. For the recent formal launch in Nicaragua this challenge has been addressed by creating a regional office in Managua, where a team has already been trained with the ongoing support of a lead technician from the core team in Mexico.

Network for Biodigestors in Latin America and the Caribbean

A second strategy around replicating the model has been to set up a network of organizations in the region to support the growth of the biodigester sector as a whole, to increase dialogue around the promotion of biogas projects as well as innovations in the field. Sistema Biobolsa is one of the founding members of this network, which is coordinated by 10 active organizations in the region that organize the activities and events to share good practice and work on common goals. The network has 500 participating organizations that include "*manufacturers of biodigesters, NGOs, research centers and universities with the objective of sharing information and experiences, identifying technical, environmental, social and economic barriers, suggesting ways to spread the biodigester technology in different countries, systematizing research and dissemination among partners and encouraging actions that influence policies related to biodigesters*," (P2P Foundation). The network has been supported by the IDB and other international organizations.

18 month growth strategy

Factor(e) Ventures is working closely now with Sistema Biobolsa towards an 18 month schedule to reach 10 million users. This plan for growth includes a process of identifying where the company wants to get to, and how to demonstrate what other investors would like to see at each critical moment in order to attract the further investment needed for this expansion. There are two parts to the internationalization plan, one is to grow in scale in Latin America and the second is to start offering biogas solutions in other parts of the world. Factor(e) has sent staff to Mexico to be trained with the company and having recently

launched a regional office in Pune, is helping Sistema Biobolsa evaluate how their solution may produce a positive impact for farmers in India. There has also been interest from several African countries and Alex was a speaker at the African Biogas Summit in Ethiopia in 2016.

In addition to initiatives in Latin America, India and East Africa Sistema Biobolsa is an active player in the international renewable energy field, with regular participation in international events to raise the profile of the company and lobby for supportive policies for biogas. The team attended the COP held in Lima in 2014 and the Clean Energy Ministerial Meeting held in San Francisco in 2016.

9. Final Reflections

Sistema Biobolsa is a fast growing social enterprise with a proven business model and clear social and environmental impact. With operations established in Mexico the company is now moving to Nicaragua and following a model of international expansion in close collaboration with one of its key investors.

Key milestones

Alex being nominated as an Ashoka Fellow in 2011 was a key milestone in terms of raising international profile for the company. In 2013 starting collaborations with KIVA was also a key moment. The zero-interest loan facility is a key component of the affordability and consequent viability of Sistema Biobolsa's solution. This relationship pioneered a new format for Kiva partners, as the first non micro-finance institution to operate as a field partner, facilitating the loans on the ground. Finally the investment from Factor(e) Ventures is also a key milestone, not only in financial terms but also in technical expertise and infrastructure for international expansion.

Challenges for growth

A challenge for growth will be to replicate the same conditions that Sistema Biobolsa has created in Mexico in different countries. Two key components are to have a local co-founder with experience and well-established contacts in the environmental sector and secondly the capacity and resources for years of building social capital amongst the national and local agricultural, environmental and energy authorities. In Mexico 30% of the income generated by the biodigesters is a result of several years of lobbying the various authorities to subsidise the technology for farmers. Each country will have a different regulatory and budgetary context and achieving this level of support may not always be possible and may take considerable time and investment of a local team on the ground. The lack of political stability in Central American countries will be an additional challenge for expansion in this region. On the other hand, the governments of Nicaragua and Honduras have implemented solid National Biogas Programs that provide constant subsidies to small farmers who wish to acquire biodigesters.

Contribution to social innovation

The key contribution to systemic change in the field of resource management will be measured not only by the successful implementation of Sistema Biobolsa's systems in Mexico and other countries, but also in the growing recognition of the biogas sector more generally. In this sense the creation of the Latin American Biodigester Network is a clear example of how the technology is becoming more widely adopted and how the company is facilitating a broader process of social innovation.

Finally, the team at Sistema Biobolsa considers the installation of biodigesters as only a first step towards promoting more sustainable technologies that serve to improve production, reduce reliance on costly external resources and overall improve livelihoods for poor farmers and vulnerable communities. The long-term goal is that this technology is to change the culture around waste at the farm level and create more empowered communities who will develop their own knowledge around sustainable resource management.

"*Our vision of sustainable resource management is one that closely resembles natural ecosystems, where there is no waste, only inputs to other productive systems. We aim to create change one farmer at a time, building momentum towards a cultural tipping point,*" Alex Eaton.