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Network for Biodigesters in Latin America and the Caribbean:

Case Studies and Future Recommendations

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Contents

Introduction

Biodigesters use waste biomass from agricultural activities – most commonly manure – to produce bio-gas and fertilizer ('biol'). The biogas can be used in kitchens, gas-lamps, for water heating in industrial processes, and in larger applications to generate electricity. The use of biogas reduces or substitutes for consumption of firewood (and therefore reduces deforestation), and/or fossil fuels, as well as, mitigates soil and water contamination from concentrated animal manure. The 'biol' is an organic fertilizer that improves crop productivity.

Thus, a biodigester is a technology to mitigate pollution and climate change that produces energy appropriate for small and large producers in the tropics, valleys and plateaus of Latin America and the Caribbean. The farmers that incorporate a biodigester in their agricultural system greatly reduce deforestation, turn manure into a form more readily utilized by plants, improve indoor air quality and human health by reducing soot (black carbon), and produce their own fuel.

Historically, the main factors driving low diffusion of small-scale biogas technology in Latin America and the Caribbean have included: 1) absent or incomplete efforts toward adaptation of the technology to the specific circumstances of the target users; 2) the strictly top-down approach of initial technology transfer programs; and 3) the lack of sustained, long-term institutional support. However, within the last few years, several local initiatives have given rise to biogas focused trainers and project developers that have begun to research, adapt, and further improve upon the existing small-scale biogas technology. This Technical Note profiles several current efforts in Latin America to start biodigester programs, and makes recommendations for their further development.

As a result of the renewed interest and efforts, the Network for Biodigesters in Latin America and the Caribbean (RedBioLAC) was formed to increase dialogue concerning: a) promotion and management of biogas projects; and b) innovations in the field. The recent RedBioLAC "Design Exchanges" (2009 & 2010) exemplify the productivity of having a forum of opportunities to tackle and share valuable innovations in materials, marketing, and approach to a project's management and finances. Currently, RedBioLAC is building momentum by beginning development of a web-based project information sharing and management platform.

Globally, successful and appropriate small-scale biogas programs have demonstrated that to ensure long-term adoption and sustainable diffusion of biogas technology, commercially viable and country specific biogas sectors (e.g. clusters of suppliers, finance institutions, R&D providers, government support, and local extension services) need to be developed to coordinate interaction and enable potential users access to the market.

Though several RedBioLAC partners in Latin America are primed for scaling up, the development of such clusters has not yet occurred. This document aims to provide a snapshot of the current reality and synthesize conclusions on the economic, institutional, cultural, and technical factors that need to be addressed. Finally, the emerging RedBioLAC is presented as a forum for exchanging experience and strengthening biodigester programs in Latin America.

Country Profiles

Bolivia

Location: Cochabamba

Partner Profiled: GTZ EnDev

Model: Tubular

Materials: Polyetheline plastic

Number of systems installed: 275

Animal Waste: Pig and cattle manure

Uses: Cooking and fertilizer production.

Cost of Biodigester: $137-$219

Contribution of User: The users pay 75-80% of the materials cost.

Management Model: Potential users request, via letter, support to GTZ. Then, GTZ sets up a meeting with everyone interested in a community. Everyone buys the materials together from suppliers that sell kits of biodigester materials, and constructs the troughs. An installation workshop is held and local technicians trained. Rural technicians train families through the process of biodigester installation, and follow-up until the system is producing gas (2-3 months). GTZ provides training to local technicians, 20-25% cofinancing, design, research and follow-up. This GTZ program is carried out through partnerships with the Centro Internacional de Métodos Numéricos para Ingeniería (CIMNE) of Spain and the Universidad Mayor de San Antonio.

Costa Rica

Location: Limón

NGO Profiled: Universidad EARTH

Number of systems installed: 2000 in Costa Rica with many other partners

Model of biodigester: Tubular

Materials: Polyethylene bag with PVC pipes

Animal Waste: Pig and cattle manure

Uses: Cooking gas is the primary use. EARTH calculated a 50% reduction in firewood consumption and a savings of 250,000 colons ($496) per year (firewood only used for red beans and meat) and a savings of 204,000 colons ($405) per year in propane. Additionally, biodigesters are used to comply with Costa Rican regulations regarding treatment of animal waste so that it does not contaminate surface waters. The biogas is also sometimes used to warm piglets and chicks.

