

Exploring the Adoption of Biodigesters in San Juan De Abajo, Mexico

Rebeca Alarcon Delgado, Ashna Jain, Melisa Marin Jaramillo, Milad Naeimi, Erica Di Ruggiero, Gregorio Leal Martínez, Natalia Mesa Sierra



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Note: Authors are listed alphabetically with the faculty mentor listed last.
Cover photo: Farmers in Las Palmas tending to their biodigester





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Critical revision of the case study report	AJ, MMJ, MN, RAD (Until Sep 5, 2025)
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Executive Summary

Climate change is increasingly undermining global food systems, with rural communities in the Global South facing disproportionate impacts resulting from environmental degradation, resource scarcity, and weak institutional support and governance structures. Dominant farming practices — in particular, heavy reliance on chemical fertilizers — worsen these challenges by polluting water sources, depleting soil quality, and contributing to emissions. Sustainable technologies like biodigesters offer an alternative by producing biofertilizer and biogas from organic waste, while advancing environmental, social, and economic gains for farmers. Yet in practice, the uptake of such technologies remains uneven across different communities. Two biodigester initiatives, with similar designs, were implemented in two demographically and geographically similar communities of San Juan de Abajo in the state of Nayarit and Las Palmas in the state of Jalisco, Mexico. While Las Palmas saw widespread buy-in and adoption, San Juan de Abajo exhibited considerably lower uptake.

We investigate the underlying factors that contributed to the low uptake of biodigesters in San Juan de Abajo. Conducted in partnership with Instituto Tecnológico y de Estudios Superiores de Occidente (ITESO) and supported by the Reach Alliance, our research seeks to generate insights into the barriers and enablers of sustainable technology adoption in rural settings. While the research focuses on a small community in Mexico and the adoption of a particular agricultural technology, the findings may also apply to a broader range of agricultural technologies and innovations in rural communities across the globe.

Our findings reveal a multidimensional set of barriers: social fragmentation, institutional mistrust, farmers' cost-benefit concerns about perceived benefits of biodigesters, different attitudes toward innovation, and logistical and structural constraints. Socially, trust among farmers

has been significantly eroded by a multitude of past experiences such as failed collective initiatives and intermediaries' exploitative behaviours toward small farmers. Institutionally, both the *Ejido* system (a collective land ownership system in Mexico) and government programs are perceived as ineffective or corrupt, creating a sense of mistrust about any new initiative including new agricultural technologies, even when they're provided at a significantly low price or free of charge. From an economic perspective, many farmers view biodigesters as labour-intensive supplements rather than substitutes for traditional methods of producing fertilizer and gas. Attitudes about innovation have been a major barrier to adoption of biodigesters too. Finally, administrative barriers such as rigid project timelines, insufficient farmer data, overburdened reporting systems, and limited access to sustained funding or localized nongovernmental organization (NGO) support all have undermined the project's long-term sustainability.

These findings have policy implications for sustainable innovation interventions not only in Mexico, but also in other similar communities. Even when interventions are well articulated and technically sound on paper, their uptake can highly vary when implemented in different contexts. The results suggest that successful interventions are more likely when they are locally embedded, responsive to evolving realities, and capable of adapting to new information as it emerges.



FIGURE 1. Local farmers assessing corn development while exploring sustainable farming approaches.

The Agricultural Sector in San Juan de Abajo

San Juan de Abajo is a small town with a population of 11,090, located in the municipality of Bahía de Banderas, in the state of Nayarit, Mexico. While it is gradually experiencing an expansion in rural tourism, its principal economic activity remains agriculture. Farmers there cultivate crops such as corn, watermelon, beans, tomatoes, and tobacco with a smaller segment of the population dedicated to livestock.¹ The town's agricultural productivity and farmer livelihoods are shaped by numerous economic, environmental, and social drivers.

Although agriculture plays a central role in the local economy, this activity is marked by persistent rural poverty, widening inequalities, fragmented governmental support for small-

scale farmers, and a commercialization structure that disadvantages those with less power in the supply chain.² Many farmers receive payments from intermediaries for their crops that do not cover their production costs, much less represent profits for them. Additionally, 100 per cent of the crop production in San Juan de Abajo is sold to international and national markets, leaving behind the local market. As a result, both the national and global market structures influence what is grown, how it is sold, and who benefits from it. For instance, although watermelon is still one of the most cultivated crops in San Juan de Abajo and is produced by local farmers, they still must deal with a lack of access to transparent and fair distribution channels. These challenges are further exacerbated by small farmers' limited capacity to meet the demands of large buyers and the dominance of intermediaries (also known as "coyotes") who act as the market liaison between farmers and global markets.³

1 María Goretti Soto Ruiz, Edel Soto Ceja, and Francisco Javier Robles Zepeda, "Vinculación Turismo-Agricultura del Municipio de Bahía de Banderas. Caso de Estudio: Centro de Calidad Nayarit" [Tourism-agriculture linkages in the Municipality of Bahía de Banderas. Case study: Nayarit Quality Centre], 2015. [🔗](#)

2 "Cómo impulsar el sector primario en Nayarit" [How to boost the primary sector in Nayarit], Universidad Autónoma de Nayarit, press release, 6 October 2021 [🔗](#); Norberto Rincón, Elías Segovia, Guillermo Aguilera, Ana López, Efraín Zavarce, and María Leal, "Los pequeños productores y su participación en el proceso de comercialización agrícola" [Small producers and their participation in the agricultural marketing process], *Revista de la Facultad de Agronomía* 21, no. 2 (2004): 172–85.

3 Rincón et al., "Los pequeños productores" [Small producers].

In Mexico, there are public policies that tend to direct funding and investment programs toward large, commercial farming operations, while others are designed to support smaller and subsistence farmers. However, in San Juan de Abajo, many producers often find themselves in a difficult position: lacking the scale to benefit from programs aimed at large producers but also unable to meet the criteria for social programs aimed at the smaller or most vulnerable farmers. This gap is reflected nationally where farms of less than five hectares account for 63 per cent of agricultural jobs yet receive a disproportionately small share of public subsidies.⁴

From an environmental perspective, crops have intensive resource requirements, including water and agrochemicals. Widespread fertilizer use, on 92 per cent of the cultivated land, has contributed to significant water pollution in the municipality and contributes to soil degradation, with compounding effects on agriculture and the surrounding ecosystems.⁵ Agricultural producers also face high input costs, lack of training, an aging workforce, and fluctuating market prices that hinder competitiveness and income stability.⁶ These challenges make it harder for farmers to sustain their livelihoods and current agricultural practices. The vulnerabilities that farmers face are further exacerbated by climate change, which disrupts planting cycles and lowers yields.⁷

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Additionally, because of San Juan de Abajo's rural-urban nature, farmers live away from their farms; this residential pattern can hinder communication and collaboration opportunities with other farmers whose lands are in close proximity.

