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**Sistema Biobolsa: Addressing Challenges of
Climate Change, Sustainable Agriculture and
Waste Management in Mexico**

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Sistema Biobolsa: Addressing Challenges of Climate Change, Sustainable Agriculture and Waste Management in Mexico

Abstract

The case chronicles the innovation in Bio-digester technology in Mexico led by Alex Eaton and Camilo Pages through a social enterprise 'Sistema Biobolsa'. It describes how the two social entrepreneurs created an innovative waste and resource management system by re-imagining 150-year old biogas production. The innovation brought together high-quality membrane, durable modular parts, and anaerobic bio-digesters that transformed animal waste into renewable energy (bio-gas) and organic fertilizer.

Sistema Biobolsa addressed several challenges that small and marginal farmers in Mexico and across the world faced – low yielding land due to excess use of chemical fertilizers, lack of organic fertilizers, unviable waste disposal methods and limited access to energy. Sistema Biobolsa converted organic waste into organic fertilizer and renewable energy. With investment of US\$ 600, a farmer with two cows could save up to US\$ 40 per month in the cost of fuel and fertilizers. The Biogas produced was environmentally friendly. It reduced methane emissions, utilized the waste, reduced deforestation, protected the soil and also improved the quality of farmers' lives. Sistema Biobolsa addressed issues like poverty, food security, and climate change and provided sustainable and productive solutions to small farmers.

To cater to the needs of different farmers, bio-digesters were available in several sizes and could be installed within a day. Farmers could start using the system after the first month of installation. The company provided loans and technical support to farmers for installation of the system.

Eaton expanded Sistema Biobolsa to Kenya, Colombia, Nicaragua and India. Still there were many issues that Eaton needed to address. He needed to improve distribution to reach out to more than 4 million small farmers in Mexico. He was looking at making a huge impact to address the issues of global warming and climate change. Can a small venture in Mexico address these big global problems?

Case

“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.”ⁱ

Felipe Calderon Hinojosa, former president of Mexico

“The bio-digester is not an end in itself but rather the means to change rural farmers’ energy use and their perception of their own conditions.”ⁱⁱ

Alex Eaton, co-founder of Sistema Biobolsa.

Small farmers contributed to 80% of the global food production. The challenges they faced were innumerable – ranging from limited access to energy, increased use of chemical fertilizers, low yielding land, decreased farm output, increased input costs, etc. These were the issues that bothered Alex Eaton (Eaton), who worked with companies involved in providing alternative energy to the poor. He partnered with Camilo Pages (Pages), who was involved in marketing eco-friendly technologies.

Eaton and Pages, along with a few social entrepreneurs started Sistema Biobolsa¹ in Mexico in 2010 as a social enterprise. Sistema Biobolsa manufactured, distributed, sold, and installed anaerobic (oxygen free environment) bio-digesters² that transformed animal waste into renewable energy (bio-gas) and organic fertilizer. This system promised clean energy and sustainable agriculture.

Sistema Biobolsa’s waste and resource management system reimaged the 150-year old biogas production, by using high-quality membrane and durable modular parts. The pre-fabricated equipment, contained a black bag made from dense, impenetrable material. The bag was set in a farm that gathered the farm, and animal waste. The wasted gathered into the bag was converted into clean gas and organic fertilizer. The equipment, available in different sizes, was manufactured in the company’s factory and was distributed across the market. The equipment could be installed in a matter of

¹Sistema Biobolsa legal name: Buen Manejo del Campo. It was registered in 2010

² Bio-digester is a tank which digests organic material biologically degrades and converts the human, animal and farm waste into usable water and gasses in an eco-friendly manner. The generated gas can be utilized for energy/ cooking and water for irrigation purposes.

hours. Eaton and his team gathered continuous feedback from the users to improve the systems.

Through this system small farmers and rural communities could convert organic waste into renewable energy and organic fertilizer. The gas had effectively replaced the conventional energy and was used for cooking, heating water, and for heating the greenhouses. This also provided affordable renewable energy for people who were deprived of electricity and energy. A small farmer with two cows could save about US\$ 28 – 40 every month on energy and fertilizers.

This had a huge impact on small farmers, increasing their productivity and reducing adverse environmental impact. In the process Sistema Biobolsa addressed the health challenges they faced due to unviable waste disposal methods. According to Eaton, *“I designed bio-digesters because in the countryside, there’s an excess of organic waste that can be converted into a reliable source of energy.”*ⁱⁱⁱ The benefits of the system were manifold, which included elimination of CHG emissions, protection of water sources, displacing of fossil fuels, exclusion of wood, chemicals and fossil fuels. On the economic front, it addressed issues like poverty, food security, and climate change and provided sustainable and productive solutions to small farmers.

By 2017, this social enterprise with proven environmental and social impact installed 3,500 bio-digester systems in Latin America, and Africa. The ease of use, efficiency, and economic viability made the system highly popular. Buoyed by the response, Sistema Biobolsa was looking at installing 10,000 systems per month in Mexico and another 50,000 per month worldwide.

The Beginning

As a child, Eaton learnt about sustainable agriculture, on an organic farm in the US. He studied in Kenya, and graduated from Colorado, and was actively involved in environmental journalism. For some time he stayed in Alaska, where he worked as wilderness guide³. Later on he moved to Latin America, to Nicaragua where he worked with an organization that was involved in installing photovoltaic⁴ and solar cooking systems. This guided Eaton towards technology that could help the poor in rural areas.

³ A tourist guide who takes tourists through nature and wilderness expeditions

⁴ Photovoltaics is used for generating electric power by using solar cells to convert energy from the sun into a flow of electrons.

At that time he came across a bio-digester in a farm. He was particularly attracted by the way the system processed animal manure in a safe and hygienic manner, producing biogas that can be used for household purposes replacing the fossil fuels and wood. Most of the systems that he came across were too large to or too complex to operate and maintain. He found that though the system was effective, the technology being used was inefficient, and caused lot of troubles for the users, due to which it was not widely embraced.

Eaton then relocated to Mexico for a conducive social entrepreneurial climate in the country. He set out to improve the technology. (***Refer to Exhibit I for Social Entrepreneurship in Mexico***) He then worked with an organization as a consultant for large scale renewable energy and bio-digester projects. At the same time, he concentrated on making smaller bio-digestable systems that could help small scale farmers. In 2005, he started creating his own design for a bio-digester. He, along with an environmental engineer Ilan Adler and a few more engineers registered International Renewable Resources Institute (IRRI), as a non-profit organization, to promote sustainability in the rural communities in Mexico, Latin America and the Caribbean. In IRRI, Eaton built the Mexico Biogas program, while continuing to work on bio-digester design and fabrication for small bio-digesters.