Contribution of user: The beneficiaries participated in the training process

Management Model: Students from the university participate in each of the installations. EARTH University is geared toward students from around the developing world that want to develop their expertise in sustainable agriculture and integrate these techniques back into their home countries. Finally, other farmers from the region were invited to participate, so they could consider installing a biodigester on their own farms.

Lessons learned: It should be noted, that the plastic available in Costa Rica is economical and more durable than similarly-priced plastics in other countries. The tropical heat also facilitates the digestion, so the smaller systems produce more gas than the biodigesters in the Andes. In Costa Rica (and not in the other countries) the manure is mixed with water, the solids are separated and the liquid is poured into the biodigester. The solids are composed and used as fertilizer as well as the liquid effluent from the biodigester. This adds an extra step of work, but it is probably a key factor in why the inexpensive biodigesters in Costa Rica last longer than when tried in other countries. EARTH University also notes that the biodigesters reduce the smells of farms, reduce the contamination of water used to wash the animal pens by 80% and a reduction in the flies and mosquitoes.

Ecuador

Location: Imbabura and Morona Santiago Provinces

NGO Profiled: CARE and Northern Technical University (UTN)

Number of biodigesters installed: 20

Models of biodigester: Hindu-style (7), Continuous flow (tubular) (2 in research and 8 in construction) and Horizontal (tubular) (3)

Materials: Hindu-style biodigester - Aluminum tank Tubular biodigester - Polyethylene bag with PVC pipes

Uses: In Ecuador, there is currently a subsidy for the cost of gas, so the biogas is not seen as of high value relative to LPG, but the fertilizer compensates the biodigester users for the investment. Hindu-model biodigesters were installed in four places in the Imbabura province. All were constructed with the purpose of (a) identifying the ideal substratum for each climate, (b) creating a prototype model, and (c) decreasing the visual impact of such a technology. The biodigesters were installed at slaughterhouses to treat the waste, eco-tourism hotels/farms, universities and communities. Tubular Biodigesters, were installed for four hours of gas per day and approximately 30-40 daily liters of biol (fertilizer).

Cost of biodigester: A Hindu-style biodigester costs USD $750 while a Tubular biodigester costs USD $500.

Contribution of user: Labor and partial materials.

Management model: Currently, CARE is working with universities, agricultural associations, eco-tourism facilities to install biodigesters. One interesting iniciative is their work with municipalities to install biodigesters at slaughterhouses as a way to dispose of animal waste.

Other institutions in Ecuador: Fundacion Ecuatoriana de Tecnologia Apropriada is planning on starting a micro-credit program for biodigesters.

Mexico

Location: Michoácan and Guanajuato

Partner Profiled: IRRI

Model: Tubular

Materials: Flexible polypropylene fabricated into the shape of a biodigester.

Number of systems installed: XX

Animal Waste: Pig and cattle manure

Uses: Use of fertilizer and then sale of products as "Natural" with possible value added. One of the biodigester users reported a savings of $38-53 in energy (gas and firewood is purchased) per month and $757/year in fertilizers. Smells and insects are reduced. The biodigesters produce 25liters of fertilizer a day and 1-2 hours of flames for cooking or heating water for bathing. In some of the systems, the water that was used to wash the pig pens had been accumulating in a lagoon and from there went into a river.

Contribution of User: The users paid $378 (5000 pesos) and the system was subsidized for the matching amount. While more expensive, these systems are more durable.

Management Model: IRRI is working to become a sustainable small business that sells biodigesters at a range of sizes. IRRI manufactures the polypropylene biodigesters themselves, which stimulated gains in efficiency, branded as Sistema BioBolsa. Their objectives include training additional government workers and organize civil groups to install and maintain biodigesters, generating small businesses in rural areas and developing a microcredit option to facilitate the purchase of biodigesters. In the long term, IRRI is also researching the development of an offset program that can add thousands of biodigesters and reduce pollution in Mexico.

Nicaragua

Location: Teustepe, Boaco

NGO Profiled: Asociacion Fenix

Number of systems installed: 10

Model of biodigester: A range of variations, using the basic principles of the tubular model were tried.