Community Context

EJIDO STRUCTURES

In San Juan de Abajo, nearly 50 per cent of the agricultural land lies within the Ejido system, which was developed after the Mexican Revolution. Ejidos are areas of communal land, where members individually farm designated plots and collectively maintain communal holdings.⁸ They are described at the national level as "one of

the most important bequests of the Mexican Revolution" and paradoxically an "irregular land tenure system" in modern day policy considerations.⁹ This model has been central to Mexico's

agrarian policy and rural development, though its role has shifted over time, especially after the constitutional reform to Article 27 of the Mexican Constitution introduced by President Carlos Salinas de Gortari. This reform marked the end of the agrarian land-distribution phase and allowed Ejido and communal lands to be privatized

4 Jonathan Fox and Libby Haight, "La política agrícola mexicana: metas múltiples e intereses en conflicto" [Mexican agricultural policy: multiple goals and conflicting interests], 2010. [↗](#)

5 "Plan Municipal de Desarrollo," Ayuntamiento de Bahía de Banderas, Bahía de Banderas, Nayarit, 2017. [↗](#)

6 "Encuesta Nacional Agropecuaria 2019" [National Agricultural Survey], Instituto Nacional de Estadística y Geografía (INEGI). [↗](#)

7 Manuel Ernesto Becerra Bizarrón and Mercedes Rosario Castellón Palacios, "Análisis de personalidad emprendedora en agricultores del municipio de Bahía de Banderas Nayarit" [Analysis of entrepreneurial personality in farmers in the municipality of Bahía de Banderas, Nayarit], *RIDE Revista Iberoamericana Para La Investigación y El Desarrollo Educativo* 14, no. 27 (2023): e524. doi:10.23913/ride.v14i27.1582.

8 Melissa Schumacher, Pamela Durán-Díaz, Anne Kristiina Kurjenoja, Eduardo Gutiérrez-Juárez, and David A. González-Rivas, "Evolution and Collapse of Ejidos in Mexico — To What Extent Is Communal Land Used for Urban Development?" *Land* 8, no. 10 (2019): 146. doi:10.3390/land8100146.

9 Ibid.

impacting how Ejidos operate and their role in rural communities — often shifting from collective governance to increased privatization and market-oriented agriculture. San Juan de Abajo was also affected by this shift; farmers often describe the Ejido as a symbolic institution or a “fraternity” rather than a place for collective governance and institutional support. In some contexts, however, there are Ejidos with strong administration that seek the collective well-being of their members.

NETWORK OF INSTITUTIONAL RELATIONSHIPS

Relationships with institutions like the federal government, NGOs, Ejido leadership, and municipal authorities affect how agricultural technologies are implemented. To ensure the long-term sustainability of a project, especially after external funding ends, it is essential to collaborate with other stakeholders such as the municipal government or the Ejido’s authorities. However, the municipal government of Bahía de Banderas often lacks the necessary data, resources, or targeted initiatives to support smaller farmers.



FIGURE 2. Bahía de Banderas municipality meeting room

Hardest to Reach

In San Juan de Abajo, starting a crop from zero is very expensive; there is not much government support, and many long-standing farmers are forced to sell their plots because they are no longer capable of cultivating them. These challenges create a constant gap between large and small farmers. While the whole farming community experiences difficulties, small producers face a higher burden because their inputs (e.g., fertilizer, feed, etc.) are more expensive, they lack direct access to markets, and they struggle to harvest year after year.

In addition to the economic pressures on farmers, San Juan de Abajo faces more complex institutional and organizational barriers. Some government programs have been created, but in many cases, they fail to reach the communities that truly need them — as a result of poor dissemination, lack of genuine intent, or limited impact. The few programs that do exist often do not reach deeply enough into the community or are directed toward towns with greater perceived economic potential. San Juan de Abajo exemplifies this, having experienced stalled development in the past few years as an agricultural community, without the advantage of coastal proximity.

Social and gender inequalities also matter. Despite having critical roles in the community and in the family, women face difficulties owning and cultivating land. Due to the patriarchal nature of the Ejido, they do not have decision-making power or influence, which excludes them from accessing support tied to land ownership or institutional representation.

Although San Juan de Abajo is not geographically isolated, the combination of marginalization, institutional disconnection, social fragmentation, and historical underinvestment has created deep and persistent barriers to social inclusion. In this context, the residents of San Juan de Abajo,

particularly small farmers, land renters, women, and elders, exemplify the Reach Alliance’s mandate to find and understand the realities of those who are hardest to reach, even when they live within proximity of broader development efforts.

Technological and Environmental Responses Emerging in San Juan de Abajo

In response to the challenges of income instability, the prevalence of “coyotes,” environmental degradation, and fragmented government and Ejido support, various actors have started exploring alternative technological and environmental interventions to promote community resilience. Instituto Tecnológico y de Estudios

Superiores de Occidente (ITESO) partners with an NGO, Paisaje Manejo Integral, and collaborates with Cuenca Sana, a civil

society organization dedicated to promoting socio-environmental resilience and climate adaptation. Together, through its initiative in San Juan de Abajo, San Juan Sustentable, these organizations work to improve climate resilience in the community. The project aims to improve integrated landscape management and promote sustainable productive practices in areas vulnerable to climate change in Jalisco, Veracruz, Chiapas, and Chihuahua.¹⁰ This case study focuses specifically on the adoption of

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biodigesters in San Juan de Abajo, an initiative promoted as a partnership between ITESO’s San Juan Sustentable and Cuenca Sana.



FIGURE 3. Entrance of San Juan Sustentable community nursery

Biodigesters are systems (usually rectangular or dome-shaped, as seen in Figure 4) that decompose organic waste, such as manure, through microbial action in an anaerobic (oxygen-free) environment. It produces two outputs:

biogas, a renewable fuel that can be used for cooking, heating, and producing electricity; and biofertilizer (biol), an organic fertilizer.¹¹ These systems align with several Sustainable

Development Goals (SDGs), including SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action). By reducing reliance on chemical fertilizers, minimizing waste, and offering a renewable source of energy, biodigesters present a pathway toward more sustainable rural development. Collaboration and knowledge sharing between ITESO and Cuenca Sana have been critical in strengthening community support and maximizing the impact of biodigesters.

¹⁰ “CONECTA,” FONNOR (Fondo Noroeste y Occidente). [↗](#)

¹¹ Olga Rivas-Solano, Margie Faith-Vargas, and Rossy Guillén-Watson, “Biodigesters: Chemical, Physical and Biological Factors Related to Their Productivity,” *Revista Tecnología En Marcha*, 29, no. 5 (2016): 47. [↗](#)