In 2007, IRRI started installing small scale bio-digesters. In the year Eaton was nominated for Switzer Environmental Leadership Fellow, where he received US\$ 30,500 grant. Then he went back to the US in 2007, to study masters in international development and engineering. During the course of his program he concentrated on studying the impact the small-scale bio-digesters could have in rural Mexico. In 2009, Eaton completed Masters with a thesis on bio-digesters and made a business plan, which went on to become plan for Sistema Biobolsa.

Eaton continued to work on finding a durable material for the bio-digester that would address the challenges rural farmers experienced with the biogas systems previously. Apart from the material, he concentrated on ease of use, manufacture, installation and transpiration.

In 2009, Eaton met Pages, who studied industrial engineering and was involved in marketing eco-friendly technologies. Pages developed interest in Eaton's vision of biodigestion and its impact on rural farmers, and both decided to start a company Buen

Manejo del Campo SA de CV in 2010 and patented the technology. Eaton became the CEO and Page the COO. They believed that use of biogas in small sustainable farms would help in addressing the issue of food security and achieve economic prosperity in rural areas.

They both then started the process of obtaining the necessary support from the government, municipality, and other public sector organizations. In 2010, Eaton received Global Social Entrepreneur award (US\$ 10,000) from IDB network. Eaton and Camela met personnel from international non-profit KIVA⁵ during a conference and started a dialogue about microlending. Eaton travelled to Europe in order to bring in investment into the venture and received first support from an individual in Sweden.

In 2011, Eaton was selected as Ashoka Fellow for “seeking to transform the culture of waste and resource management among small-scale Mexican farmers through the introduction of appropriate bio-digester systems”. In the same year a television reality show was conducted in Mexico - ‘Iniciativa Mexico 2011’ for social start-ups. The show was organized by the Government secretariat for social development (SEDESOL) where Sistema Biobolsa won the second prize from among 57,000 applicants and the company was covered extensively in the media, due to which it became popular across the country. This also brought in angel investment of US\$ 1 million. With this capital, Sistema Biobolsa built manufacturing plant in Toluca, Mexico. In 2011 and 2012, 100 bio-digesters were installed in 10 states across Mexico.

In 2012, Echoing Green, a global non-profit organization that provides fellowships, seed-stage funding, and strategic support to social entrepreneurs, recognized Sistema Biobolsa as one of the top 10 Entrepreneurs in Latin America. Eaton participated in Ashoka Change makers, American Express Emerging Innovators Campaign and was nominated as a Buckminster Fuller Challenge⁶ Finalist. Same year, he also delivered a TedX talk in Mexico. The company was widely covered in local and international media organizations. This helped it develop relationship with governments and rural

⁵Anybody from across the world can become a part of KIVA and lend their money to entrepreneurs working in the areas of education, clean energy, and other social causes.

⁶Buckminster Fuller Challenge is an annual international design competition that awards \$100,000 to the most comprehensive solution to a pressing global problem.

cooperatives to install bio-digesters. In 2013, the company received a major public order from Food Security Program in Tlaxcala to install 100 bio-digesters.

The venture received support and investment from several investors including individuals and companies in the US and Europe. One such company was ENGIE, a France-based energy company, which invested through its solidarity investment fund that lent support to social enterprises working in the area of energy poverty. The other investors included Factor(e) ventures, a company that supported early stage entrepreneurs. From 2015, Sistema Biobolsa received three year US\$ 100,000 donation from Greater Impact Foundation⁸, which also provided a working capital loan.

Over the years the component of sales in the revenue generated by Sistema Biobolsa increased from 46% in 2010 and 2011 to 95% of the total revenue in 2014. (**Refer to Exhibit II for Revenues from Sales Vs Grants**) The company broke even in 2014 and achieved net profit of 18% on sales of just over US\$ 1 million. By then it installed 2,000 systems. (**Refer to Exhibit III for Sistema Biobolsa Revenue and Expenditure**) In 2014 MIF (IDB)^{iv} provided a grant of US\$ 250,000 to help the company systematize and consolidate. This led to the development of integrated Customer Relationship Management systems. In 2015 the company was recognized as a B-Corporation⁹.

Need for Clean Energy

In the new millennium the challenges that humanity was facing were Food security, poverty, climate change and environmental degradation. Small farmers produced 80% of the food and cultivated most of the arable land. But the farmers in the developing world lacked access to finance, technology, and used age old methods pushing them into a vicious circle of poverty. Their basic energy needs were met by biomass fuels like firewood that had led to higher deforestation and poor indoor air quality causing

⁷Factor(e) is a venture development firm with a mission to improve lives in the developing world through increased access to sustainable energy and related services.

⁸The *Greater Impact Foundation* funds stage two for-profit social enterprises that focus acutely on poverty eradication.

⁹B Corporations refer to companies that balance purpose and profit. Such companies consider the impact of their decisions on workers, customers, suppliers, community and the environment.

respiratory diseases. In order to increase the production, farmers resorted to using chemical fertilizers and pesticides, which lead to erosion of soil quality. This had compelled the farmers opt for stronger fertilizers. All this had adverse impact on climate.

Mexico¹⁰ was the second largest agricultural market in Latin America, with agriculture accounting for 3.5% of the country's GDP. 21% of the Mexican population lived in rural areas. There were more than 4 million small scale farmers in Mexico. Due to impact of climate change the farmers in Mexico were witnessing extended periods of drought, and also hurricanes, rains, and floods. One of the major reasons for erratic weather was the methane produced from animal manure, chemical fertilizers and deforestation, according to Environmental Defense Fund, one of the world's largest environmental organization.

The farmers faced severe challenges due to poor waste management systems. In Mexico and in other Central American countries animal manure was piled in the farms. Sometimes it was kept for over a year, so that it could become organic fertilizer. However this stale manure attracted flies, and polluted aquifers.

At the same time these farmers relied mostly on imported chemical fertilizers. The cost of these fertilizers was prohibitive and their continuous use had an adverse impact by depleting the essential nutrients for crop production. This led to lower yield. Another challenge they faced was the cost of energy. The farmers mostly used LPG as input energy. The availability of which was erratic in the rural areas.

Bio-digesters were in existence for more than 150 years, and at that time it was used in India in a leper asylum as a source of energy to power lights. In agriculture it was used in Germany in the 1940s.

The anaerobic biodigesters worked by processing the waste, just as animals process their food. For example the stomach of cow had billions of bacterial cells which breakdown the food the animal ate and released methane as a by-product. Similarly the anaerobic bio-digesters used bacteria to convert waste into biogas.