Materials: Polyethylene plastic (1) polyethylene plastic for biodigesters (1) ferrocement tank (2) high-density ethylene from Mexico (2) a combination of cement basin with plastic cover (4)

Cost of biodigester: USD $60 (cheap plastic), USD $90-$220 (concrete tank) and ~$700 (polyethylene)

Contribution of user: Each family participated in every facet of construction, from the preparation of the materials to completion. Needed materials that were already in the communities were supplied by the families. Each family, depending upon their finances, also built a stove.

Management Model: The communities were selected because Asofenix had already developed solar water pumping projects in each of the communities, and maintained a relationship with the communities. Each community has difficulty in the access of firewood, there are cattle, and there is excessive use of chemical fertilizers. Technicians were trained from the community.

Lessons learned: The biodigesters of common black polyethylene plastic was simple, and the principal problem found was the fragileness of the plastic. It damaged easily (within 30 days) due to the presence of domestic animals. Secondly, the biodigester made of polyethylene plastic (imported from Costa Rica) proved more resistant to sunlight, but is difficult to repair in the case of a hole. A ferrocement, cylindrical biodigester was constructed, which is very resistant to any mechanical force, domestic animals, and weather conditions, but makes it difficult to detect the leakage of gas. The third model that was constructed was locally known as a “pila” (basin). It is constructed of concrete in an area of 2 cubic meters with a covering made of common plastic. It is easy to construct and maintain. The covering is most prone to damage from animals, family activities etc, and currently the plastic used is being replaced with higher-quality plastic, even though it costs eight times as much. The fourth model uses plastic polypropylene which has a high density and is manufactured in Mexico (IRRI), which has proved durable, easy to install, but more expensive.

In 2011, HIVOS and SNV are launching a large biodigester program in Nicaragua, which envisions 5000 biodigesters installed through a program that combines financing, training of micro-enterprises and oversight by a national committee. At time of publication, initial studies have been completed, but the institutions involved in the implementation were still being determined.

Peru

Location: Cajamarca

NGO profiled: Soluciones Practicas-ITDG

Number of systems installed: 25

Model of biodigester: Tubular biodigesters custom-fabricated by CIDELSA, a Peruvian plastics company

Materials: Pre-fabricated geomembrane bag (1.25m diameter and 8m long) with a PCV pipe for the entrance, an outlet for the liquid effluent and an outlet for the solids (a design innovation from the workshop). A PET line for gas conduction to a gas reservoir in the kitchen, and to two clay burners.

Uses: The 10,000 liter biodigesters are used mainly to produce organic gas for cooking and lighting as well as the production of organic fertilizer.

Animal waste: Cow manure. ITDG also has an experimental biodigester with guinea pig manure.

Cost of biodigester: USD $641(1800 soles)

Contribution of user: The user provided all labor, some materials (metal bars, tubes and cement for the roofing structure, cement and sand for the entrance and effluent pools, straw for insulation) and 10% of the total cost of the biodigester ($70).

Management model: The biodigesters beneficiaries were selected because they were agricultural technicians, previously trained by ITDG to provide agricultural support in their communities. These technicians regularly visit their neighbors to provide veterinary services and advice on crop cultivation. To select the beneficiaries, the ITDG team used a questionnaire, socioeconomic survey, home visits and interviews. Once the families were selected, they agreed to contribute the counterpart, and they participated in a 5-part training series. The five courses that users receive were 1) Tubular Biodigester, 2) Components of a Biodigester and Processes for its Construction and Installation, 3) Care and Maintenance of a Family Biodigester, 4) Using the Products of a Biodigester and 5) Management Model

ITDG's objective is to help biodigester users form a microenterprise that commercializes fertilizer. However, laboratory tests revealed that high-altitude biodigesters do not process the manuel to a degree that sufficiently eliminates the E. Coli content of the effluent, thus making the product ineligible for commercialization.

Conclusions and Recommendations

While there are a number of experiences with biodigesters in Latin America, wide-scale dissemination has not yet occurred. This section will summarize the challenges and recommendations for expansion of biodigester programs in Latin America relating to: 1) Economic and Institutional Factors; 2) Cultural Issues; and 3) Technical Considerations.