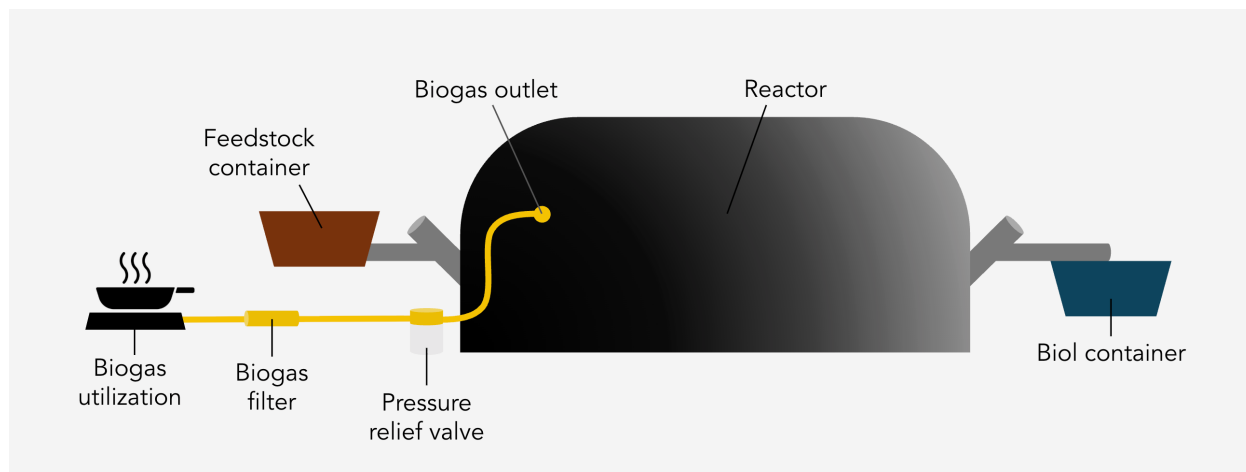


FIGURE 4. General operation of a biodigester

The Project's Strategic Goals

The project aims to develop more sustainable production systems that improve the integrated management and conservation of biodiversity in the agricultural landscape, as well as promote the co-design of climate change mitigation and adaptation strategies in San Juan de Abajo. Secondary objectives include facilitating community participation, promoting the transition to sustainable production practices in San Juan de Abajo, and developing capacity-building tools. From the funding perspective, the donors' main goal is generally to reduce climate degradation, in recognition that food systems have a significant impact on the environment. In addition to the environmental impact, ITESO and Cuenca Sana see biodigesters as a tool to improve farmer livelihoods because the application of biol can lead to reduced input costs and the use of biogas can offset fuel costs, potentially providing debt relief.

IMPLEMENTATION OF BIODIGESTERS

The biodigester initiative is a demonstration project with a five-year duration between 2021 and 2026, allowing farmers to see how the

technology works on some farms with the hope that over time farmers will decide to implement it after seeing the benefits. Funds were provided for 26 biodigesters, of which 23 were installed in Las Palmas and the other 3 in San Juan de Abajo, where there were lower interest levels. San Juan de Abajo and Las Palmas are located quite close to each other as Figure 5 shows, less than 12 kilometres apart. To qualify to receive a biodigester, farmers were required to have constant access to water, crops, and feedstock (i.e., livestock manure), and have a way to use biogas, most often through domestic uses like stoves. They were responsible for the preparatory excavation costs, an approach intended to strengthen their sense of ownership.



FIGURE 5. Map of the region, including San Juan de Abajo and Las Palmas

Even with clear benefits, some farmers continue to doubt biodigesters' benefits or face seasonal challenges, since they have to move their livestock to the mountains during dry periods, disrupting consistent access to feedstock.



FIGURE 6. Farmers showing a biodigester installed in Las Palmas

THE FARMING COMMUNITY AND TECHNICAL SUPPORT

ITESO and Cuenca Sana cultivate genuine personal relationships with farmers by seeking to understand their needs and challenges and discussing biodigesters as a tool to contribute toward more sustainable practices that can benefit them. Since Cuenca Sana has biodigester projects in various locations, their standard practice is to hire a local engineer to work in each region, enabling strong connections and more site visits. Cuenca Sana reaches farmers by first speaking with farm leaders and leaders of the Ejido. A wider audience is then reached through “snowballing,” where these leaders connect Cuenca Sana with other ranchers and farmers.

In addition to one-on-one conversations with farmers, Cuenca Sana has organized workshops and seminars to educate people about biodigesters across Mexico. Once a farmer is interested, Cuenca Sana’s local engineer verifies

whether the farm meets the requirements of successfully using a biodigester, and if the requirements are met, Cuenca Sana installs the biodigester once the farmer excavates the site. A representative from the organization visits the farm every few months to ensure that the system is operating smoothly and to troubleshoot any issues. This type of involvement and interaction ensures that producers are not only equipped to manage the systems but also that they have access to ongoing support in case of a system failure.

FUNDING STRUCTURE

Figure 7 illustrates the project’s funding structure and its various actors including high-level donor organizations and Mexican environmental funds. Large institutions and funds such as the World Bank, the Green Climate Fund (GCF), and Global Environment Facility (GEF) provide capital for sustainable development projects globally. To disseminate these funds and facilitate project monitoring and evaluation, national and regional organizations act as the liaison between donor organizations and the projects themselves. The Fondo Mexicano para la Conservación de la Naturaleza (Mexican Fund for Nature Conservation or FMCN) is a national private, nonprofit organization that funds projects centred on conservation, sustainable management, and capacity building.¹² Given Mexico’s vast size and diverse ecosystems, FMCN recognized a need for regional funds, and in 2013, FONNOR (Fondo Noroeste y Occidente or Northwest and West Fund) was established in response to the need for localized partners that have a deep understanding of their region and can channel economic resources fiscally. FONNOR is a private funding organization that oversees projects throughout Northwestern Mexico.¹³ Through periodic calls for proposals, it seeks projects that align with its mandate. One such call under FONNOR’s

¹² “We Protect Mexico’s Natural Heritage,” FMCN. [↗](#)

¹³ “CONECTA,” FONNOR (Fondo Noroeste y Occidente). [↗](#)

