

# Resource recovery from livestock waste: A compilation of business cases from the Global South



INITIATIVE ON  
One Health

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# Introduction

In the past few decades, rapid growth in the livestock sector of developing countries has led to the generation of millions of metric tons of livestock waste (Tarafdar et al. 2021) including animal manure, feed residue, bedding materials, litter, hair, feathers and animal carcasses (Parihar et al. 2019; Shakya et al. 2022). The improper disposal of such livestock wastes can cause severe environmental and health impacts such as greenhouse gas emissions, loss of soil fertility, water degradation, particulate pollution, respiratory diseases, food and water borne illnesses (Brusseau and Artiola 2019; Mateo-Sagasta et al. 2018).

This has created a necessity to find an alternative approach for livestock waste management, paving the way to a transition towards circular bioeconomy with the uptake of resource recovery technologies. Livestock waste, especially manure, is proven to provide enormous opportunities for the recovery of valuable resources that can not only improve environmental sustainability but also offer higher economic gains that can contribute to overall development in the low- and middle-income countries of the global south (Montoro et al. 2017; Meyer et al. 2021).

The report covers the detailed description of 26 business cases, that utilize different livestock waste treatment technologies for recovery of valuable resources, in three main categories, as follows: i) recovery of energy and biofertilizer from animal manure and abattoir waste, ii) recovery of soil nutrients and organic matter from animal manure and abattoir waste, and iii) recovery of feed for aquaculture from animal manure and abattoir waste (Figure 1). The three business models are elaborated further in Taron et al. (forthcoming), which shows the possible extensions of the business models and compares them based on their strengths, weaknesses, opportunities, and threats.

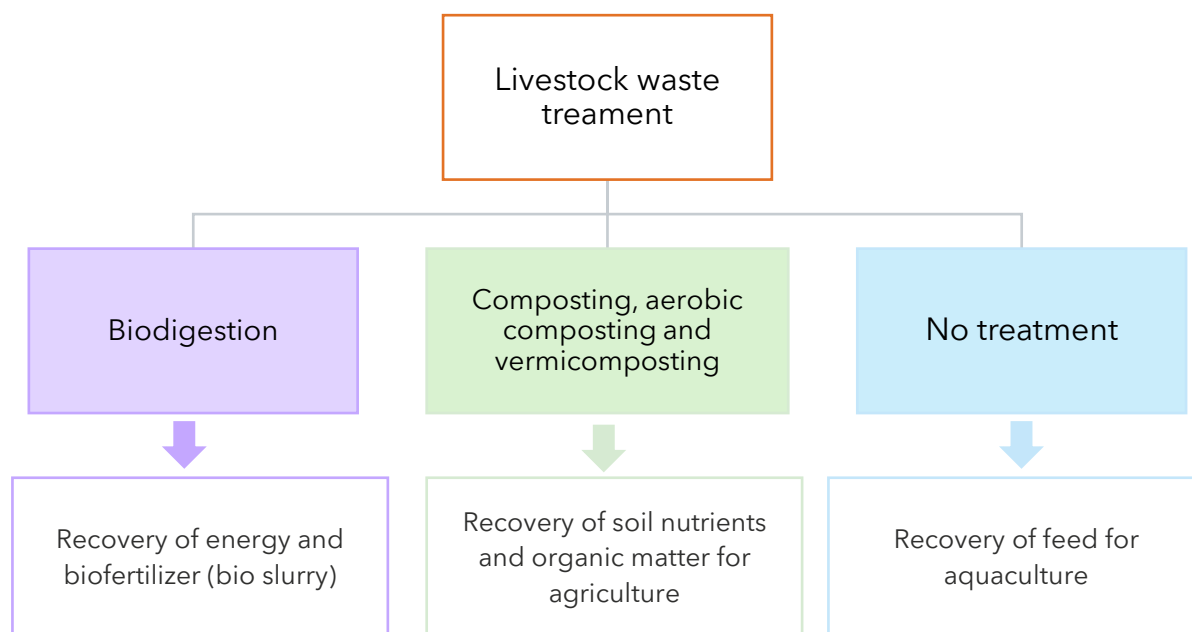


Figure 1. Recovery of valuable resources from different livestock waste treatment technologies

Source: Authors' creation

# Recovery of energy and biofertilizer from animal manure and abattoir waste

Developing countries have immense potential for biogas (bioenergy) production from livestock waste, as livestock farming plays a significant role in rural livelihoods and economies of the respective countries (Banda and Tanganyika 2021). Among various livestock wastes, cow dung and slaughterhouse wastes are widely used for biogas production.

The composition of biogas produced varies with the composition of the raw material used. In general, biogas constitutes 50-75% CH<sub>4</sub>, 25-50% CO<sub>2</sub> along with hydrogen sulfide, ammonia and water vapor in trace amounts. With CH<sub>4</sub> being the only component contributing to heating value (Surendra et al. 2014), it was estimated that 1 m<sup>3</sup> of biogas constituting 60% CH<sub>4</sub> has a heating value of 21.5 MJ (5.97 kWh of electricity equivalent). Moreover, biogas has a potential for diverse end use applications such as heating, power generation and as transportation fuel. In most of the developing economies, biogas is widely produced at small scale using household biogas digesters which are used primarily for lighting and cooking, with only a few commercial biogas plants operating for electricity generation.

Meanwhile, biogas production units also generate bio slurry which is a byproduct of anaerobic digestion. It was estimated that animal manure produces 87.3% (mass) of biogas slurry while only generates 1.7% (mass) of methane (Ke et al. 2022). The bio slurry constitutes 93% of water and 7% of dry matter, of which 4.5% is organic matter and 2.5% is inorganic matter. It contains considerable amounts of macro (N, P, K) and micronutrients (Zn, Mn, B) necessary for plant growth which makes it an ideal source of organic fertilizer and as an efficient alternative for expensive synthetic fertilizers (Kumar et al. 2015).

The section covers business cases including a) household or community level farms subsidized by the government, b) biogas plants under public-private partnership and c) biogas manufacturing units under private entities, which also recover a major part of bio slurry for organic fertilizer production along with energy recovery (as shown in figure 2). The cases are from several developing countries such as India, Nepal, Mexico, Colombia, Costa Rica, Ecuador, Ethiopia, South Africa, Kenya and Tanzania.