Economic and Institutional Factors

Due to the high costs of inputs, follow-up and maintenance, a sustained biodigester program requires innovative financing mechanisms and inter-institutional collaboration. In the long-term the cost of high-quality biodigesters must come down through economies of scale, for it to reach a price point accessible to the majority of rural farmers who could take advantage of its benefits.

The pilot projects, profiled in this document, have exposed both the opportunities for the application of biodigesters, but also the need for a programmatic approach that includes financing mechanisms that make biodigesters accessible to rural farmers, provisions for long-term maintenance, and sustained public support. In order to scale-up the benefit to the end user, both in financial terms (cost of fuels, sale of products, etc.) and non-financial gain (reduced indoor air pollution), training must be clear in order for the end user to justify any upfront financial investment. Secondly, there must be credit and partial subsidies to support the purchase and after-sales maintenance of the biodigesters. Third, there must be institutional arrangements and clear roles of NGOs, micro-enterprises, government and supporting institutions. Policy environments that include ordinances for the treatment of organic refuse, to protect water resources, play a favorable role in the promotion of biodigesters. A large-scale program of dissemination would require financial and logistical support from state entities, as has happened in several countries in Asia.

Micro-finance may prove to be a way to make biodigesters more accessible, however biodigesters are not widely accepted as an investment that easily yields profits to repay a loan.

Furthermore, there are few MFIs in very rural areas, which are best suited for biodigesters. The low level of current dissemination means that there is little existing demand from potential customers. A successful biodigester program requires a pool of potential users who fully understand the benefits, as well as, the technical requirements in advance (animals, cost, space, water, labor). Currently, government subsidies for LPG, and not biodigesters, create a difficult competition for biodigesters. Adding to the challenge, there are few businesses that sell, install and service small-scale biodigesters. The intermediary micro-businesses would require incentives or logistics support for installation and follow-up.

A recommended implementation strategy would consist of the following main components:

1. Setting institutional frameworks for cluster development: Starting or strengthening dialog and agreements among local actors (technicians, entrepreneurs, project developers, technology suppliers, finance institutions, R&D providers, local and national government entities, among others) that are already beginning to work on, interested, and/or able to work on a comprehensive biogas program. The realization of local workshops for identifying and setting local agendas for the development of clusters. Targeting development of biogas clusters able to finance and install at least 1000 systems per year in each region by 2014.

2. Development of web-based project platform where the main tasks are: Optimizing the exchange of information and resources among implementing partners; Central platform for project coordination; data management of demonstration projects; support quality assurance system (see point 7 below); Communication of the process to the public and dissemination of findings.

3. Setting up demonstration projects and marketing of technology: installation of 100 small-scale biogas digesters in each region as a means to demonstrate viability, facilitate training, and catalyze the formation of the regional clusters. Practical experience gathered by these and other projects in the region will be the base for local educational and marketing campaigns.

4. Training modules and workshops for entrepreneurs along the technology supply chain: local technicians, possible importers and producers will be addressed. Comprehensive training modules will be created and offered covering relevant issues like materials; performance; ease of installation; operations and maintenance; post-installation services; emission and pollution reductions; fertilizer production; how to pair micro-finance with carbon financing and government subsidies; among others.

Cultural Issues

There are also cultural challenges that must be taken into consideration.

- Requires motivation and demonstration of results that provides incentive to use bio-gas and 'biol' produced from owned resources and invested family work.
- Cultural habits; use of wood to cook certain dishes (cannot be substituted).
- The use of manure for cooking is not accepted in some places.

Criteria that influence the successful adoption of biodigeters include:

- Difficulty in collecting firewood and other means of cooking (LPG or electricity). For example, focus should be on areas with deforestation problems, and not where LPG is subsidized.
- Adequate number of animals concentrated near the house.
- The biodigesters should help families at different economic levels.
- Enthusiasm of the family and commitment of members (men and women) to take on all the duties (manual labor, feeding the biodigester, maintenance, use of biogas).
- The family should be owner of their land or have stable living conditions.
- The location to build the biodigester must be selected with technical considerations (firm soil, solar radiation, area free of flooding, sufficient non-chorinated water, proximity to enough land to use the fertilizer, etc.)
- Biodigester design and size should reflect the particular need of the family (gas production, fertilizer, etc.)