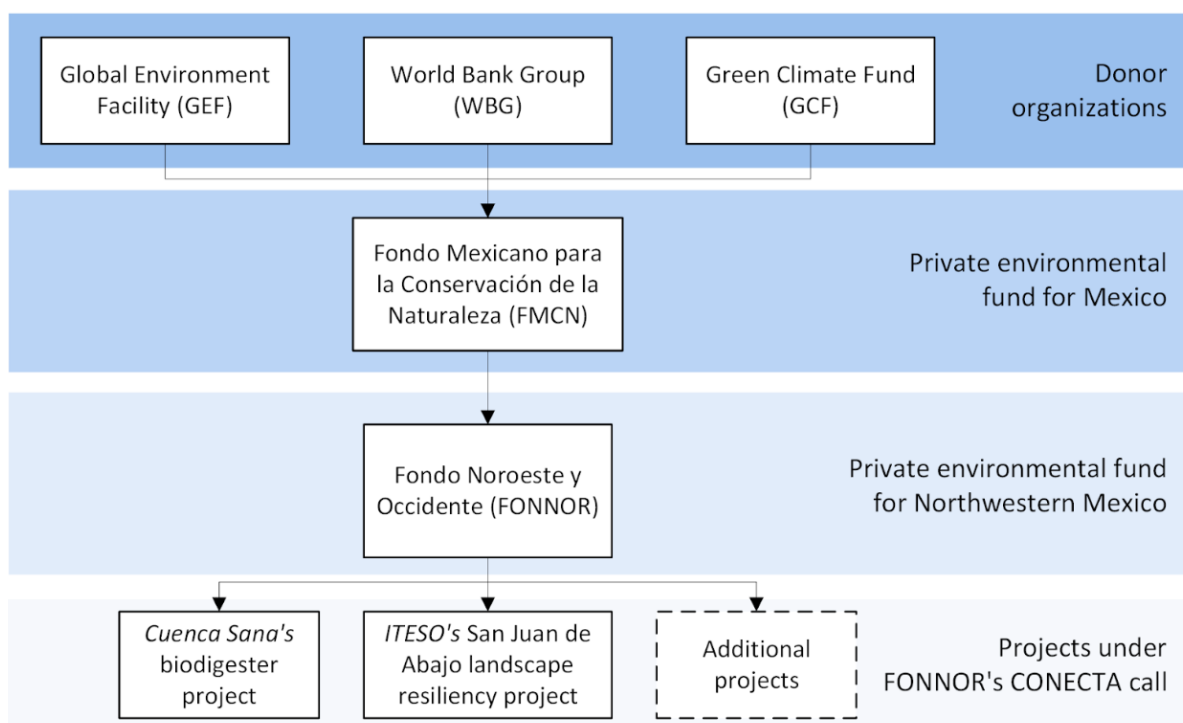


FIGURE 7. The projects' funding structure

watershed and biodiversity conservation program was called CONECTA, short for Connecting Watershed Health to Sustainable Livestock and Agroforestry Production, which has a five-year term (2021 to 2026). Two of the five projects accepted into CONECTA were ITESO's project on landscape resiliency systems in San Juan de Abajo and Cuenca Sana's project implementing biodigesters in various farming communities. Through the CONECTA network, the project leads at ITESO and Cuenca Sana identified significant overlaps in their goals and recognized that collaboration could propel both projects forward. The initiative to implement biodigesters in San Juan de Abajo formed as a result of this collaboration.

FONNOR translates the projects' challenges, needs, and impacts to higher-level donor organizations through site visits and regular impact reporting. ITESO and Cuenca Sana report on a set of key performance indicators (KPIs) every three months related to:

1. Fostering participatory social engagement with the development of sustainable production systems;
2. Developing capacity-building tools for the transition to sustainable production; and
3. Promoting the transition to sustainable production practices in the context of San Juan de Abajo.

The KPIs were developed by ITESO researchers and Cuenca Sana to ensure relevance and feasible reporting. Once FONNOR receives these KPI reports, they extract data that FMCN, GEF, GCF, and the World Bank are looking for. FONNOR identifies what they call "treasures," or stories to communicate meaningful project impacts that might not be conveyed through structured KPI reports. FONNOR's representation of ITESO and Cuenca Sana's impact to its donors is an essential component of the projects' sustained implementation. It does, however, require significant time and effort for both the implementers (ITESO and Cuenca Sana) as well as FONNOR to build a deep understanding of the community and the realities on site.

Case Study Approach

RATIONALE AND RESEARCH QUESTION

While the biodigester project in San Juan de Abajo was well designed and implemented, its adoption rate among farmers is lower than in the nearby community of Las Palmas. Motivated by this observation, we sought to identify key barriers and enablers that influence biodigester adoption in rural communities, using San Juan de Abajo as the case study. San Juan de Abajo's contrast with Las Palmas, which has a similar culture and other sociodemographic and agrarian characteristics and more widely adopted the technology, provides a comparison. Identifying the fundamental causes of divergent adoption and uptake between different communities can help policymakers, funders, and project implementers design stronger adoption strategies for biodigesters and more broadly, agricultural technology across Mexico and even globally.

RESEARCH METHOD

We began with a literature review to identify potential enablers and barriers to biodigester adoption, which guided the development of semi-structured interview questions. We then conducted 14 interviews in Spanish with stakeholders including farmers from San Juan de Abajo and Las Palmas — some who own biodigesters, some who are hesitant about them, and some who were unaware of them — Ejido leaders, municipality officials, representatives from FONNOR, and biodigester experts from Cuenca Sana. The interviews revolved around key themes including trust, community dynamics, market structures, attitudes toward innovation, and funding challenges. We then systematically coded and analyzed the interview data to identify shared and divergent viewpoints on adoption barriers and enablers and detect patterns in the data.

Findings

Our findings highlight the complexity of agricultural technology adoption, specifically in the case of biodigester adoption. Environmental conditions and individual-level factors shape farmers' decisions about what practices they adopt. The region's agricultural history, weak institutional support, and unfair market structures create a difficult environment for innovation, further influencing decision making. Individual-level decisions about whether to adopt technologies like biodigesters are filtered through farmers' tolerance for risk, levels of trust in both the technology and its promoters, and their general attitudes. We therefore must approach technological change not simply as a technical fix, but as a process that must navigate deeply embedded social, cultural, and institutional dynamics.

While adequate funding and long-term self-sufficiency are essential, adoption success also depends on how much farmers trust each other, the perceived usefulness of the technology, and support during its implementation. The challenges observed with the adoption of biodigesters are not limited to this context because partners from CONECTA, ITESO, and FONNOR have also encountered similar difficulties when promoting other sustainable practices, such as transitioning to agrochemical-free production. In other words, the social and institutional barriers we identified may be applicable across various types of agricultural innovation. This multidimensional system view is illustrated in Figure 8.

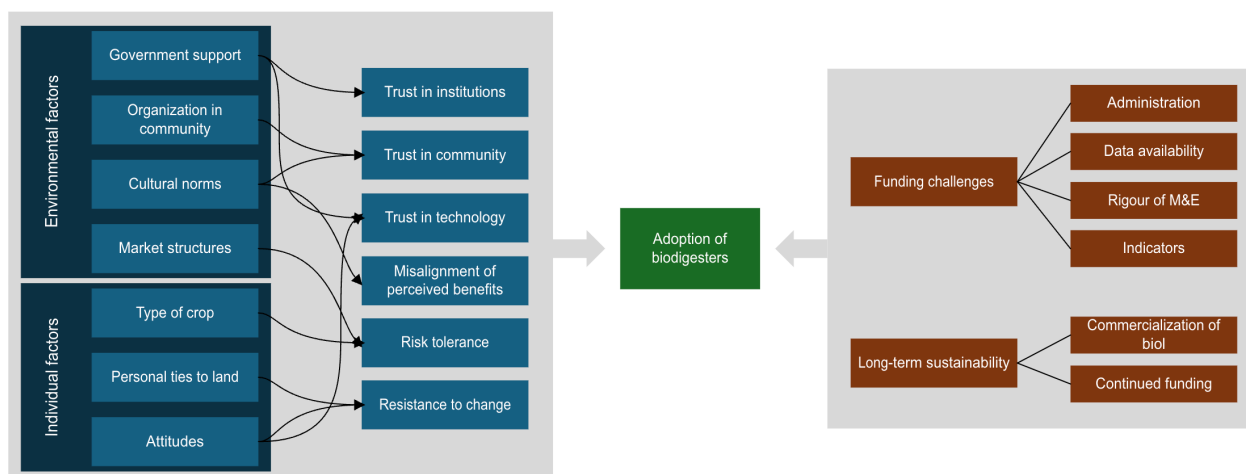


FIGURE 8. A system view of biodigester adoption

LAYERS OF TRUST: FAMILY, COMMUNITY, MARKET RELATIONS, AND INSTITUTIONS

Trust that affects farming practices and ultimately technology adoption, includes family, community, market, and institutional level dynamics.

Trust within families. Understanding the foundation of trust within families sheds light on the level of social cohesion across the wider community; San Juan de Abajo, for instance, is made up of people with very strong family ties. However, this does not translate into collaboration beyond the family unit where the level of closeness and socialization between different families is significantly weaker.

This phenomenon is apparent in agriculture, where being a farmer is often an activity passed down from generation to generation. As one of the farmers put it, “We have always done it here as a family or by myself ... before yes, with my dad, of course.” Other participants described their children’s lack of interest in farming and a desire to shift away from family farming activities. Younger generations are moving to work in the growing tourism industry in the municipality of Nayarit, looking for better opportunities and quality of life.