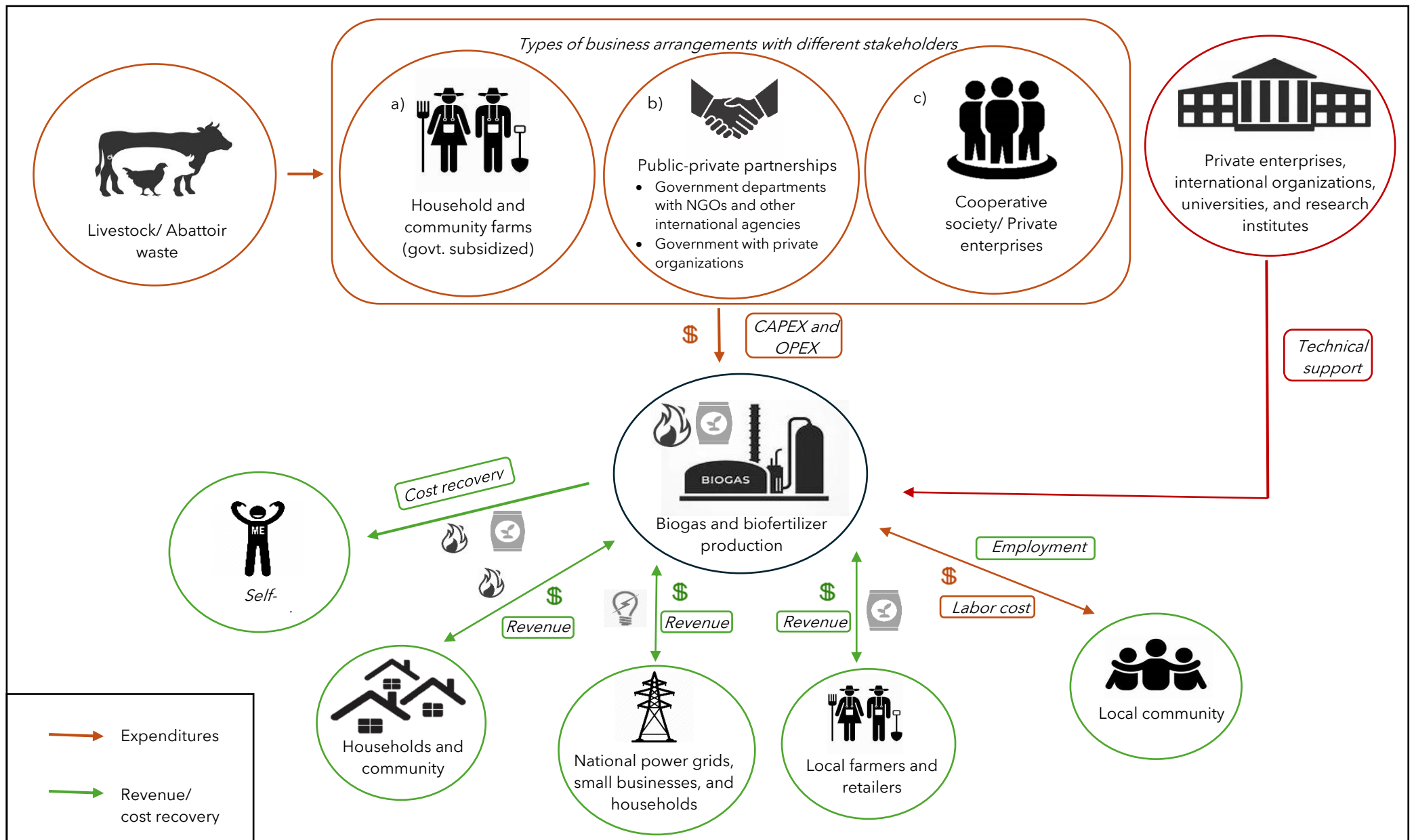


Figure 2. Value chain of energy and biofertilizer recovery business cases  
 Source: Authors' creation

## a) Household and community level farms (government subsidized)

### Zakariyapura cluster model, India

#### Business case



<b>Case name</b>	Zakariyapura cluster model
<b>Location:</b>	Zakariyapura, Anand, Gujarat, India
<b>Waste input type:</b>	Livestock manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	2019
<b>Scale of business/case:</b>	<i>Amount of waste used:</i> 40-50 kg per household. <i>Quantity of product recovered:</i> 0.8-0.9 kg of biogas and slurry per household
<b>Major partners:</b>	National Dairy Development Board (NDDB)

Map credits: Bing Map

#### Executive summary

Zakariyapura is a cluster model in the Anand district of Gujarat, India, which has gained recognition for its successful adoption of biogas. 368 out of 461 households in Zakariyapura have installed flexi biogas units. The biogas plants are owned and operated by individual farmers, who contribute their cow dung as the primary feedstock. The farmers are not required to pay for the biogas plants which are provided free of charge by the government. However, they are responsible for the maintenance and operation of the plants. In return, they receive access to renewable energy for cooking and lighting in their homes and organic fertilizer for use in agriculture. A cooperative manages the procurement of bio-slurry (residue from biogas plants). The slurry is collected from women milk producers, tested, and the price is directly transferred to their bank accounts. A plant with a 10-metric tonne capacity is installed for processing bio-slurry. The milk society is responsible for manufacturing and packaging of slurry under the brand name Sudhan.

## Value chain and stakeholders' involvement

The project is funded and supported by the Indian government through the National Biogas and Manure Management Programme (NBMMP) and is implemented by local government agencies such as the Gujarat Energy Development Agency (GEDA) and the Gujarat State Biotechnology Mission (GSBTM). The mobilization and spreading of awareness for biogas are mainly carried out by NDDDB. Academic institutions such as the Anand Agriculture University (AAU) are also involved in the project, providing technical expertise and research support. Local farmers' organizations are also involved in the project, helping to coordinate the installation and maintenance of the biogas plants and providing feedback and input on the project design and implementation.

## Financial outlook

Table 1. Financials of Zakariyapura cluster model

Item	Amount
Investment cost (per household) (in thousand USD)	0.36-0.38
Annual operation and maintenance cost (per household) (in thousand USD)	0.04
Total annual revenue (per household) (in thousand USD)	0.5
Payback period (in years)	1

Source: Authors' creation

## SWOT Analysis

Table 2. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>The Zakariyapura cluster model provides an innovative solution for managing organic waste while simultaneously generating clean energy.</li> <li>The model contributes to sustainable development by reducing greenhouse gas emissions, improving soil fertility, and providing an alternative to fossil fuels.</li> <li>The model provides employment opportunities in waste management and other related sectors, thereby contributing to local economic development.</li> <li>The involvement of women in decision-making and biogas production promotes gender equality and empowers women in the industry.</li> </ul>	<ul style="list-style-type: none"> <li>The initial investment required to set up the biogas plant and related infrastructure can be high, making it difficult for some communities to afford.</li> <li>The biogas model is heavily reliant on a consistent supply of organic waste, which can be a challenge to maintain in some areas.</li> <li>The model requires a specific skill set to operate, which can limit the pool of potential operators.</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>The biogas model can be replicated in other communities facing similar waste management and energy challenges.</li> <li>The model can be expanded to include the production of additional by-products such as organic fertilizer or biogas-powered electricity.</li> <li>With the increasing global demand for renewable energy, the biogas model can position itself as a viable and sustainable option in the market.</li> </ul>	<ul style="list-style-type: none"> <li>The biogas model faces competition from other renewable energy sources, such as solar or wind power.</li> <li>Changes in government policies or regulations can affect the viability and profitability of the model.</li> <li>Natural disasters or disruptions in the supply chain can impact the availability of organic waste and the operation of the biogas plant.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

Zakariyapura cluster model is a community-led approach for developing biogas infrastructure in rural areas of Gujarat, India. The model involves creating small-scale biogas plants that can convert livestock waste and other organic matter into biogas, which can then be used for cooking, heating, and lighting.

In terms of scalability, the Zakariyapura cluster model has the potential to be scaled up to other rural areas in Gujarat and other regions where similar conditions exist. Additionally, the Zakariyapura cluster model is replicable because it is based on simple, low-cost technology that is easy to implement and maintain. The biogas plants are made from locally available materials, and the community is trained to operate and maintain them. Other rural communities could adopt this model without significant technical expertise or financial resources. Overall, the Zakariyapura cluster model has the potential to be scaled up and replicated in other rural areas to provide a sustainable source of energy and reduce the environmental impact of livestock waste.