Technical Design Considerations

Among profiled NGOs, there is consensus on the preference of biodigester with tubular plastic (particularly the Taiwan type) over concrete models because:

- It is easier to detect potential gas leaks.
- There are no seismic risks, a serious consideration in Latin America.
- Easier to install.
- Transportation of materials is easier for installation on remote communities.
- In cold climates it is possible to install insulation. The cold climates of the Andes inhibit the production of gas, in comparison to tropical climates.
- Technical benefits of horizontal flow: higher biological benefits and less "short circuits" (undigested material leaving the outlet).
- Smaller initial investment.
- The Taiwan type of biodigester will provide longer use and more gas pressure (although not constant).

However, there are considerations regarding material selection:

- Ordinary polyethylene has little resistance to solar radiation, and degrades rapidly (less than one year if directly exposed to the sun). Better results are obtained using plant nursery (high density) polyethylene because it contains additives that diminish degradation (three years can be expected). The life of the plastic can be doubled if the digester is placed in the shade or under a roof.
- Polyethylene does not allow gluing, forcing the use of bindings made of tire intertubes.
- This process may cause installation errors: ruptured plastic, deformation of the entry and exit tubes, and leaks due to untight bindings.
- It is a fragile material; therefore there are risks during transportation, installation, and operation.
- It is not easy to patch holes that may form in the material.

The use of polyethylene on tubular biodigesters has played a vanguard role when compared to rigid models of concrete or bricks. But its disadvantages cause a high number of ruptures and abandonment of the systems, which diminishes the return of the investment. Therefore, for future grand scale projects, the use of polypropylene/geomembrane and PVC has been proposed:

• They are stronger materials, therefore present less transportation and installation risks.

• It is possible to centralize certain phases of production, improving quality control and ease of on the process of installation.

• They have a longer life span and possibly higher financial revenue, even at a higher initial cost than polyethylene. However, the higher-quality plastics do imply a higher upfront investment. The use of more durable materials (like polypropylene), centralizing certain phases of production, and ease to patch eventual holes in the material, should all allow a longer lifespan of the biodigester. If prefabricated digesters are to be considered, discussions on centralization and globalization will ensue. Technical and economic issues about manufacturing at a medium centralized scale should be established (regional/provincial factories). On the other extreme, centralization and standardization could be considered. The exact design and selection of materials depend on the financing. If people have to finance the entire project and do not have the capital, biodigesters will continue to be made with cheap, short-lived materials (polyethylene). If there are credits or other forms of financing, then materials can be more durable (polypropylene/geomembrane or PVC).

Future Research Needs

There are many institutions doing biodigester research, such as EARTH University in Costa Rica, Centro para la Investigacion de Sistemas Sostenibles de Producion Agropecuaria (CIPAV) in Colombia, Universidad Mayor de San Andres in Boliva, and Soluciones Practicas with Universidad Politecnica de Cataluña in Peru. The role of universities needs to be ramped up and coordinated. RedBioLAC has developed an initial set of standardized parameters for measurement, accessible online.

- Need to standardize and certify (Research and development)
- Assessment of the combustion's efficiency, which is directly related to the emission of harmful compounds when combustion is incomplete.
- Assess the filtration of the H2S. Initial studies in Peru in 2010 found that small filters of iron shavings, have minimal efficacy.
- Identify the pathogens existing in biodigester fertilizer and assess for use in vegetables and other foods.

- Fertilizers benefits need to be defined, as well as its applications and treatment (drying), in order to find a market for it. Due to possible pathogens, it’s important to define and reduce the risk of its applications.
- Research different materials and designs to optimize performance and minimize cost. Final destination of materials (the possibility of recycling used material).
- Turbulence, break-up of the surface scum, and bigger surface for bacteria propagation.
- Shape of the trenches. At present, the trapezoidal form is being used because it is easy to build and stops walls from collapsing.
- Location of the material’s outlet and inlet
- Insulation materials

RedBioLAC Strategic Plan and Organization

Introduction

The exchange of experiences among the research, development and advocacy groups of this technology in Latin America has been limited until the year 2009, when the first Workshop for Exchange of Experiences with Biodigesters in Latin America was established in Peru, from which The Netwrok for Biodigesters in Latin America and the Caribbean emerged.

Vision

To be the referring organization that provides research, development, implementation and advocacy of the use of biodigesters to stimulate the management of natural resources and promote the socioeconomic wellbeing of Latin American and Caribbean people.