¹⁰ In 2012, 45.5% of the population of Mexico, or 53.3 million people, were in a situation of poverty, and lacked the income necessary to satisfy their essential needs

For several years the use of bio-digesters was prevalent in the Latin American countries. There were several attempts by governments and private institutions to create small scale bio-digesters in Latin America. But they could not bring in much impact either on the farmers' lives or on the environment. The main reason being lack of appropriate maintenance, low quality material used, which reduced the durability and use of ineffective waste management technologies. Due to these, the farmers did not show preference to use biogas for productive activities.

Some of the other systems were too expensive. Most of these systems took a long time to install, and there was no follow-up, to see if the systems were being used in an appropriate manner. Eaton said, *"a huge disadvantage of being a small farmer today is you live in an environment filled with flies and horrible odor, with animal waste contaminating rivers, lakes and watersheds."*

Sistema Biobolsa closely resembled natural ecosystems, which did not generate much waste. Whatever was generated became an input to another system. According to Eaton, "We take that waste and turn it into a clean, renewable energy source."v Through this system they wanted to provide integrated solution to provide better health, cleaner drinking water, improved productivity and better quality of life to the farmers. **(Refer to Exhibit IV for the use of Biogas)**

The Bio-digester System

The mission of Sistema Biobolsa was to empower farmers to manage their own resources in order to build a better future for themselves and their families. This was to be achieved through a well-designed technology and by raising awareness about the system and its benefits.

The Sistema Biobolsa's modular bio-digester was considered to be a disruptor in biogas space, and was credited with creating the first functional business model around biogas. This carefully designed system was technologically competitive and was made of geomembrane, a highly durable material. Using the system the farmers could turn animal waste into biogas to fuel stoves, lights and other equipment.

Sistema Biobolsa was a waste-to-nutrient ecosystem comprising several steps including onsite diagnosis, tailored financing, installation, training, long-term support for biogas and fertilizer use.

The bio-digesters, meant for small and medium sized farms, were available in 15 different sizes. The farmers can choose the bio-digester based on the number of animals in the farm. They were made of high quality raw materials. They were designed to withstand harsh rural climate and ensure long product life at low maintenance costs. It was manufactured in Toluca, in adherence to the just-in-time schedule and zero waste concept. It was tubular, prefabricated, modular, flexible and could be fit into a pallet, which eased packaging and distribution (due to the flat-pack system 10 packs fit in one truck). It could be transported easily into the hinterlands of rural Mexico through any mode of transportation available.

Sistema Biobolsa's biogas system, which lasted for 15 - 20 years, consisted of two main components – reactor (that can be compared to a large bag – Bolsa refers to bag in Spanish) and tubes. The reactor was made of linear low-density polyethylene geomembrane and was of 1.5 mm thickness. It was in black color to enable absorption of heat that can break down waste. The geomembrane had an estimated lifetime of more than 50 years. It optimized solar heat and kept the internal bacteria alive. According to Prapas, co-founder of Factor[e] Ventures “A cow can step on this bag and it won't pop. In fact, stepping on—rather, kicking—the geomembrane every few days is how farmers keep the bacteria-rich contents mixed.”¹¹

The tubes and assemblies were made of hydraulic and sanitary PVC. It had the capacity to operate from 4 m³ to 40 m³ of liquid. Every day the bio-digester received farm waste and manure, mixed with water (1part manure to 3 parts water). (***Refer to Exhibit V for the characteristics of Sistema Biobolsa***)

The reactor was placed in a trench in the farm, and was connected to a source of human or animal waste and water. The reactor was closed to enable anaerobic process, which was breaking down organic material by micro-organisms in the absence of oxygen. This process produced biogas, which is a mixture of methane, carbon dioxide and other gases, along with digestate (a nutrient source that can be used as fertilizer). A tube connects the reactor to another bag that collects the biogas. This was connected to a pipe leading to the home / farm where the biogas was used. Another tube funnelled biol or liquid organic fertilizer from the reactor to an external tank. (***Refer to Exhibit***

¹¹ “Gut Instinct: Introducing Bioenergy in Rural Mexico,” <https://demandasme.org>, Fall Winter 2016

VI for different parts of the Biobolsa system). Sistema Biobolsa developed a water treatment system using aquatic plants to further treat any waste water from the biodigester.

It took about 30 days for the system to reach its full productive capacity, after which the gas and biol were obtained every day. Experts compared bio-digesters to rainwater harvesters and solar panels as it also generated power by reinvesting natural resources into the ecosystem.

Just after the launch the team found that there was a huge gap as far as bioenergy ecosystem was concerned in Mexico. Previously low-income families were not under the purview of bioenergy initiatives. “There is a whole chain of innovation that has to happen when you launch a new product. There are so many supporting elements that have to become a reality.”^{vi} Said Eaton.

Outreach Programs

The main challenge was making people who had scarce resources spend a substantial amount on a product, whose benefits they were yet to witness. To enable this, the company carried out ground level, rural outreach programs.

In order to make the local people understand the importance of bio-digester the founders took the help of a local legend about a red dragon. According to the folklore, the dragon ate trees and breathed fire. Eaton said, “I came up with my own legend about a blue dragon that eats waste and breathes blue fire to speak to the origin of energy.” Through this story the company could generate interest about biogas among rural and poor communities. He said, “People started calling [biogas] ‘the new flame.’ It was a significant starting point.”

There is not much knowledge about the opportunities available in waste-to-resource systems and given the fact that the technology was not popular, the company devised a strategy to approach the customers. The technicians at Sistema Biobolsa were from the local communities and many of them were the users of the system. Initially they spread a word about the system and the benefits they reaped from the system, which included reduced energy costs, and re-cycling waste into, source of energy and organic fertilizer.

Once a farm decided to own a system and install it, the company conducted a baseline assessment. The technicians used their smartphones to input data pertaining to the number of animals and people, expenditure incurred on fertilizer, LPG, other fuel, time spent to collect firewood, etc.