## Socio-economic, health and environmental benefits

The Biogas model presented here has a variety of socio-economic, health, and environmental impacts, which are detailed below:

Socio-Economic Impacts:

- Offers job opportunities in waste management and other related sectors.
- Addresses energy poverty by providing access to clean energy, increasing income through biogas and by-products, contributing to rural development,
- Improves food security by decreasing organic waste and increasing fertilizer availability.

Health Impacts:

- Enhances indoor air quality by reducing traditional cooking fuels like wood and charcoal.
- Decreases health hazards associated with poor waste management, such as the spread of diseases and environmental contamination.

Environmental Impacts:

- Decreases greenhouse gas emissions, contributing to climate change mitigation.
- Provides an organic waste management solution, lowering the amount of organic waste.
- Decreases dependence on fossil fuels, contributing to a more sustainable energy mix.
- Enhances soil fertility by producing organic fertilizer.

Overall, this business model has the potential to provide multiple benefits to society while reducing negative impacts on the environment and human health.

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## Banas biogas plant

### Business case



<b>Case name</b>	Banas Biogas Plant
<b>Location:</b>	Banaskantha District, Gujarat, India
<b>Waste input type:</b>	Cow manure and Potato
<b>Value offer:</b>	Energy, soil nutrient and organic matter,
<b>Organization type:</b>	Public
<b>Status of organization:</b>	2020
<b>Scale of business/case:</b>	<i>Products recovered:</i> 800 Kg of BioCNG per day, around 8 tons of solid fertilizer per day and around 70 000 liter liquid fertilizer per day
<b>Major partners:</b>	Banas Dairy, KIS Group

Map credits: Bing Map

### Executive summary

Banas Dairy was registered as Banaskantha District Cooperative Milk Producers' Union Limited in 1969. It had been procuring milk from dairy farmers in nearby villages in Dama Gram Panchayat of Deesa Taluk. Under the new initiative on Waste to Wealth, they have set up a biogas plant in February 2020. Towards this, the dairy commenced procuring cow dung from 254 dairy farmers with more than five cows/ buffaloes from 12 villages. The cow dung collected from these households is weighed, and the quantity is marked using a mobile App. Along with the payment for milk, USD 0.012 for the cow dung is credited every 15 days to the beneficiary account. The biogas plant has the capacity to treat 40 tonnes of cow dung and potato waste each day. The biogas produced is then purified into Bio CBG (compressed Biogas) and Bio CNG (compressed natural gas) and used as fuel for vehicles; the slurry is converted into organic manure for use in agricultural fields, thereby safeguarding the environment and the same time, promoting waste management.

### Value chain and stakeholders' involvement

The stakeholders of the business case include dairy farmers who provide primary feedstock (cow dung) for the biogas plants. Banaskantha District Cooperative Milk Producers' Union Limited involves in the treatment of cow dung and biogas production, while KIS group offering technology transfer and government of India providing strong financial support in terms of subsidies.

## Financial outlook

Table 3. Financials of Banas dairy biogas plant

Item	Amount
Investment cost (in thousand USD)	987.5
Annual operation and maintenance cost (in thousand USD)	5749.2
Total annual revenue (in thousand USD)	210.2
Payback period (in years)	5.4

Source: Authors' creation

## SWOT Analysis

Table 4. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Strong partnership with the government</li> <li>• Low-cost and environment-friendly technology</li> <li>• Improves the hygiene and sanitation of the farms and locality</li> <li>• Provides a renewable and clean energy source</li> </ul>	<ul style="list-style-type: none"> <li>• Limited market for bio-fertilizers</li> <li>• Low price of slurry</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Potential for up-scaling</li> <li>• Favorable Govt. Policy both at the state level as well as the national level</li> <li>• Raising funds from other sources</li> <li>• Rising LPG price in India</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of awareness of biogas production</li> <li>• Solar power is more favoured</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

The business has high potential from the perspective of scalability and the environmental benefits it provides. According to Mr. Arun Baroka, Additional Secretary, Swachh Bharat Mission- Grameen, Department of Drinking Water and Sanitation (DDWS) (Ministry of Jal Shakti), this project has enormous potential and can be replicated across the country. Due to the low unit cost of production and rising petrol price, it has the potential for a significant market and customer base.

## Socio-economic, health and environmental benefits

The project is undoubtedly environment friendly given that in normal circumstances, methane, a greenhouse gas which emanates from cow dung, disperses into the atmosphere and contributes to global warming and several health concerns. Through this venture, methane gas is tapped and converted into fuel. Reduction of greenhouse gases:

800 kg/day of CH<sub>4</sub> equivalent to 20 tons of CO<sub>2</sub>/day.

Additionally, there shall be a reduction of 2.87 tons of CO<sub>2</sub>/day when 800 kg CBG replaces petrol as fuel.

Moreover, it offers employment opportunities to the local community while contributing to economic development.

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## Women's cooperative for processing animal dung

### Business case



<b>Case name</b>	Women's cooperative for processing animal dung
<b>Location:</b>	Mujkuva village, Anklav taluka, Anand, Gujarat, India
<b>Waste input type:</b>	Livestock manure
<b>Value offer:</b>	Energy, soil nutrient and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	2017
<b>Scale of business/case:</b>	<i>Amount of waste used: 50-60 Kg per household</i>
<b>Major partners:</b>	Mujkuva Sakhi Khad Sahakari Mandli and National Dairy Development Board (NDDB)

Map credits: Bing Map

### Executive summary

Mujkuva village is located in Anklav taluka of Anand district in Gujarat, India. It is situated 3km away from the sub-district headquarters and 21km away from the district headquarters with 600 households, owning two-three buffaloes each, who depend predominantly on dairying. The dung produced by the animals – 15-20 kg by adults and 10-12 kg by calves – was stored in an open space, locally known as Ukeda, for later use as manure. Apart from not capturing the actual economic value of dung, open composting is also a source of greenhouse gas (GHG) emission. In 2017, NDDB organized 40 women dairy farmers from Mujkuva to form a self-help group (SHG) called 'Jai Ambe'. Each member got a new-generation biogas plant with a prefabricated digester installed at home. Biogas produced serves as a stable source of cooking energy. The slurry from the biogas unit is transported to the Sudhan manufacturing factory. The price of slurry ranges between Rs. 0.75 to Rs. 2 depending on the quality. The biofertilizers are sold under the brand name Sudhan. The fertilizers are mainly sold to the local farmers, Gujarat State Fertilizers & Chemicals Limited and other companies.

## Value chain and stakeholders' involvement

In this business case, the main stakeholders are Mujkuva Sakhi Khad Sahakari Mandli, the National Dairy Development Board (NDDB) and the Government of India. Mujkuva Sakhi Khad Sahakari Mandli has taken up slurry processing and manufacturing of organic fertilizer. NDDB's Sudhan trademark aids Mandli in creating an identity and ensuring the quality of its products. Farmers contribute to 12 percent of total cost of biogas technology as well as provide primary raw material for biogas production. Other stakeholders such as Sistema Bio and fertilizer companies also have a crucial role in biogas production and biofertilizer sales, respectively.