As one of the farmers reflected, “the capitalist system we live in turns us into predators toward each other. I look out for what’s mine.”

This migration reduces both intergenerational continuity in the farming families and the number of active community members involved in farming activities. As this happens, it is only natural that the word-of-mouth exchange of agricultural knowledge and tacit practices also declines. The self-contained (and sometimes shrinking) family creates a barrier to sharing innovative practices across the town and hinders the adoption of agricultural technology. The farmers said that word of mouth is one of the most powerful tools within the community, but it can’t work if families aren’t talking to each other, which is something

that becomes more apparent as farming families grow more isolated and younger generations abandon farming professions.

Community dynamics and fragile ties among farmers. Interpersonal trust within the farming community is often fragile and influenced by competition, envy, and prior negative experiences of working together. Farmers described how envy or fear of being outcompeted drives people to withhold information, even from close friends. As one of the farmers reflected, “the capitalist system we live in turns us into predators toward each other. I look out for what’s mine.” This mindset shaped by capitalism, competition, and precarity



FIGURE 9. Farmers in Las Palmas with an irrigation tank, another type of agricultural technology

also signals skepticism toward institutions and market structures, where economic insecurity turns even close relationships into competitive threats. People's trust is undermined by a normalized belief that success is a zero-sum game, making collaboration seem risky and collective action hard to cultivate and sustain. Their protective behaviour stems from a logic of self-preservation, shaped by the perception that opportunities are scarce, and trust can be easily exploited.

In fact, the social culture in the town of San Juan de Abajo reflects this skepticism toward others. One participant said, "There are people who are very jealous ... they don't let you into the plot. They don't tell you any product they used in their crop," which helped us identify displays of ego or pride in farming methods when some farmers preferred to keep their plots private and were unwilling to share any technology or product that they used in their crop. People were often careful about the information they chose to share and demonstrated a lack of solidarity; many mentioned that they don't lend out tools or equipment under any circumstances.

In contrast, in Las Palmas many of the participants, especially small-scale farmers, showed greater willingness to support each other. As one farmer shared, "We lend each other machinery, like fencing for the livestock." But in San Juan de Abajo, the lack of solidarity likely impacts the community's ability to spread and scale innovations like biodigesters. Sharing resources and information is a powerful tool for increasing adoption; in many cases, farmers who already had biodigesters installed gave away biol, which helped convince others to adopt the technology as well.

Trust can also be eroded through negative experiences with intermediaries, or "coyotes," who act as middlemen in crop production. Many of these intermediaries not only purchase crops, but also provide essential inputs, particularly seeds and supplies, which creates a dependency, forcing farmers into unidirectional relationships with them. Past betrayals among friends and intermediaries within the farming value chain have also made farmers cautious.

One farmer from San Juan de Abajo illustrated this point when he mentioned that “You already know that man knocked down a friend the other day or took his money — I’m not going with him anymore.” He also mentioned that farmers get tricked by new coyotes: “Look ... we identify them and know who pays and who doesn’t give, but sometimes new ones come in and that’s where one gets lost.” He further explained that coyotes use that trust in the relationship to start treating farmers unfairly and lowering prices: “Well, it’s just that each one is coming themselves. We are getting to know them — they introduce themselves, they are good payers — and well, they sell you that, and now those who are currently [involved], well, nothing like that.” Of course, trust can sometimes be found with some people, but it’s rare. One farmer told us “But they’re rare. There’s always an advantaged one.”

Even when the farmer recognized it might be possible to collaborate with another farmer, the idea of competition was still present when the farmer mentioned there would always be “an advantaged one,” referring to one who ends up unjustly benefiting more than others, highlighting potential invested interests, not only economic, but also reputational or related to access to clients and information. Going into a collaboration with that mindset hinders the trust-building process made by organizations like ITESO in a context where coyotes actively promote competition among farmers and adopt practices that divide them. This limits the potential for creating collective action.

Institutional distrust and local technicians. Trust in formal institutions, whether in the municipal government or Ejido, is extremely low. As one of the farmers summarized, “Nobody. Neither one nor the other. Not even among families ... A trust in the government is seriously not held.” One of the farm leaders also added that Ejidos “don’t work, they are abandoned. But there they are — a monument to disorganization.” This echoes past experiences that farmers mentioned in interviews, where they were presented with

the advantages of being organized with the Ejido but failed to see the benefits in action because of “the disorganization, the ambition of the administrator.” Therefore, when initiatives like the biodigester project are introduced, there is often a high level of skepticism from the community. Farmers question whether they will receive the promised support and if the technology will function effectively. Another example is ITESO’s initiative to plant trees along the riverbank to support more sustainable farming systems and restore ecosystems. The project faced significant pushback from farmers, who are concerned about losing even a small portion of their productive land, despite the potential long-term benefits for both their farms and the sustainability of their business.

Local technical experts embedded in the community are sometimes able to overcome skepticism. Farmers were notably more trusting of local technicians, who supported biodigester adoption and provided ongoing advice. One local technician mentioned that a lot of the solar panels the government gave out were just left unused because no one ever came back to help maintain them. It’s experiences like these that show why people in San Juan de Abajo are more likely to trust someone who provides ongoing support, rather than institutions that have let them down too many times before.

EJIDO GOVERNANCE AND ORGANIZATIONAL CHALLENGES

Even with the best intentions, it is hard to move forward when the structures meant to support farmers, like the Ejido, no longer feel useful or trustworthy. Many farmers feel left out, unheard, or disillusioned after years of seeing little change. At the same time, the exclusion of women, young people, small farmers, and other groups marginalized from leadership structures — along with power imbalances between established land owners and those with less access to land or decision-making power — make it difficult to build

the cooperation needed for collective action. These internal governance challenges can shape or even undermine community-based efforts like the biodigester initiative.

Ejido limitations in agricultural development.

In San Juan de Abajo, as in other Mexican municipalities, the institutional landscape of farming communities is heavily dictated by the presence of the Ejido. Many of the current limitations come not only from its structure, in which very few people are given decision-making power with little or no enforcement and oversight, but also how it is governed and led. Most farmers see many of the Ejido's initiatives and processes as ineffective, offering little visible change, causing frustration, and hindering the practicality and functionality of this system. In some cases, people refer to the lack of updated statutes, communal meetings, and programs that could support their farming activities. As one participant explained, "Ejidots have to have their statutes, but sometimes these statutes are not updated ... they're back from the 1920s."

Although the Ejido system is frequently expected to act as the entry point or legitimacy for agricultural initiatives, it often lacks the community's trust and organizational capacity to carry out this function well. With previous failed attempts to create different programs, there seems to be no trust in the Ejido system because sometimes the programs benefited only a few people, whether because the system was corrupt or just poorly organized. Some farmers noted that "better each one is alone." This mindset limits the potential of Ejidos to become vehicles for development and to create sustainable agricultural programs in partnership with NGOs, government institutions, or private organizations. With initiatives like the biodigesters it becomes difficult to create spaces for shared learning, community building, or the project's long-term sustainability.