The technicians trained the families intending to use the bio-digester. Once the system was ready in a farm in a particular community that became a prototype and was shown to other in the nearby communities. According to Eaton, “The best tools to build community awareness are farmers demonstrating the benefits of the technology within a local framework of value. 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.”^{vii}

Financing

The equipment was sold as an integrated package consisting of necessary connections, appliances and a biogas cookstove. The system installed for a small farm produced 1 m³ (volume of one cubic meter equal to 1000 liters) of biogas every day, and gave biogas for 2 to 4 hours. The smallest and most popular biodigester was called BB4 and contained 4 m³ of waste storage. It cost US\$ 600, including tubing, installation, a cookstove, a boiler burner and gas filters. At the other end was BB240 with 240m³ of waste storage. It could be used in farms with upto 110 cattle and produce heat for 60,000 sq. Ft greenhouse. It cost around US\$ 12,000. **(Refer to Table I for the details of Sistema Biobolsa)**

Table I

Briefing about Functioning of Sistema Biobolsa
<p>(For a small scale operation with 6 pigs or 2 cows)</p> <ul style="list-style-type: none"> • 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 • 1m³ of biogas (2kWh equivalent) produced per day (30kg per month), i.e. 2 to 4 cooking hours per day • Average savings of 480 USD per family per year • Small scale biogas generators and other accessories available for larger systems • Mitigates the equivalent of 3 tons of CO₂ per year

Though the system was highly useful, its cost was prohibitive for small farmers. Hence Sistema Biobolsa started loan program way back in 2011, and ensured that the savings were used to pay back the loans. In 2012, Sistema Biobolsa partnered with global microfinance organization KIVA to offer loans. According to Eaton, “*KIVA loans us the money, and we pay KIVA back as our customers pay us.*”^{viii} The amount loaned by KIVA accounted for 40% of the total cost. For each loan Sistema Biobolsa uploaded the lending petition to KIVA. The loans were secured through international lenders and transferred to Sistema Biobolsa. (***Refer to Exhibit VII for loan eligibility criteria***).

The remaining was covered through subsidies provided by the government of Mexico. A part of the cost was borne by the customer. This arrangement benefited the company as the risk was limited. The company planned to phase out government support. According to Esther Altorfer, Sistema Biobolsa’s finance director, “*The subsidies are a good way to support new technology, but our strategy is to offer credits ourselves and keep this market-based.*”^{ix}

The loans were tailored based on the circumstances of the farmers and was based on the calculation of the farmers’ existing energy and fertilizer expenditure. This information was taken into consideration to design payback scheme, where monthly payments were just equal to monthly savings generated by bio-digester. Many times the savings exceeded installments making the payback easy for customers. This motivated them to install the system. The loan instalment was collected during the regular follow up and monitoring visits.

Once the customer showed interest in the system, the evaluation of the credit application began. Information about the financial position of the applicant was taken along with details of two guarantors. The guarantors needed to be local residents, and should not have been employed with companies going for liquidation.

The salesperson was responsible for doing the assessment of the applicant and of the guarantors. The information was given to credit coordinator who was responsible for verifying the information.

Many farmers did not have any bank account or credit history. For this Biobolsa developed a series of credit survey questions about the number of animals, types of

crops, seasonality of farm income, animal health, cleanliness, annual payment details, size of family, food cost, education costs etc.

This data was then posted on the CRM system into a data collection application called Taroworks, a company that belonged to Grameen Foundation¹². Through this app the sales people or technicians entered the data into smartphones and uploaded into database whenever internet was available. Once all the credit survey questions were uploaded, the credit coordinator reviewed the information. They reviewed each answer carefully to determine the eligibility of loan.

Installation

The head office was located in Mexico city, and there were three regional offices and operations were spread across 25 states in the country. A team of two technicians installed the product in just a few hours. At that time the customers were trained on using the system. There was a one year guarantee on the product and 20-year guarantee on the geomembrane. The installation was completed in 2-5 hours.

After the installation, monitoring was done, and after 30, 90 and 180 days feedback was taken from the customers, and their queries were resolved. The initial monitoring was done to ensure that the system was working as intended and any problems were diagnosed. During the second check up the production of fertilizer was checked.

(Refer to Table II for the details of technical support provided)

In the 180 day follow-up it was ensured that all the outputs were stable and customer feedback was gathered. During these checkups information about the impact that the system had had on the productivity and the farmers' lives was collected. The monitoring data allowed Sistema Biobolsa to measure impact and gain feedback from the customer about the functionality.

The data collected prior to installation was compared with the data collected after six months. This data became a part of the CRM system of the company. This was used to bring changes to the system, and also in education programs. After 180 days, the technicians certified the family using it as 'local experts' and they could participate in peer-to-peer validation, future events and also demonstrate their product.

¹² Grameen Foundation is a global non-profit organization that works to replicate Grameen Bank microfinance model around the world.

Table II

Technical Support Provided by Sistema Biobolsa's Technicians	
<ul style="list-style-type: none"> • An initial diagnostics • first training on how to use the system and how to use biogas – on the day of installation • Three visits after Installation <ul style="list-style-type: none"> ○ 1 After 30 days, technical visit with a training on biogas ○ 2 After 90 days, technical visit with a training on biol. ○ 3 After 180 days, technical visit with an evaluation of adoption and impact. • Establishment of performance targets based on the climate and type of animal manure used (for the 10 m³ size) <ul style="list-style-type: none"> ○ hot climate (>23°C) - 14.6 m³ ○ temperate climate (15°C to 22°C) - 9.7 m³ ○ cold climate (<15°C) - 5.8 m³ 	

Though such engagement was highly expensive, and such processes were usually automated, the company wanted to reduce their engagement with the customers, in order to maximize the benefits from the product. Sistema Biobolsa sold carbon credits, and the proceeds were used to finance the follow-up activities.

The Impact

Sistema Biobolsa believed that small, sustainable farms played a major role in bringing in economic prosperity. It involved low-income groups as consumers, distributors and employees. It aimed at creating a culture of sustainable resource management, by increasing the number of systems installed. On the impact he desired to create, Eaton said, *"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."*^x

The founders started in a small way with the aim of installing the systems one after the other. They were of the view that over the years the farmers have realized the negative impact that chemicals and fertilizers, fossil fuels, have caused to the environment and the way their lives were affected. Sistema Biobolsa provided a combination of knowledge and technology leading to creation of sustainable resource management, improved rural livelihoods empowering farmers.

The Sistema Biobolsa digester converted 75% to 85% of volatile solids in organic waste to biogas. According to Eaton, *“If we had tried to stretch that extra 10 percent, we would have had to compromise a lot on affordability and usability. To serve the customers we want, we had to strike a balance between function and technical efficiency.”*¹³

The standard design, size and installation procedure reduced the cost of the project and installation. The technology could be scaled to millions of small farmers. As the systems were modular they could be used in small or large farms without any problem.