## Financial outlook

Table 5. Financials of Women' cooperative of Mujkuva

Item	Amount
Investment cost (per household) (in thousand USD)	0.5
Annual operation and maintenance cost (per household) (in thousand USD)	0.6
Total annual revenue (per household) (in thousand USD)	0.5
Payback period (in years)	1.2

Source: Authors' creation

## SWOT Analysis

Table 6. Business model assessment -SWOT analysis

STRENGTH		WEAKNESS	
<ul style="list-style-type: none"> <li>Community ownership and women participation</li> <li>Strong partnership with the NDDB</li> <li>Low-cost and environment-friendly technology</li> <li>Improves the hygiene and sanitation of the farms and locality</li> <li>Provides a renewable and clean energy source.</li> </ul>	<ul style="list-style-type: none"> <li>Limited market for bio-fertilizers</li> <li>Low price of slurry</li> </ul>		
OPPORTUNITY		THREAT	
<ul style="list-style-type: none"> <li>Potential for up-scaling</li> <li>Favorable Govt. Policy both at the state level as well as the national level</li> <li>Raising funds from other sources</li> <li>Rising LPG price in India</li> </ul>	<ul style="list-style-type: none"> <li>Lack of awareness of biogas production</li> <li>Solar power is more favoured</li> </ul>		

Source: Authors' creation

## Scalability and replicability potential

There is great potential for scaling up the business model since many other households in the village are interested in biogas. The state government also has a motive to replicate the model in other states. The critical factors behind the success of the business model are:

- Partnership with local communities, local governments, and local authorities.
- NDDDB, Central and State Government support
- Low-cost technology
- Effective governance system
- Transparency in operation

### Socio-economic, health and environmental benefits

The project is undoubtedly environment friendly due to its role in improving livestock waste management, reducing GHG emissions and promoting organic farming practices. However, this business model is an example of successful biogas projects that have empowered women by giving them more control over their energy choices and providing them with new economic opportunities. In this case, special attention has been paid to ensure that women have equal access to resources and training and that their voices are heard in the decision-making process.

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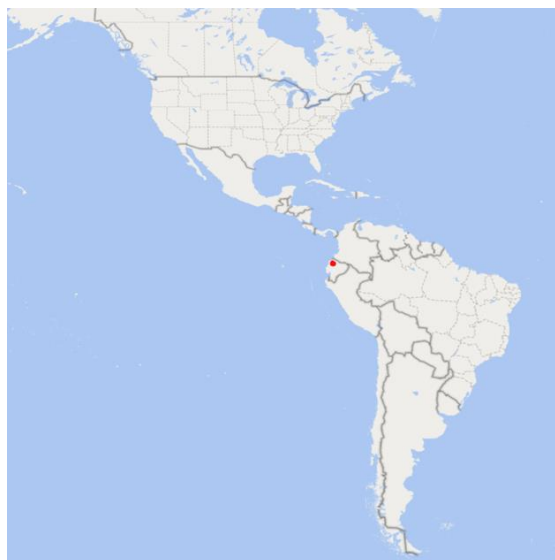
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# Climate resilient waste management and energy capture technologies

## Business case



<b>Case name</b>	Design and scale-up of climate resilient waste management and energy capture technologies in small and medium livestock farms
<b>Location:</b>	Ecuador Provinces: Santo Domingo de los Tsáchilas, Pichincha, Tungurahua, Imbabura, El Oro
<b>Waste input type:</b>	Pig waste, Cattle manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	Biogas plants installation in 2018
<b>Scale of business/case:</b>	<i>Product recovered:</i> Biogas - 43 m <sup>3</sup> /day Liquid organic fertilizer (Digestate) - 3,570 L/day
<b>Major partners:</b>	Funded by: UNIDO, in the context of Climate Technology Centre & Network (CTCN)  Project coordinated by CIMNE with its local partners INIAP and Instituto de Investigación Geológico y Energético - IIGE, with collaboration from the Ministerio del Ambiente and the Universidad Regional Amazónica Ikiam.  Biodigesters suppliers: Sistema Biobolsa Manolo Muñoz Mundo Intag Biodigestores Ecuador

Map credits: Bing Map

## Executive summary

With the aim of contributing to the sustainable modernization of medium and small-scale agricultural producers in Ecuador, the project Design and scale-up of climate resilient waste management and energy capture technologies in small and medium livestock farms, carried out the installation of 8 biodigesters with volumes between 5 and 42 m<sup>3</sup>. Biodigesters allow the management of waste generated in agricultural activity to produce energy and biofertilizer, increasing the resilience of families in the face of climate change and avoiding possible contamination of soils, waters and air, and therefore preventing negative impacts on human health and biodiversity. With the installation of these biodigesters, around 43 m<sup>3</sup>/day of biogas and 3,570 l/day of digestate are generated. These products are be used by producers for internal consumption. The proper use of biogas and digestate allows savings of 5,447 USD/year for small producers and a saving for the state through gas subsidy of 4280 USD/year.

## Value chain and stakeholders' involvement

The project is funded by The United Nations Industrial Development Organization (UNIDO), in the context of Climate Technology Centre & Network (CTCN) and coordinated by CIMNE with its local partners INIAP and Instituto de Investigación Geológico y Energético - IIGE, with collaboration from the Ministerio del Ambiente and the Universidad Regional Amazónica Ikiam. The biodigesters are supplied by private ventures such as Sistema Biobolsa, Manolo Muñoz, Mundo Intag and Biodigestores Ecuador. Small and medium-sized agricultural producers, who are responsible for the operation and maintenance of the biodigesters and are the beneficiaries of the technology.

## Financial outlook

Table 7. Financials of Climate resilient waste management and energy capture technologies

Item	Amount
Investment cost (in thousand USD)	2.2
Annual operation and maintenance cost (in thousand USD)	1.7
Total annual revenue (in thousand USD)	5.4
Payback period (in years)	N/A

Source: Authors' creation

## SWOT Analysis

Table 8. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Treatment of livestock waste</li> <li>• Use of renewable energy (Biogas).</li> <li>• Use of organic fertilizers (Digestate)</li> <li>• Decrease in the carbon footprint.</li> <li>• Compliance with regulations.</li> </ul>	<ul style="list-style-type: none"> <li>• High installation costs of biodigesters, mainly in smaller volumes.</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Reduction in the impact of bad odors on neighbours.</li> <li>• Installation of biodigesters on neighboring farms</li> </ul>	<ul style="list-style-type: none"> <li>• Possible limitations by regulatory institutions for the use of digestate</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

In Ecuador there is institutional interest in promoting the development and dissemination of biodigesters:

- **Ministerio de Energía y Recursos Naturales no Renovables (MERNNR):**  
The MERNNR published the first Bioenergy Atlas of the country, which shows the potential for biogas production according to different wastes. It developed informative workshops for small and medium producers on biodigester technology and has installed demonstrative biodigesters.
- **Ministerio del Ambiente (MAE)**  
The MAE developed a project called Generation of Capacities for the Energy Use of Agricultural Waste (GENCAPER). It published: (i) a manual with the analysis of technologies and experiences of biodigesters in Ecuador in the field of medium-sized producers and food processing industries; and (ii) manual for the installation of tubular geomembrane biodigesters. The MAE implemented six biogas systems. The MAE requested technical assistance from the Climate Technology Center & Network (CTCN) for the development of the national biodigester program.
- **Ministerio de Agricultura y Ganadería (MAG)**  
The MAG developed a bioinputs production program in different parts of the country, that considers digestate.
- **Ministerio de Comercio Exterior, Producción, Inversiones y Pesca (MPCEIP)**  
MPCEIP has supported specific projects for the treatment of wastewater from slaughterhouses using biodigesters.