Power dynamics. Institutional issues in the community are closely related to power dynamics that reinforce the disconnection we observed in the community between those who hold decision-making power and those without it. In general, the people who own land and participate in the Ejido are older men. Women and young people have very little representation in leadership roles, despite critical involvement in daily work and within the family structure. Some of the women we interviewed have taken on leadership responsibilities, attending meetings because the men in the household are often too busy working the land. In these cases, women can play a very important role in the adoption of the initiatives discussed in meetings and become a key bridge for the implementation and spread of projects like the biodigesters.

This was the case in Las Palmas during a financial workshop for farmers. Most of the attendees were women who showed interest and played an essential role in advocating for initiatives like the biodigester project. In contrast, in San Juan de Abajo, the community seemed more socially fragmented and skeptical toward women's participation in the farming system. Because leadership and decision making are concentrated among a small group within the farming community, women and young people often feel excluded from engagement processes that could enhance farming practices. This exclusion creates a sense of disconnect and reinforces the belief that collective efforts primarily serve the interests of the powerful rather than the whole community, ultimately discouraging projects like the biodigester initiative.

Municipal governmental and logistical

constraints. Government programs usually do not have the necessary flexibility to respond to farmers' interest in innovation. One municipal leader explained that programs are set by fiscal year ahead of time, "We have fixed institutional programs ... and as it is already determined every year for a fiscal year, which is already available, we cannot go further." Typically, programs

are organized and tied to fixed timelines and budgets, which hinders the government's ability to respond to local conditions and sustain farmers through the adoption process. Farmers can be discouraged when initial curiosity or openness to innovation is met with bureaucratic limitations.

Furthermore, when the municipal leaders were asked about targeted assistance for smaller farmers with fewer resources, they acknowledged, "Right now we don't have it; we are currently working on finding options for them." Attempts to secure more accessible financing have not succeeded. One official mentioned a failed effort to negotiate reduced interest rates for small farmers with a local financial institution. The official recalled, "I was looking for farmers to be charged the minimum, but it didn't end up working out." Some government programs also have technical requirements that farmers might not understand or explicitly comply with, further hindering their accessibility. For example, a farmer who was officially called a "businessman" instead of a "producer" was blocked from accessing an agricultural support program through the federal treasury. The absence of, or difficulty in obtaining, targeted support suggests access inequality.

MARKET STRUCTURE AND SOCIAL INEQUALITY

Many of the struggles that farmers face in San Juan de Abajo go beyond institutional barriers. The way the market works — who controls it, who benefits, and who is left behind — plays a huge role in shaping their everyday decisions. Small farmers are caught in systems that are often unfair and hard to navigate. Intermediaries dominate trade, opportunities to organize and support each other often fall apart, and accessing export markets is out of reach for most. These conditions make it harder to try new solutions or build long-term change in farming practices, market participation, or local collaboration, especially when trust is low and support is limited.

Intermediaries and failed collective action.

Reliance on coyotes reflects a market failure in which farmers can be taken advantage of and remain without guarantees in the absence of transparency and equity in the marketplace. This situation is mostly experienced by small producers who still depend heavily on coyotes, especially those growing export crops like watermelon. As one participant said, "There is a person who owes about 3 or 4 million pesos and is happily going about their life," referring to a coyote who avoided consequences despite leaving farmers in large debt. This shows how bad the situation can get when working with coyotes, sometimes leaving entire families in bankruptcy. Large producers can completely remove these coyotes from their value chains and connect directly with certain export markets. But the lack of market access for small farmers contributes to unstable prices, which impact farmers' risk tolerances, potentially making them less inclined to make any changes such as using new technologies that disturb the status quo.

To overcome this issue, farmers in San Juan de Abajo have tried to create alliances or cooperatives to improve negotiation power or eliminate the need for intermediaries all together, but it has failed on several occasions because of a lack of trust and willingness to organize within the community. We repeatedly observed how the farming system in San Juan de Abajo encourages individual decision making and discourages risk sharing or collective bargaining — strategies that could help create a more resilient and community-based approach to cultivate growth opportunities and a chance at improved collective livelihoods. Although there is a need for a better negotiation system so that farmers receive fairer prices and a more just market dynamic, organizing farmers has proven to be quite tricky. They constantly mention that it is difficult to agree with others, primarily because they lack trust. An organized system for buying and selling agricultural inputs and outputs could potentially change the entire dynamic of the market and create a fairer value chain in which the farmer is justly remunerated.

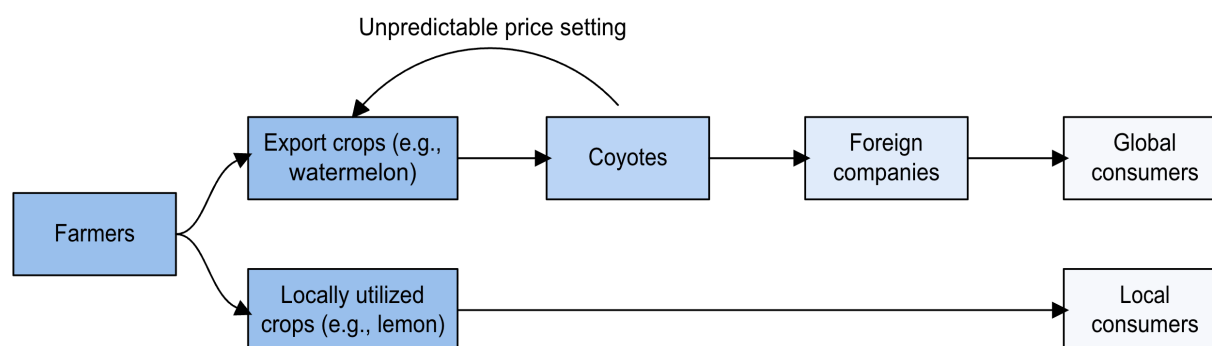


FIGURE 10. Crop commercialization pathways: from farmers to local and global markets

Export barriers and lack of government support.

There are international trade barriers that are difficult for farmers to overcome, especially small farmers. Many export products such as watermelon come with strict requirements and complex processes, which encourage and reinforce the participation of intermediaries. Several farmers noted the high burden of complying with food safety programs, mentioning that “You have to meet a series of requirements that they send. If you don’t follow them, well, sell it to Mexico.” That is, export markets are inaccessible. In addition to strict requirements, both the export and local markets penalize farmers for low production capacity. Since many multinationals are looking for large volumes of crops, small farmers are left with very little bargaining power. This, combined with the high cost of inputs, such as fertilizers, pesticides, and water, which farmers are usually unable to buy in bulk, reduces their profitability. With limited financial and administrative capacities, farmers struggle to secure favourable deals in the international market, leaving them at the mercy of unfair coyote practices. These challenges, combined with the lack of government subsidies and access to equipment or technical assistance, contribute to an unsupportive environment for farmers.

Farmers are increasingly struggling. Some are no longer able to improve their productivity or livelihood, making them feel powerless and

unmotivated. Farmers do not feel secure or supported enough to try something new, like biodigester technology, especially when they’re already under so much external pressure.

Although supporting NGOs do cover the up-front cost of biodigesters, farmers still need economic security, time, trust, and long-term commitment to fully adopt them and maintain them over time. Despite farmers’ care for their land and interest in implementing best practices, when they don’t see a clear path to financial stability or improving their market position, even environmentally beneficial solutions like biodigesters become out of reach.