The customers could realize cost savings immediately after installing the system. One month after installation, the system started producing fertilizer and biogas. The farmers could save on buying fertilizers and also on petroleum and gas. The savings were estimated to be US\$ 20 per month in energy costs. In the first year the farmers witnessed 30 to 40% rise in crop yields. *Prapas*, who visited a few customers said, *“I was expecting to see people using the gas for cooking only. Instead, I saw that the family had so much gas, they had bought a boiler so they could have hot showers. It represents such a dramatic change in quality of life.”*¹⁴

Another customer, who was a farmer with 100 cows said that he used to find managing animal waste a huge task, but after the installation of the system, he got not only fertilizer but also energy to heat greenhouses. Many families reported that they were generating more biogas than they needed. Many farmers said that they were growing better crop due to use of organic fertilizers. A few of the customers said that they could heat the barn that kept piglets warm in the night leading to healthier animals. A farmer said, *“Take a look around now; there are no flies. It’s cleaner now.”*

Biogas offered many more benefits. In the agriculture sector it helped in reducing methane emissions, which had a huge global warming potential – 23 times higher than carbon dioxide. Agriculture sector also polluted water sources with animal waste, fertilizers, chemicals, pesticides etc. By transforming methane and carbon dioxide into

¹³ “Gut Instinct: Introducing Bioenergy in Rural Mexico,” <https://demandasme.org>, Fall Winter 2016

¹⁴ “Gut Instinct: Introducing Bioenergy in Rural Mexico,” <https://demandasme.org>, Fall Winter 2016

renewable energy, Sistema Biobolsa was able to reduce the greenhouse gases from farming related activities.

The use of bio-digesters led to improved waste management, resulting in reduced water pollution and sanitary risks. Due to use of renewable energy, dependence on fossil fuels and wood reduced considerably, leading to reforestation. Reduced the use of firewood led to lower deforestation and better health due to lesser indoor pollution.

The use of organic manure led to protection of soil and farmers could save on expensive chemicals and fertilizers. (***Refer to Table III for The Impact of Sistema Biobolsa***)

Table III

Environmental Impact – Sistema Biobolsa
150,000 tons of waste managed 4,500 tons of biogas produced 17,000 tons of CO ₂ mitigated 350,000 tons of biof (organic fertilizer) produced

Source: IDB Report

The impact reports showed that full cost of the system could be repaid in 8 to 18 months. Once the money was paid, the farmers experienced an increased disposable income and savings. It showed that on an average a farmer with 3 hectares (around 7.5 acres) of land saved US\$ 260 on fertilizers in one year, by replacing chemical fertilizers with biofertilizers. Their use resulted in large and more powerful crop yield.

Each farmer saved about US\$ 28 to US\$ 40 per month on fossil fuels like LP gas, which was the main source of cooking and heating. Through the biogas the farmers could also power their homes and farms.

In a span of about six years 2.4 millions of animal waste was treated by Biobolsa. Over the years the number of systems installed was showing an increase. Over 75% of the systems sold were very small, 15% were medium and 10% were of large scale. (***Refer Table IV for the Details of the number of Systems installed***)

Table IV

Number of Systems Installed						
	2011	2012	2013	2014	2015	Total
Systems installed	184	395	531	777	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%	

Source: IDB Report

Sistema Biobolsa addressed critical challenges like waste management, soil degradation, adverse affects of chemical fertilizers, growing energy costs, deforestation, etc. The final impact of all this was on climate change.. Observers also said that due to better yield from the farms, the migration to overpopulated cities could also reduce. Prapas said, Sistema Biobolsa has been “*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.*”^{xi}

Going Global

The company was of the view that the bio-digester technology could have a huge impact on the rural poor by providing a source of waste management and clean energy. To support the farmers, the company decided to not only sell the equipment but also train rural families on using the bio-digesters to process waste into energy. The founders planned to reach millions of small farmers across the world through this system.

To replicate the model in other international markets, Sistema Biobolsa worked with solar energy system distributor - Tecnosol - in Nicaragua. Several biodigestors were sold in this manner. The main problem with the model was the lack of follow up and maintenance mechanism.

Another strategy adopted to replicate the model was to setup a network of organizations to support the growth of bio-digester sector and promote the biogas projects and innovations. This method was followed in Latin American and the Caribbean. Sistema Biobolsa worked with 10 organizations to organize events and share good practices and work on common goals. More than 500 organizations were participants in this network. The objective of this network was sharing information and

experiences, identifying technical, environmental, social and economic barriers, suggesting ways to spread the bio-digester technology in different countries, systematizing research and dissemination among partners and encouraging actions that influence policies related to bio-digesters. This was supported by IDB and other organizations.

Factor (e) was also working with Sistema Biobolsa closely and was looking at reaching 10 million users in 18 months. Factor(e) was looking for a scalable and replicable bio-digester model. Inspired by Sistema Biobolsa's smallest and largest units, it decided to invest in Sistema Biobolsa. Factor(e) entered into agreement with Sistema Biobolsa for equity and technical support in 2016. They planned to identify the areas where Sistema Biobolsa could enter into, and attract further investment. In the first phase it planned to grow in Latin America and in the second phase it was looking at expanding across the world. Factor(e) launched a regional office in India to help Sistema Biobolsa evaluate the impact it could have in India.

Several African and Asian countries were also interested in this biogas system and the company had shipped bio-digesters to Ghana, Nigeria, Madagascar, Haiti, and also to South American countries Cuba and Peru. The founders were also looking at venturing into these countries where the waste management practices were unsustainable. In 2016, the company trained 12 people to start the operations in Nicaragua. In July 2016 the first international office was started with a manager and two local employees.

Looking Ahead

There was a huge potential for bio-digesters across the world. As per the Food and Agriculture Organization of the United Nations, there were more than 500 million small farms in the world^{xii}, while the number of digesters was only around 10 million, showing a huge gap between supply and potential demand. There were more than 2 billion farmers in the world, and most of them were among the poorest in the world. According to Eaton, *"I want to create a base of users that leads to a tipping point ... a collective aha moment in farming."*^{xiii}

The company had over 35000 people using the biogas technology in six countries. But there were an estimated 4 million small farmers in Mexico alone, which the company had to reach, in order to have a full scale impact.

The company's business model was profitable and it was looking at expanding into new markets and extend its social, economic and environmental impact. The pilot projects were running in several Central American countries, Haiti, East Africa and India. It planned to enter these countries by 2018.

Though the use of biogas sector in Mexico was growing, Its usage in agricultural sector was still limited, due to lack of suitable motors to convert biogas into electrical or mechanical energy. Sistema Biobolsa hosted workshops with local mechanics to convert products designed for other power sources to biogas. These included small equipment like stoves to large motors. It then bought those machines from the mechanics to sell them along with bio-digesters. Eaton said, *"Three to five years down the line, we hope [the market will have grown so much] that we'll just be able to direct people to a local store if they want to buy a biogas-powered motor."*^{xiv}

It also developed generators that can be used to pump water, heat water, or generate electricity. It started using these on an experimental basis with funds obtained from Visions and KIVA.