The previous experiences in biodigesters and efficient support from technology providers, research organizations and an incipient network of actors have strengthened the baseline for biogas adoption in the country.

### Socio-economic, health and environmental benefits

- Reduces the need for forestry exploitation by reducing the use of firewood.
- Reduces consumption of fossil fuels.
- The use of biogas as an energy source reduces costs on the farm.
- Savings on the purchase of fertilizers.
- Energy independence in remote rural areas.

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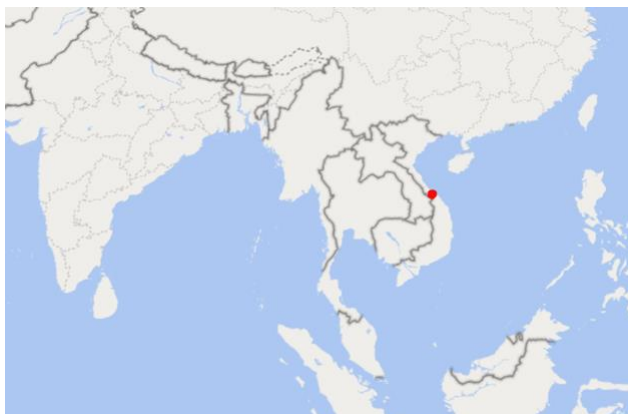
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## Biogas from pig waste

### Business case



<b>Case name</b>	Small-scale biogas plants: a case study from central Vietnam
<b>Location:</b>	Thua Thien Hue, Central Vietnam
<b>Waste input type:</b>	Pig manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	2003
<b>Scale of business/case:</b>	<i>Quantity of product recovered: 6 m<sup>3</sup></i>
<b>Major partners:</b>	Ministry of Agriculture and Rural Development and Dutch development organization SNV

Map credits: Bing Map

### Executive summary

Since 2003, Vietnam has initiated a nationwide initiative known as the "Biogas Programme for the Animal Husbandry Sector" (BPAHS). This program is implemented by the Biogas Project Division of the Ministry of Agriculture and Rural Development, in collaboration with the Dutch development organization SNV. Over the years, more than 100,000 household biogas plants have been constructed through this program. Notably, in the Thua Thien Hue province in central Vietnam, 2,900 family biogas plants have been installed. Furthermore, the initiative has involved comprehensive training for builders, facilitators, and technical teams to ensure the quality and sustainability of biogas plants. These trained experts also provide valuable user training to maximize the benefits of biogas technology.

### Value chain and stakeholders' involvement

The value chain of the Biogas Programme for the Animal Husbandry Sector (BPAHS) in Vietnam involves various stakeholders at different stages of biogas technology adoption, from production to end-users. Here's an overview of the value chain and the involvement of key stakeholders:

- **Feedstock providers:** Farmers engaged in animal husbandry are the primary feedstock providers. They supply livestock manure as the raw material for biogas production.
- **Biogas system manufacturers:** Private companies or organizations manufacture and supply biogas digester systems, gas storage tanks, and associated equipment.
- **Installation and construction:** Skilled individuals or teams are responsible for constructing and installing biogas digesters on farmers' properties.

- **Technical support:** Technical experts provide training and technical assistance to builders, ensuring the proper construction and maintenance of biogas systems.
- **Financial support:** Banks, microfinance institutions, or government agencies may offer financial support, including subsidies and low-interest loans, to help farmers afford the initial investment in biogas systems.
- **Program management:** The MARD division is responsible for overall program management, including planning, implementation, and stakeholder coordination.
- **Knowledge sharing and capacity building:** International organizations like SNV collaborate with the Vietnamese government to provide technical expertise, knowledge-sharing, and capacity-building activities.
- **Local authorities:** Local government bodies facilitate the program's outreach, coordinate with communities, and support biogas installations in their regions.

## Financial outlook

Table 9. Financials of biogas from pig waste in Vietnam

Item	Amount
Investment cost (per household) (in thousand USD)	0.3
Annual operation and maintenance cost (per household) (in thousand USD)	0.1
Total annual revenue (per household) (in thousand USD)	0.2
Payback period (in years)	2.5

Source: Authors' creation

## SWOT Analysis

Table 10. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"><li>• The presence of KT1 and KT2 biogas plant types, which are based on the established Chinese fixed dome model, ensures a reliable and proven technology for biogas generation.</li><li>• The use of anaerobic processes for organic matter decomposition and biogas production is a sustainable and eco-friendly method.</li><li>• The gravity-driven movement of materials within the biogas plant simplifies the process and reduces the need for additional energy input.</li><li>• The availability of the KT2 type allows for flexibility in design and operation, particularly in areas with challenging soil conditions or high-water tables.</li></ul>	<ul style="list-style-type: none"><li>• Problems associated with the angle and blockages of the inlet pipe can disrupt the organic matter flow into the digester, affecting biogas production.</li><li>• BGP placement at inconvenient distances from pig sheds, toilets, or the farm hinders accessibility and adds operational and maintenance challenges.</li><li>• The issue of unstable construction, especially during the rainy season, highlights concern about workmanship quality and the need for skilled builders.</li></ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"><li>• Addressing construction and maintenance issues through training programs for builders and users can improve the overall performance of BGPs.</li><li>• Identifying suitable locations for BGPs, considering proximity to animal facilities and user convenience, can enhance accessibility and functionality.</li><li>• Implementing quality control measures during construction can mitigate stability issues during adverse weather conditions.</li></ul>	<ul style="list-style-type: none"><li>• Seasonal variations, especially heavy rains during the rainy season, can pose threats to the stability and functionality of BGPs.</li><li>• A shortage of skilled builders may continue to result in construction quality issues.</li><li>• Inadequate awareness among users about proper operation and maintenance may persist as a threat to the sustainability of BGPs.</li></ul>

Source: Authors' creation

## Scalability and replicability potential

SNV collaborates with MARD to provide technical expertise and financial support for construction of biogas plants, which increases the replicability of biogas technology in Vietnam. Moreover, provincial, and district-level authorities are also involved in the implementation of the BPAHS program which is responsible for construction of thousands of biogas plants in several areas of Vietnam.

## Socio-economic, health and environmental benefits

The project has several benefits such as reduction in the use of fossil fuels, improved livestock waste management, reduction in GHG emissions, employment creation, cost savings, energy independence and adoption of organic farming practices.

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# Ghana Kumasi Abattoir Biogas

## Business case



<b>Case name</b>	Ghana Kumasi Abattoir Biogas
<b>Location:</b>	Kumasi, Ghana
<b>Waste input type:</b>	Abattoir waste
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	Completed 2020
<b>Scale of business/case:</b>	178 tons per day of waste, 434 m <sup>3</sup> of biogas per day
<b>Major partners:</b>	UNIDO, Korean government

Map credits: Bing Map

## Executive summary

Kumasi Abattoir Company Ltd. is one of Ghana's largest abattoirs. It is a publicly owned company established in 1993 but started operations in 1998. Its core business is the slaughtering of cattle, small ruminants (mainly goats and sheep) and pigs, as a service to animal owners; cold storage of meat products; and the processing of meat into sausages, bacon, cooked ham, prime cuts, etc. The abattoir is situated just south of the Kumasi ring way, at coordinates 6°39'36.3" N 1°36'16.6"W. The total area of the abattoir is approximately 7 hectares of which about half of it is occupied by the production area, an old wastewater treatment plant and a pond. The main types of waste generated are solid waste and wastewater. The solid waste mainly consists of solid rumen content and dung, with a total quantity of about 8 tons per day. The wastewater mainly consists of flushing water, blood and liquid rumen content, with a total quantity of 170 tons per day.