ATTITUDES TOWARD INNOVATION

Generational differences, barriers among large producers, and institutional and logistical constraints can shape people’s attitudes toward innovation.

Generational differences. Interviewees initially stated that younger farmers often use new techniques and are more open to innovation, but they later revealed a different reality. In practice, these younger producers are closely tied to older or larger-scale farmers, whose influence ultimately determines whether new technologies are adopted. This was evident in some comments made by municipal leaders: “It will be necessary to first convince the father, at times, and then the young producers.” A farm leader admitted

that younger producers in San Juan de Abajo are “aspirationalists,” aspiring to be like other farmers with high social and economic status, so they follow what the larger or older producer adopts. Considering that the average age of farmers in the region is 54 — a demographic that is often described as particularly resistant to change — if younger generations are closely following older farmers, they may also adopt more change-resistant attitudes.

Resistance among larger producers. Big producers are often particularly resistant to changing their farming practices. A farm leader explained how “It’s harder to engage in this with the big guys — they’re more reluctant to change their techniques, to change their procedures — because what they say, if I’ve done it this way all the time and look at the results, why would I have to change anything about my process?”

Success can deepen farmers’ sense of power and independence to such an extent that innovation seems unnecessary. For producers who have established their name and income, change can threaten to disrupt economic security and social status. The environmental advantages that can come from implementing new practices are often overlooked. As a farm leader put it, “There is environmental awareness, there is care for the planet, but unfortunately for the people in my region, it is something secondary. It is not the main reason to implement that type of technology.” There is a higher need for an economic incentive, which sustainable technologies typically cannot achieve in the short term.

MISALIGNMENT OF PERCEIVED BENEFITS

Alignment between the biodigesters’ benefits and farmers’ needs is an enabler of adoption. Farmers generally need to see urgent economic needs being met as opposed to long-term

environmental benefits. Biodigesters might not seem to solve an immediate and acute problem, compared to other technologies like pesticides, even though they can provide economic benefits in the long term through reduced input costs and the sale of biol. One municipal official said some farmers hesitate to adopt biodigesters because they think “I already know how to do it [current methods of agriculture using chemical fertilizers]. It gives me yields and I am going to keep being like that,” and they do not see significantly higher yields with biol.

Moreover, operating a biodigester requires the user’s time and effort for feeding it with feedstock and removing and storing the biol, in addition to the financial cost of excavating the site. This has led to resistance from some farmers who

believe that the costs outweigh the benefits. As rational actors, some farmers postpone their adoption until they

see the full benefits of the technology adopted by others. This has been referred to as spillover effect in innovation studies, whereby once a new technology is introduced, it takes time to be adopted by others once they observe the benefits. One farmer interviewed was hesitant about biodigesters at first but installed one after seeing his friend take advantage of it.

FUNDING CHALLENGES

Funding the programs that support the use of the technology in the first place can be difficult. A member of FONNOR’s team highlighted several challenges.

Administration. In order for FONNOR to accept a project proposal, the institution applying must be legally constituted, have years of experience, and have been vetted against corruption. Since many farmers do not legally constitute businesses, the community has to be represented by an NGO or another institution like ITESO. Even

Since many multinationals are looking for large volumes of crops, small farmers are left with very little bargaining power.

then, giving money to an organization is not as simple as it seems; without strong governance and management, it can cause more trouble than benefit. FONNOR often seeks to obtain a letter of support from the Ejido, however getting such a letter requires buy-in from the Ejido's leadership and time to cultivate a relationship with them. Strong governance is crucial to mobilize funds that support the implementation of biodigesters.

Data availability. A member of FONNOR told us that “the culture of registration or data analysis is not as big as we wish here in Mexico,” evidenced by the lack of farmer data (e.g., number of cattle, area of farm, type of crop, etc.) collected by the municipality. Farmers themselves seldom have written registries of their production, which leaves implementing organizations like ITESO or Cuenca Sana to capture this type of data for reporting. This absence of data not only leads to an increased workload for implementers but can also deter funders from working with communities without partner institutions with the capacity for data collection and analysis.

Rigour of monitoring and evaluation. As the funding structure illustrates in Figure 7, the highest level of funding comes from the donor organizations, namely the World Bank, GCF, and GEF. For them to evaluate the projects, they need reports that flow from field-level interventions through FONNOR, to FMCN, and then the donors. ITESO and Cuenca Sana are required to submit reports to FONNOR every three months, which is relatively frequent compared to most development projects that require annual reports. The reporting needs of the donors are intense in terms of frequency, and the implementers are often the ones to write the reports and fill out forms after long days in the field, which can be very exhausting.

Communicating impact to donors. Creating deep and sustained impact takes time and is difficult to measure. This is a challenge for most

sustainable development projects that need to comply with high-level, frequent reporting expectations. The donors can be quite demanding and without being closely in touch with the day-to-day action in the field, it can be difficult to develop and report on realistic KPIs. Sometimes the implementers choose KPIs that are too ambitious and difficult to meet, yet they still do not convey the “magic” of the project. FONNOR aims to find this so-called magic and translate it into a narrative or more suitable indicators that can be conveyed to the donors. The need to shift the focus from “outputs” to “impact” is a continuous effort for both the implementers and FONNOR.

LONG-TERM SUSTAINABILITY OF DEVELOPMENT PROJECTS

Development projects are usually considered “sustainable” when they can deliver an appropriate level of benefits for an extended period after major financial, managerial, and technical assistance from external donors is withdrawn.¹⁴ For the intervention we studied in this case, the question arises: how can long-term sustainability be achieved after the funding period ends in 2026? The prospect of extending the funding term length is a possibility in one of two cases: either the implementers have money left over and need additional time to execute activities that will use the money, or they convince the donor that not all the project's needs have been met. While extending the funding period can enable continued impact, it does not necessarily foster long-term sustainability in the community.

Cuenca Sana is currently pursuing the commercialization of biol as a means to generate income to continue the project, distribute biol more widely, and empower farmers to capitalize on their outputs. The local engineer at Cuenca Sana aids the farmers interested in selling biol

14 “Sustainable Development: OECD Policy Approaches for the 21st Century” (Paris: OECD, 1997). [↗](#)

with technical advice. There was also considerable interest from farmers in Las Palmas during a workshop about the financial model behind biol commercialization, with the underlying goal of supporting their self-sufficiency. Developing a community-driven business model can provide sustainable income and scaling opportunities even after the donors leave.

Lessons Learned

The research revealed three major lessons learned about the social, institutional, and cultural dynamics that shape adoption of agricultural technology.

CULTURAL READINESS AND SOCIAL ACCEPTANCE

Technical feasibility and funding are important but not sufficient to ensure a lasting impact. Attitudes toward change and willingness to adapt shape adoption decisions. In San Juan de Abajo, even when some farmers were offered free biodigesters (excavation not covered), they would express initial interest but not follow through. Before implementing new initiatives, assessing the community's readiness for change can be helpful and identifying strategies for addressing barriers that are context-sensitive and culturally appropriate. This can involve surveys, interviews, or pilot programs to gauge openness and identify potential obstacles.