Though the company had become financially successful, it had several lofty goals ahead – reducing pollution in rural areas, address the issue of global warming, and reach small and medium farmers across the world to create a more sustainable economy. **(Refer to Exhibit VIII for Global Goals of the company).**

At the micro level there were some issues that the company needed to address. One was the commercialization of biol. Though it was claimed that excess biol could be sold as a fertilizer. Several farmers were not sure of its chemical composition in order to either sell it or use it in their farms. Biol was not a commercially viable commodity, as it had only 1% nitrogen, which meant that huge quantities were required to fertilize.

The main challenge with Sistema Biobolsa, according to the investors, was that the model could become unviable as the company grew, as engaging with the customers so closely was an expensive affair. But the company was of the view that such high level of engagement was needed to ensure the long-term use of the product.

Another challenge it could face was to replicate the conditions that it had created in different countries. It required experienced people with well-established contacts, capacity and resources. In Mexico the expansion was smooth as there had been several

years of lobbying by various authorities to subsidize energy and use alternative energy. But the regulatory mechanisms and budgets in other countries could be different, thus the company might have to spend considerable time and effort to lobby with various authorities to obtain subsidies and also obtain loan funding.

Sistema Biobolsa attracted some high profile partners like the Clinton Global Initiative and the Nature Conservancy, through whom it planned to expand its activities to other parts in the Latin American Region, the Caribbean and Africa.

Eaton saw a future in Sistema Biobolsa's increased use among farmers as their productivity also grew. The market for small-scale bio-digesters in Mexico was estimated at one million units, equal to 25% of smallholder farms in Mexico. The future of Sistema Biobolsa depended on expanding into new markets rapidly, and also in finding new applications for the equipment like farming equipment powered with biogas. In Eaton's words, ". For us, success is when we make farming more viable and more dignified. Rather than your farmyard being filled with manure and flies, if you have this high-tech piece of equipment, and you're no longer cooking over this smoky wood stove, you can create a quality of life that's significantly better."

Exhibit I

Social Entrepreneurship in Mexico

Mexico has a long cooperative tradition. Right from the 19th century social entrepreneurship was encouraged in Mexico. In the 1930s General Law of Cooperative Societies was enacted through which legitimated State intervention in the internal affairs of cooperatives.

In 1991, the then President Carlos Salinas created the National Fund for Support to Social

Enterprises to support creation of enterprises and projects with a social aim that contribute to the development of communities, groups and social organizations. It also promoted cooperation between the private and social sectors with the support of states and municipalities.

The cooperatives in the country do not receive government funding and therefore looked for ways to generate income to accomplish their social mission. In the aftermath of the 1985 earthquake the NGO sector started grow. But there was fierce competition for resources among these.

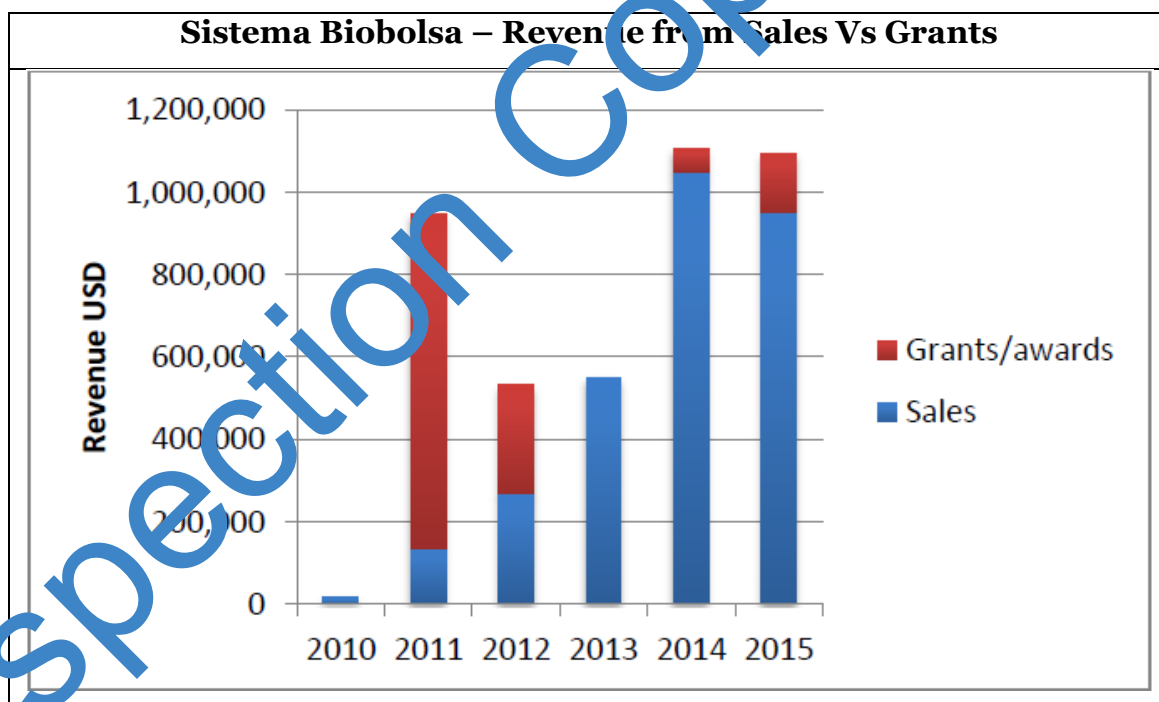
Mexico has three types of social enterprises

- Those whose profits are divided between the shareholders
- Nonprofit organizations whose profits are reinvested in social causes
- Hybrid social enterprises with those that share profits and nonprofit enterprises

In early 2000s, the government created a program to support social entrepreneurship - National Institute for Support to Social Enterprises, which contributed to the creation of 20,000 enterprises. In 2013, the government launched National Institute for Entrepreneurs to support entrepreneurs. Through this the government provided funding for entrepreneurs who promote social business.