Mission

To be a network of institutions related to applied research and advocacy of anaerobic biodigesters to stimulate comprehensive treatment and management of organic waste as a strategy to improve the wellbeing of the Latin American and Caribbean people.

Objectives

- Exchange of information and experiences among the RedBioLAC participants.
- Identify and overcome the technical, environmental, social and economic barriers.
- Propose projects, mechanisms and ideas to advocate the biodigester technology in LAC.
- Form alliances that facilitate the adoption of biodigester technology.
- Systematize research and advocacy among partners (Health, Finance, Politics, Education, Industry and Commerce).
- Promote the incorporation of other organizations, institutions and researchers in the field of biodigesters.
- Encourage actions of influence and incidence of politics related to biodigesters.

Background

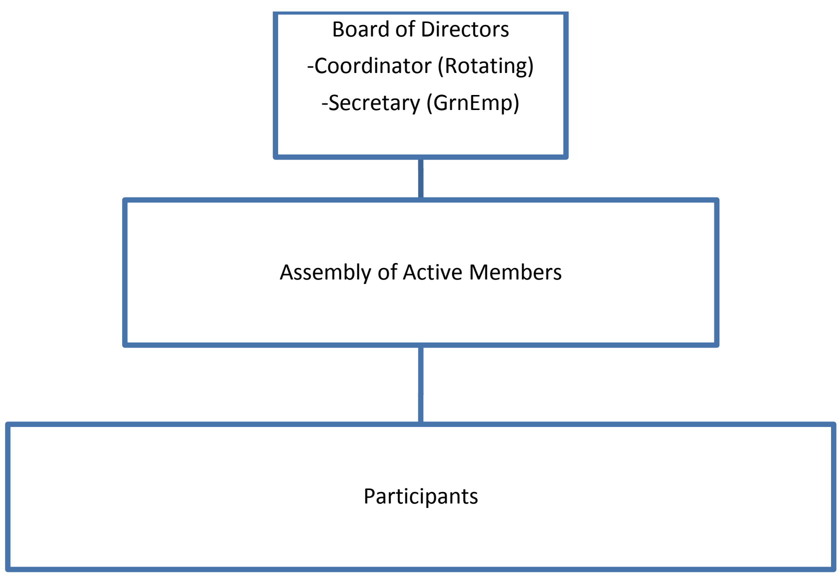
In the framework provided at the Workshop on Exchange of Experiences with Biodigesters in Latin America, that occurred between May 18th and 22nd of 2009, at Cajamarca in Peru, we agreed to establish the Network of Biodigesters for Latin American the Caribbean - RedBioLac. In Costa Rica, we reunited to formalize the first Strategic Plan of RedBioLac on May 12th to 14th, 2010 at EARTH University.

Competencies

- Technical expertise in the design and manufacturing of a wide variety of designs of biodigesters for implementation in rural Latin America.
- A consortium of NGOs, research centers, businesses, universities and cooperative agencies.
- Practical experience with different methods of advocacy of biodigesters and models of negotiation, including sales of pre-manufactured biodigesters, subsidized sale of material 'kits', installation in agricultural settings, creation of cooperatives to sell 'biol', etc.
- Knowledge of markets and national politics that stimulate or hinder the advocacy of this technology.
- A proven record of coordination among members, including the organization of two international events (in Peru and Costa Rica), the development of joined proposals, establishment of a virtual forum and financial negotiations of donations in 5 countries.

Governance

RedBioLAC will be anchored in a full democratic base and will be guided by a system of self-governing in the principle of representation through the following organisms.



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- Jaime Marti, GTZ and CIMNE
- Alex Eaton, International Institute of Renewable Resources
- Rafael Escobar, Practical Solutions-ITDG
- Raul Botero, EARTH University

Contact: www.redbiolac.org

List of RedBioLAC Members

Aprotec	Colombia
Asociación Fenix	Nicaragua
CARE	Ecuador
CIDELSA	Peru
CIMNE y GTZ EnDev	Bolivia
Fundación Ecuatoriana de Tecnología Apropiada	Ecuador
Green Empowerment (GrnEmp)	USA
Instituto para una Alternativa Agraria	Peru
Inter-American Development Bank	USA
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