TRUST AS A FOUNDATION FOR ADOPTION

Hesitation to adopt biodigesters in San Juan de Abajo was also deeply influenced by a lack of trust that farmers have toward institutions and community projects, and often stems from negative experiences working with other farmers or coyotes (intermediaries). Rebuilding this trust

is essential to achieve widespread adoption of new technology. After implementing the project, placing local "trust agents" (community facilitators) to bridge the gap between technical solutions and local realities might prove helpful. If the trust agent has implemented new practices, their demonstration of proof-of-concept can positively influence the community's trust. Additionally, if the trust agent is a respected community member who already holds credibility, it can help build trust even more. These facilitators can provide ongoing support to community members, build trust, and work toward project sustainability after external funding ends. Over time, these relationships create the social foundation needed for farmers to exchange knowledge, take calculated risks, implement, and sustain innovations like biodigesters.

DATA GAPS

A persistent challenge mentioned by municipal leaders in San Juan de Abajo is the lack of up-to-date data on farmers, their activities (e.g., crop type, production volume, livestock, etc.), and their needs. This makes it difficult for the government to design effective programs or initiatives that address the needs of farmers and track progress. Establishing a comprehensive farmer database developed by the municipality can mitigate these challenges by enabling efficient communication, targeted outreach, and data-driven decision making.

QUESTIONS REMAINING

The low adoption of biodigesters in San Juan de Abajo, despite technical support and clear environmental benefits, is rooted in deep social, institutional, and economic dynamics. Key barriers include a lack of trust in institutions and between farmers, fragmented community and market structures, a perception that the technology's economic and environmental benefits do not outweigh the effort and uncertainty involved, and

a resistance to change. While the research focused on San Juan de Abajo in Mexico, the findings can inform future policy to consider factors that can affect adoption of new agricultural technologies in other similar communities.

While this case study provides valuable insights into the challenges of adopting biodigesters in San Juan de Abajo, it also highlights deeper systemic questions that remain unanswered. One critical issue is the misalignment between the timelines of donor expectations and the slower, trust-building processes required for meaningful and sustained community buy-in. Future research should explore how environmental and international development interventions can better accommodate the relational and iterative nature of innovation adoption by marginalized communities, particularly those historically

underserved by institutions. Moreover, farmers' reluctance to be early adopters of technology like biodigesters, even when clear economic and environmental benefits exist, points to a broader need to understand attitudes, norms, and beliefs shaping adoption and how risks are perceived and managed in challenging socioeconomic contexts. Mechanisms that reduce the real and perceived costs of early adoption, including community-led demonstration models, targeted government subsidies, or outcome-based guarantees, could be instrumental in addressing this challenge. Understanding how institutional mistrust and fragmented social capital can be repaired or circumvented through alternative community governance models is critical to inform future interventions.



FIGURE 11. Part of ITESO's riverbank vegetation project

Research Team



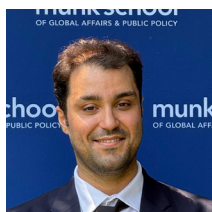
Rebeca Alarcon Delgado is a recent graduate from the University of Toronto where she earned a double major in political science and work and organizations. As a Laidlaw Scholar, she conducted research on the process of upskilling in Canada's agricultural and technological sector, gaining hands-on experience in qualitative data collection through interviews and stakeholder engagement. She later expanded this work through her final-year capstone project, deepening her focus on digital agriculture and its evolving role in shaping the sector. After graduation, Rebeca will be joining a technology consulting firm where she will support change management initiatives that help organizations adapt to digital transformation.



Ashna Jain is a recent graduate of industrial engineering at the University of Toronto. Her travels to over 80 countries have inspired her interest in sustainable development, leading her to pursue a master of applied science degree at U of T's Water and Energy Research Lab. Ashna's global development experiences include creating hydrogels for smallholders in Uganda through the Canada-Africa Innovation Fellowship, designing a water-monitoring process for Nipissing First Nation, developing agriculture recommendations in the Philippines, exploring scaling biochar in the Global South through Engineering for Change, and designing a low-cost baby incubator for the Philippines. Through internships at BBA Consultants and Green Island as well as advocacy work with Engineers Without Borders, she has explored various facets of the global energy transition.



Melisa Marin Jaramillo recently graduated with a master of science degree in sustainability management from the University of Toronto, with a background in business administration and a diploma in sustainable corporate leadership from Oxford University. She has over three years of experience in ESG strategy, sustainability frameworks, and value chain analysis, working with organizations across Colombia, the US, and Canada. She currently works at Loblaw, advancing strategies related to sustainable sourcing. Coming from a farming family, Melisa has developed a deep interest in agricultural sustainability. Her research and professional work have focused on sustainable food systems, where she applies both systems thinking and a grounded understanding of rural realities to corporate and community-based sustainability initiatives.



Milad Naeimi is a graduate of the Master of Global Affairs program at the Munk School of Global Affairs & Public Policy, University of Toronto, and currently works as an economist with the Canadian federal government. His academic focus is on innovation policy, with a particular interest in technology policies. Prior to his graduate studies, he worked as a civil engineer in Afghanistan, primarily on World Bank-funded infrastructure projects in rural communities. This background inspired his interest in development research.

His main takeaway from this project is how context and local realities shape policy outcomes, whether in infrastructure projects he once implemented in Afghanistan or the agricultural technology policies he now researches in Mexico.



Erica Di Ruggiero is an associate professor of global health and director of the Centre for Global Health at the Dalla Lana School of Public Health at the University of Toronto. Di Ruggiero's research evaluates the health and health equity impacts of different policy and program interventions and governance structures on marginalized groups, such as labour policies and interventions. She is the editor-in-chief for *Global Health Promotion* and has been recognized for her outstanding accomplishments, contributions, and leadership throughout her 15 years with the Canadian Institutes of Health Research (CIHR), specifically its Institute of Population and Public Health. Prior to joining the University of Toronto, she was the inaugural Deputy Scientific Director with the Canadian Institutes of Health Research-Institute of Population and Public Health.



Gregorio Leal Martínez has worked since 2003 with rural and urban organizations on issues related to the social and solidarity economy and food sovereignty in Mexico and Argentina. He has designed methodologies and tools to support organizations on issues related to production, consumption, credit and savings, and the creation of value chains. Gregorio joined ITESO in 2019, and works at the Interdisciplinary Center for Social Education and Outreach in training processes linked to social relevance and the articulation of social and solidarity economy processes. He holds a bachelor of science in education from ITESO University, with a specialization in popular education, and a master's in social economy from the National University of General Sarmiento in Argentina.



Natalia Mesa-Sierra is a biologist with a master's and PhD in ecology. Her professional trajectory has focused on the ecology and conservation of seasonally dry tropical forests, among the most threatened ecosystems worldwide. In Colombia, she investigated how forest quality influences red howler monkey populations, while in Mexico she evaluated the conservation status of poorly studied dry areas in Veracruz. This work generated valuable knowledge on biodiversity, ecosystem services, and the relationships between natural capital, human communities, and traditional knowledge. She has extensive experience in biodiversity assessments, tropical dry forest ecology, geographic information systems, and ecosystem service evaluation. Currently, she is a full-time academic at ITESO's Interdisciplinary Center for Social Education and Outreach. From this space, she contributes to ecological restoration of dry forests across their distribution and collaborates in transdisciplinary projects that promote social and ecological transformations aimed at mitigating and adapting to climate change.



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