Waste disposal of the abattoir was causing problems for the neighboring communities. Therefore, the Government of Ghana implemented a pilot industrial biogas plant at the abattoir with the support of UNIDO and The Korean government. Total annual production of biogas of the biogas plant is about 152,000 m<sup>3</sup> (846 m<sup>3</sup>/d), annual net electricity production is 85,750 kWh/a (245 kWh/d), annual LPG substitution is 32,309 kg/a (92 kg/d), and annual fertilizer production is 175 t/a on dry matter basis (500 kg/d on dry matter basis).

## Value chain and stakeholders' involvement

Major stakeholders:

- Planning, strategies, awareness and financing – UNIDO
- Technical design, infrastructure development, construction, monitoring and evaluation - Daewoo Engineering Korea
- Operation and maintenance - Abattoir
- R&D - KNUST
- Customer segments - Abattoir units and farmers

## Financial outlook

Table 11. Financials of Ghana Kumasi Abattoir Biogas

Item	Amount
Investment cost (in thousand USD)	1385.2
Annual operation and maintenance cost (in thousand USD)	15.0
Total annual revenue (in thousand USD)	216.9
Payback period (in years)	8

Source: Authors' creation

## SWOT Analysis

Table 12. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"><li>• Availability of abattoir waste</li><li>• Reduced costs of energy for the abattoir</li><li>• Waste processing to meet environmental regulations.</li><li>• Production costs lower than revenue from output</li><li>• Strong partnership (Ghana, UNIDO and Korea)</li></ul>	<ul style="list-style-type: none"><li>• Elevated investment cost</li><li>• Technical limitations and capacity gaps</li></ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"><li>• Reduced environmental challenges.</li><li>• Reduced human health risks.</li><li>• Cost effective electricity generation and use.</li><li>• Demand for organic soil nutrients.</li></ul>	<ul style="list-style-type: none"><li>• Import of the technology</li><li>• Competition from other entrants in the business</li><li>• Capacity gaps for scaling</li></ul>

Source: Authors' creation

## Scalability and replicability potential

This is a large industrial scale biogas plant, whose investment costs are relatively high. This is suitable for sites where there is a readily supply of large volumes of wastes, such as abattoir waste. Its benefits are not only economic but has multiple environmental and socio-economic benefits. This made a transfer of technology between Korean biogas technology and Ghana. It can be used as a unique pilot project for expansion of similar technologies across Africa.

## Socio-economic, health and environmental benefits

The implementation of the biogas plant has several benefits in the following aspects 1) reduced cost of disposal of waste, 2) alternative source of electricity, 3) replacement of LPG, 4) replacement of Diesel, 5) benefits from production of bio-fertilizers. Moreover, the production costs of the biogas are much lower than the revenue from the gas produced. In addition to the economic benefits, it offers several environmental benefits such as prevention of land pollution and GHG emission reduction, which has led to reduced human health risks.

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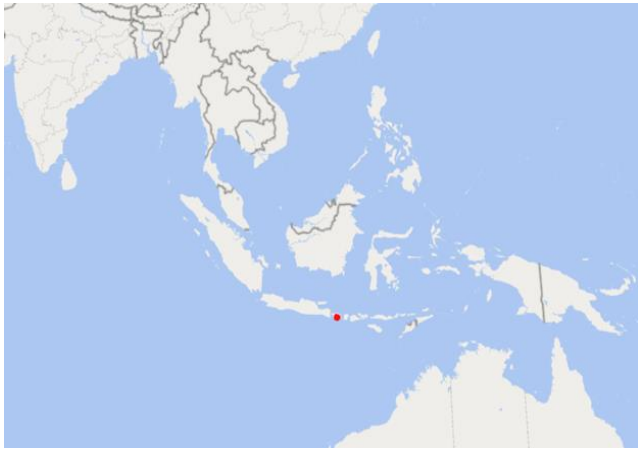
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# Household Biogas Development Programme

## Business case



<b>Case name</b>	Household Biogas Development Programme
<b>Location:</b>	Tumbak Bayuh, Mengwi, Bali, Indonesia
<b>Waste input type:</b>	Pig manure, Cow dung and food waste
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	2015
<b>Scale of business/case:</b>	<i>Quantity of product recovered:</i> 0.8 kg per day
<b>Major partners:</b>	su-re.co (Sustainability & Resilience)

Map credits: Bing Map

## Executive summary

Indonesia's National Energy Policy aims to increase the share of renewable energy in the country's energy mix. The government has set targets for renewable energy capacity, including biogas, to reduce dependence on fossil fuels. The government has introduced feed-in tariffs (FiTs) for renewable energy sources, including biogas. FiTs guarantee a fixed price for electricity generated from renewable sources, making it financially viable for investors to develop biogas projects. The government also collaborates with international organizations and NGOs to implement biogas projects, facilitate technology transfer and provide training and capacity-building programs to promote the use of biogas technology among local communities. The biogas project, with key partners including the local community, su-re.co, and international funding agencies, focuses on utilizing pig manure for raw biogas generation. It offers the community affordable clean energy, bio-fertilizer, and cost savings.

## Value chain and stakeholders' involvement

The value chain of biogas production involves a series of steps from feedstock collection to end-use applications. The value chain begins with collecting organic materials, known as feedstock from farmer households, that can be used to produce biogas. Common feedstocks include pig manure, other animal manure like cow, sewage sludge, and food waste. In some cases, feedstock may require pre-treatment to enhance its digestibility and improve biogas production. Pre-treatment methods can include chopping, shredding, or grinding the materials. Anaerobic digestion is the core process in biogas production. It takes place in a controlled environment where microorganisms break down the organic matter in the feedstock in the absence of oxygen. The resulting biogas is self-consumed by the farmers. Besides, the government, international agencies and NGOs play a crucial role in providing technical expertise to facilitate biogas production.

## Financial outlook

Table 13. Financials of Indonesia household biogas development programme

Item	Amount
Investment cost (per household) (in thousand USD)	0.3
Annual operation and maintenance cost (per household) (in thousand USD)	0.01
Total annual revenue (per household) (in thousand USD)	0.2
Payback period (in years)	4 - 6

Source: Authors' creation

## SWOT Analysis

Table 14. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Abundant organic waste</li> <li>• Environmental benefits</li> <li>• Community engagement.</li> <li>• Alternative renewable energy source</li> </ul>	<ul style="list-style-type: none"> <li>• Higher initial investment</li> <li>• Lack of technical expertise</li> <li>• Limited scale</li> <li>• Low community acceptance</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Government support</li> <li>• Local market development</li> <li>• Sustainable transformation</li> <li>• Research and innovation.</li> </ul>	<ul style="list-style-type: none"> <li>• Fluctuations in energy prices and market conditions can impact the economic viability of the project.</li> <li>• Competition from other entrants in the business</li> <li>• Bali is susceptible to natural disasters, such as earthquakes and volcanic eruptions, which could damage biogas infrastructure.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

This business model has enormous potential for replicability and is already successfully implemented in 96 places across Indonesia. With little more support from the government, the potential for scalability can be increased by many folds.