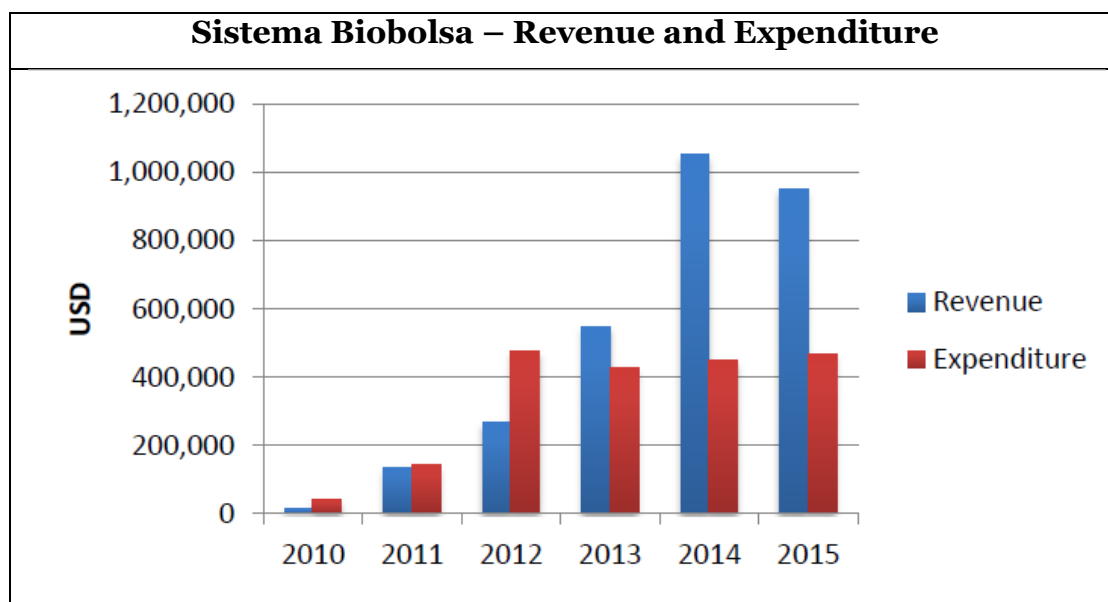
Compiled from various sources

Exhibit II



Source: IDB Report

Exhibit III



Source: IDB Report

Exhibit IV**Benefits of Biogas****Better Health**

Due to the use of biogas use of wood for cooking would reduce, impacting the quality of indoor air. The contaminated indoor air was one of the major causes of respiratory health issues and related deaths among millions across the world.

Clean Drinking water

The way the animal waste was stored, and the use of chemical fertilizers directly increased nitrogen and organic loading in drinking water. This led to water borne diseases and health issues. Bio-digesters provided a solution through which the use of chemicals could be reduced

Productivity

The use of biogas provided the farmers a low-cost energy that allowed them to diversify into making other products like cheese and yogurt. Due to use of organic fertilizers the crop productivity improved and the expenses reduced

Quality of Life

The animal waste that was kept outside attracted flies and eliminate odour. Due to the use of bio-digesters the waste was no longer stored outside.

Environmental Sustainability

The biodigesters help in cutting down the greenhouse gas emissions, prevented water contamination, reduced the use of chemical fertilizers and helped in decreasing deforestation.

Compiled from various sources

Exhibit V**Sistema Biobolsa – Characteristics**

Durability: The reactor, also called Biobolsa, is fabricated out of linear low density polyethylene (LLDPE) geomembrane of 1 to 1.5 mm thickness. The tubes and assemblies are made out of hydraulic and sanitary PVC. The selection of materials was made to offer Sistema Biobolsa a long lifespan in the harsh conditions of the countryside. With the adequate maintenance, the geo-membrane can provide the system with a total lifespan above 35 years exposed to UV rays.

Pre-Fabricated: The system is composed of pre-fabricated components in order to optimize packaging, transportation and easy installation. The manufacturing process complies with the strictest quality control standards.

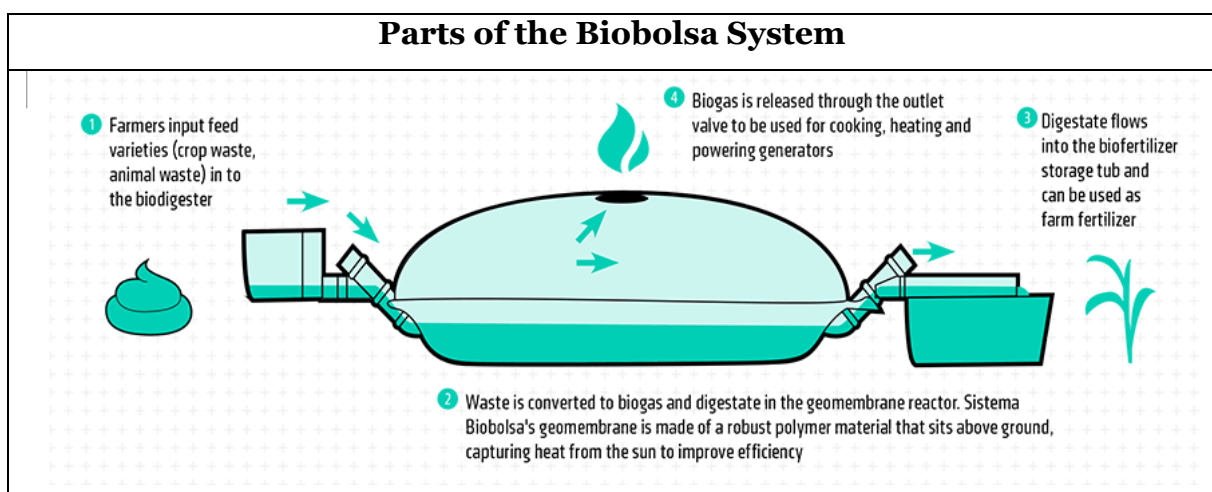
Variety of sizes: The product catalog offers 11 standard sizes of reactors, from 4m³ to 40 m³ in liquid phase.

Modular: The design allows the interconnection of different Biobolsa reactors, aiming at increasing the system's treatment capacity volume from 50m³ to 240 m³ in liquid phase. The Sistema Biobolsa can be adapted to a wide range of scenarios, allowing to expand the system according to the growth of user demand.

Easy operation and maintenance: The operation and maintenance routine of Sistema Biobolsa should not represent more effort than the benefits brought by the technology. Any family member or worker can carry out these activities. Easy and quick waste input, effective agitation, very low and periodic maintenance, low-cost long term maintenance and the characteristics that differentiate Sistema Biobolsa on the market.

Source: www.sistema.bio

Exhibit VI



<https://demandasme.org>

Exhibit VII

Loan Eligibility Criteria

Criteria that should be considered, without exception, before moving forward with a credit application:

a) Area of Influence: The farm and the home of the applicant must be located within a radius of 2 to 3 hours from the field office. In the case that one of these two is not within this radius, the credit must be denied.

b) Ownership of the Farm: The applicant must be the owner of the farm in which the bio-digester will be installed. (This is already a requirement to install a Sistema Biohóls bio-digester, but it must be reconfirmed).

c) The income generated by activities related to the bio-digester {livestock (production of manure) and agriculture (use of bio)} need to represent at least 20% of the total household income.

d) Age of Borrower and Spouse: They must be of legal age (18 years) and younger than 65. If the applicant or the applicant's spouse is over 65 years of age, it is preferred to put the credit in the spouse or child's name, or they must put one of their children as a co-signer.

e) Seniority: The applicant must possess a seniority of at least three years in their livestock or agriculture.

f) Consult a Credit Bureau: To proceed with any operation, you must enquire with a credit bureau to obtain information about the applicant and their co-borrower. To continue the process, the history consulted must not include the below cases labeled as "deny".

g) When the farm is owned by partners, all partners must be consulted.