## Socio-economic, health and environmental benefits

The biogas system expands access to clean and reliable energy. This not only improves the quality of life but also helps to create new employment opportunities. Usage of biogas for cooking and lighting in households and businesses can reduce their reliance on costly fossil fuels, such as LPG or kerosene, leading to cost savings. Moreover, rural women and children are more benefited due to clean and smokeless kitchens.

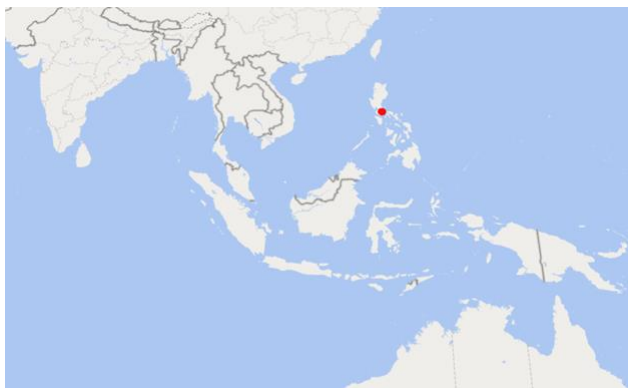
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## First Quezon Biogas Corporation (FQBC)

### Business case



<b>Case name</b>	First Quezon Biogas Corporation (FQBC)
<b>Location:</b>	Candelaria, Quezon Province, Philippines
<b>Waste input type:</b>	Chicken Manure, rice straw and corn Stover
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public
<b>Status of organization:</b>	2018
<b>Scale of business/case:</b>	<i>Amount of waste used:</i> 14 000 tonnes of chicken manure, 7 000 tonnes of rice straw and 8 000 tonnes of corn stover. <i>Quantity of product recovered:</i> 1.2 MWe
<b>Major partners:</b>	First Quezon Biogas Corporation and Yamato Technologies

Map credits: Bing Map

### Executive summary

First Quezon Biogas Corporation (FQBC), the association of local poultry farmers, developed a waste-to-energy pioneering project for production of biogas and electricity in Philippines. The project received a subsidy under the Renewable Energy Act (the RE Act) of 2008, which focuses on promoting the development of renewable energy projects and reducing reliance on fossil fuels. The corporation utilizes 14 000 tonnes of chicken manure, 7 000 tonnes of rice straw and 8 000 tonnes of corn stove to generate 1.2 MW of electricity from biogas and biofertilizer (as a byproduct) which is used as organic compost.

### Value chain and stakeholders' involvement

First Quezon Biogas Corporation (FQBC) developed a partnership with the Singaporean co-investor Yamato Technologies Pte. Ltd (co-owner) and EnviTec to address the annually accumulating tons of poultry manure through a waste-to-energy pioneering project in the country.

## Financial outlook

Table 15. Financials of FQBC

Item	Amount
Investment cost (in thousand USD)	6700.0
Annual operation and maintenance cost (in thousand USD)	500.0
Total annual revenue (in thousand USD)	9700.0
Payback period (in years)	5

Source: Authors' creation

## SWOT Analysis

Table 16. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Sufficient resources</li> <li>• Financially attractive since the average conventional energy price is relatively very high.</li> <li>• Saving on waste transportation costs</li> <li>• Free electricity for the host village</li> <li>• Job opportunities for local community</li> <li>• Reliable power supply</li> </ul>	<ul style="list-style-type: none"> <li>• Higher initial investment</li> <li>• Dependency on external technology</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Favorable policy and regulations related to renewable energy.</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of awareness on biogas opportunities</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

At the time of the initiation of this project, Philippine energy prices are at an average of about 0.23USD/kWh. This was not only the most expensive in Southeast Asia but also comparable to highly developed countries such as Japan, according to a target market analysis conducted by the German-Philippines Chamber of Commerce and Industry (GPCCI). Thus, Philippines offers enormous potential for production of affordable biogas energy.

## Socio-economic, health and environmental benefits

The Bio Digester not only generates low-carbon energy and biofertilizer, it also reduces harmful methane emissions from livestock waste, increases energy security, and improves waste management and sanitation. Moreover, it provides free electricity of 50 kilowatts per month to the host village, 22 families residing near the plant, aside from jobs, livelihood and other business opportunities. The biogas plant is also capable of supplying reliable power supply to around 6 000 households in the rural areas of Candelaria.

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## b) Public-private partnerships

### Nyongara Slaughterhouse Biogas

#### Business case



<b>Case name</b>	Nyongara Slaughter House Biogas
<b>Location:</b>	Dagorretti, Kenya
<b>Waste input type:</b>	Solid and liquid slaughterhouse waste
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public-private partnership
<b>Status of organization:</b>	Since 2011
<b>Scale of business/case:</b>	300 kg of waste per day, generating 9 kWh of electricity per day
<b>Major partners:</b>	United Nations Industrial Development Organization (UNIDO), Kenya Industrial Research and Development Institute (KIRDI), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP)

Map credits: Bing Map

#### Executive summary

The Nyongara slaughterhouse is located in Dagorretti on the outskirts of Nairobi. Dagorretti is an area well known for slaughterhouses that supply meat to different regions of Nairobi and its environs. The waste generated by the slaughterhouse was polluting Nairobi River. Therefore, the National Environmental Management Authority (NEMA), an environment regulatory body, was shutting down the slaughterhouse units that were not meeting the regulatory norms of treating their waste. This catalysed partnership between Nyongara slaughterhouse and UNEP, UNIDO and KIRIDI through the Ministry of Environment to develop and demonstrate a solution to not only treat the waste but also provide monetary benefits to the slaughterhouse units through biogas production. The biogas operations began in 2011 and the biogas produced is used for heating and to generate electricity primarily for refrigeration and lighting purpose. The slurry output from the plant is high in nutrients and is used in cultivation of tomatoes within the slaughterhouse. Based on the success of Nyongara biogas plant, the proprietor of Nyongara slaughterhouse is planning to set up a business for treating waste from other slaughterhouse units in Dagorretti, Kenya to produce biogas and sell the electricity back to slaughterhouse units.