Source: *sistema.bio*

Exhibit VIII

Sistema Biobolsa – Global Goals	
1. NO POVERTY	Sistema Biobolsa reduces small farmers' expenses and creates savings opportunities by displacing fossil fuels and chemical fertilizers. Farmers generate additional revenue by improving their productivity in a cost-effective way and selling the organic fertilizer.
2. ZERO HUNGER	The organic fertilizer produced by the system increases the yield of small farmers' fields, improving their capacity to grow food in a sustainable manner. Harvests are increasingly productive and plants more vigorous.
3. GOOD HEALTH AND WELL-BEING	Biogas replaces wood in the kitchen, reducing the exposure to toxic smoke and the risk of contracting chronic respiratory diseases. Waste treatment improves the sanitation at the farm, eliminating potential sources of infection.
4. QUALITY EDUCATION	Sistema Biobolsa educates all of its direct beneficiaries on sustainable farming practices, and on providing maintenance to high-quality technology. Our education program is based on UNESCO's 5 principles of Education for Sustainable Development. Most of the farmers say they will use their savings to pay for their children's school and university fees, providing better access to education.
5. GENDER EQUALITY	27% of Sistema Biobolsa's users are women. As they displace fossil fuels and no longer need to collect wood to cook thanks to their bio-digester, they generate monetary and time savings. They are being empowered to start new businesses or improve existing ones, which creates opportunities for additional income and economic independence for them and their families.
6. CLEAN WATER AND SANITATION	

<p>By treating animal or human waste in an anaerobic digester, Sistema Biobolsa provides sanitation at a low cost and in a productive way.</p>
<p>7. RENEWABLE ENERGY</p> <p>Sistema Biobolsa transforms waste into renewable energy (biogas) that can be used to cook, heat water, or produce electricity.</p>
<p>8. GOOD JOBS AND ECONOMIC GROWTH</p> <p>Sistema Biobolsa is creating high quality jobs in rural areas, paying above-average wages with opportunities for professional and personal development for its employees.</p>
<p>9. INNOVATION AND INFRASTRUCTURE</p> <p>Sistema Biobolsa has re-imagined bio-digesters as high-quality, modern durable gas for smallholder farmers. We have revolutionized the way waste was perceived, transforming it into productive and clean resources</p>
<p>10. REDUCED INEQUALITIES</p> <p>Sistema Biobolsa empowers small farmers who currently lack access to energy, health, technology and financial services by providing them with opportunities to improve their quality of life through productive activities</p>
<p>11. SUSTAINABLE CITIES AND COMMUNITIES</p> <p>Sistema Biobolsa treats the waste of entire communities through a biological process, improving sanitation and providing sustainable energy.</p>
<p>12. RESPONSIBLE CONSUMPTION</p> <p>Sistema Biobolsa users represent more than 15,000 people who have the potential to grow organic food on over 60,000 hectares every year for self-consumption and sale. They are ambassadors of responsible consumption using local and sustainable resources. 7,000 children are growing up in an environment where energy is auto-generated.</p>
<p>13. CLIMATE ACTION</p> <p>Sistema Biobolsa reduces greenhouse gases emissions on small farms by converting methane in CO₂, eliminating fossil fuels, chemical fertilizers and reducing deforestation. The smallest system reduces at least 2 tons of CO₂ equivalent per year</p>
<p>14. LIFE UNDER WATER</p>

	Sistema Biobolsa has treated more than 2.4 million tons of waste, avoiding the contamination of rivers and other water sources, directly protecting underwater biodiversity and life.
15. LIFE ON LAND	Sistema Biobolsa eliminates woodfuel from small farmers' houses, thereby reducing deforestation. We train farmers to adopt sustainable farming practices on their fields, protecting biodiversity.
16. PEACE AND JUSTICE	Sistema Biobolsa promotes a peaceful society living in harmony with the environment and natural resources, encouraging communities to live together and to share their Experiences
17. PARTNERSHIP FOR THE GOALS	Sistema Biobolsa partners with most of the UN major groups: governments, NGOs, youth and women organizations, scientists and researchers, universities and academic institutions, farmers groups and private companies, all of them heading towards the sustainable development of rural communities

Source: Sistema Biobolsa

ⁱ "Sistema Biobolsa: Taking Circular Economy to the Countryside," www.elcuartosector.net. 2018

ⁱⁱ "Study of Social Entrepreneurship and Innovation Ecosystems in the Latin American Pacific Alliance Countries." Inter-American Development Bank, July 2016.

ⁱⁱⁱ Elizabeth Meza Rodríguez, "Sistema Biobolsa," www.solutionsandco.org,

^{iv} MIF refers to Multilateral Investment Fund of Inter-American Development Bank.

^v Vanessa Ho, "Alex Eaton: Helping small farmers turn animal waste into clean energy," <https://news.microsoft.com>, June 17, 2016

^{vi} "Gut Instinct: Introducing Bioenergy in Rural Mexico," <https://demandasme.org>, Fall Winter 2016

^{vii} John Converse Townsend, "Agricultural Innovation, In Reverse -- Waste As A Resource: Q&A With Ashoka Fellow Alex Eaton," www.forbes.com, August 15, 2013.

^{viii} "Gut Instinct: Introducing Bioenergy in Rural Mexico," <https://demandasme.org>, Fall Winter 2016

^{ix} "Gut Instinct: Introducing Bioenergy in Rural Mexico," <https://demandasme.org>, Fall Winter 2016

^x John Converse Townsend, "Agricultural Innovation, In Reverse -- Waste As A Resource: Q&A With Ashoka Fellow Alex Eaton," www.forbes.com, August 15, 2013.

^{xi} “Study of Social Entrepreneurship and Innovation Ecosystems in the Latin American Pacific Alliance Countries,” <https://publications.iadb.org>, July 2016.

^{xii} www.fao.org

^{xiii} Carly Schwartz, ““Smells like Opportunity” Mexican Farmers are turning Cow Pies into Proverbial Gold,” <https://qz.com>, December 11, 2015.

^{xiv} “Gut Instinct: Introducing Bioenergy in Rural Mexico,” <https://demandasme.org>, Fall Winter 2016