## Value chain and stakeholders' involvement

Major stakeholders:

- Planning, technical design, infrastructure development and construction - UNIDO
- Financing and administrative approvals - UNDP
- Operation and maintenance - Nyongara slaughterhouse
- R&D, monitoring and evaluation - KIRDI
- Advocacy and awareness - UNDP and KIRDI
- Customer segments - Abattoir units and farmers

## Financial outlook

Table 17. Financials of Nyongara slaughterhouse

Item	Amount
Investment cost (in thousand USD)	50.0
Annual operation and maintenance cost (in thousand USD)	3.0
Total annual revenue (in thousand USD)	5.0
Payback period (in years)	5

Source: Authors' creation

## SWOT Analysis

Table 18. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Low O&amp;M and labor requirements</li> <li>• Readily availability of waste</li> <li>• Waste processing to meet environmental regulations</li> <li>• Strong partnership</li> </ul>	<ul style="list-style-type: none"> <li>• Large land requirement</li> <li>• Import of equipment</li> <li>• Limitations of technicians</li> <li>• Higher installation costs</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Reduced environmental challenges.</li> <li>• Market offers from other slaughterhouse units.</li> <li>• Cost effective electricity generation and use.</li> <li>• Increasing demand for low-cost power due to unreliable electricity</li> <li>• Demand for organic soil nutrients.</li> </ul>	<ul style="list-style-type: none"> <li>• Potential human health impacts due to biogas leakage</li> <li>• Competition from other entrants in the business</li> <li>• Insufficient awareness and capacity</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

This pilot biogas plant is highly suitable for slaughterhouses across Africa on reducing pollution and promoting resource recovery. The enterprise itself has plans to scale up the biogas plant to process waste from other slaughter-house units. It has demonstrated energy savings and environmental protection, as well as cost recovery. This provides opportunities for a zero-waste operation for slaughterhouses. Scientists and engineers from the KIRDI were involved in the implementation from the very beginning of the activity, which enabled UNIDO to transfer the know-how and skills to local technicians, so that the maintenance, replication and up-scaling process would be easier.

## Socio-economic, health and environmental benefits

The project was initiated to assist slaughterhouse units to meet the environmental regulations, and thus reduce pollution of land and water bodies. The biogas plant aims to provide solutions for other slaughterhouses to treat their waste to meet NEMA's requirements. The economic benefits include reduction in the cost of energy from USD 0.20 to USD 0.09 per kWh. The biogas produced can also result in energy savings of 5,227 USD per year which would enable a payback in 5 years. The biogas produced is used for electricity generation which improves the energy security of the region. The project has also reduced CO<sub>2</sub> emissions by 108 tons per year. Besides, the biogas plant provides employment in operation and maintenance. Reopening of these closed units will result in restoration of lost jobs. Additionally, if the enterprise gets into production of organic fertilizer from the slurry output, it provides additional benefits to the environment by offering sustainable organic soil nutrients.

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## Business case



<b>Case name</b>	FasoBiogaz
<b>Location:</b>	Industrial zone of Kossodo, Ouagadougou, Burkina Faso
<b>Waste input type:</b>	Slaughterhouse waste and other available organic substrates
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Public-private partnership
<b>Status of organization:</b>	2015
<b>Scale of business/case:</b>	<i>Amount of waste used:</i> 40-60 m <sup>3</sup> /day <i>Product recovered:</i> 630-740 m <sup>3</sup> /day of biogas
<b>Major partners:</b>	Catalyse Energy Burkina Faso, FasoBiogaz SARL

Map credits: Bing Map

## Executive summary

FasoBiogaz SARL is an enterprise founded in 2012 by two Dutch entrepreneurs. The enterprise is located in the industrial zone of Kossodo in Ouagadougou, Burkina Faso, and operates the first industrial biogas plant connected to the SONABEL power grid. The plant, with an installed electrical capacity of 275 kW, is transforming slaughterhouse waste and other available organic substrates into biogas and biofertilizer. While biogas is transformed into electricity and injected into the national power grid, the biofertilizer is commercialized under the brand name "Nourrisol".

## Value chain and stakeholders' involvement

The project is a private-public partnership, where 50 per cent of the cost comes as a subsidy from the Dutch government and the rest 50 per cent as a private sector investment. The biodigesters will receive organic waste from a slaughterhouse and a brewery nearby and use the gas to produce electricity which is sold to the national electricity company SONABEL. The organic material in the biodigesters is taken out and sold as fertilizer. Three products – liquid fertiliser, solid bio fertilizer and organic soil amendment – are advertised on the FasoBiogaz website. The sale of organic fertilizer is also advertised on a poster outside the plant. Farmers and local community can bring their own containers to collect the digestate on site.

## Financial outlook

Table 19. Financials of FasoBiogaz

Item	Amount
Investment cost (in thousand USD)	364.6
Annual operation and maintenance cost (in thousand USD)	90.0
Total annual revenue (in thousand USD)	156.9
Payback period (in years)	2.9

Source: Authors' creation

## SWOT Analysis

Table 20. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>The biogas plant is located near the main source of the substrate.</li> <li>Stable demand for biogas</li> <li>Multiple income sources such as biogas, electricity and biofertilizer</li> </ul>	<ul style="list-style-type: none"> <li>The investment costs for large biogas plants are relatively high and require subsidies</li> <li>Requires partnership with local communities for raw materials supply.</li> <li>Limited local technical expertise</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>Potential for up-scaling</li> <li>Favorable Government policies</li> <li>Strong partnership with the government.</li> </ul>	<ul style="list-style-type: none"> <li>Lack of awareness of biogas production</li> <li>Solar-power is more favoured.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

According to the original plan, FasoBiogaz aims to grow the capacity of the pilot plant to 1.375 MW stagewise. The first stage with a planned increase in capacity to 550kW with the creation of 22 permanent jobs. Furthermore, this business is the first large-scale successful biogas project in the region and has lots of potential to be followed by other businesses.

## Socio-economic, health and environmental benefits

The project's benefits are mainly linked to the recovery of slaughterhouse waste to produce energy and fertilizer which fall under the following categories:

- Reduction of Greenhouse Gas (GHG): The business help to reduce the emissions of GHG, including methane (CH<sub>4</sub>). The process also helps to reduce CO<sub>2</sub> emissions by producing clean energy from organic waste.
- Renewable energy: Production of renewable energy which contribute to the reduction of national petroleum consumption. A possibility to sell electricity directly to consumers. The heat produced and not valorised in the process could be used for the refrigeration of the slaughterhouse products, thereby reducing its energy consumption.
- Biofertilizer: Biofertilizer helps to promote organic farming practices and reduce the use of expensive chemical fertilisers for farming.

## References

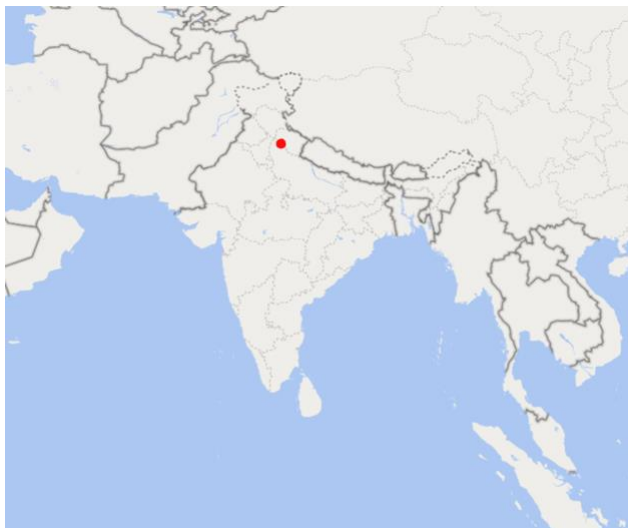
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## c) Private enterprises

### Bio-CNG Plant at Krishnayan Gaushala

#### Business case



<b>Case name</b>	Bio-CNG Plant at Krishnayan Gaushala, Haridwar
<b>Location:</b>	Naurangabad, Gendikhata, Najibabad Road, Haridwar, Uttarakhand, India
<b>Waste input type:</b>	Cow dung
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	Operational from 2017
<b>Scale of business/case:</b>	<i>Amount of waste used: 20 Tons per day</i>
<b>Major partners:</b>	Oil and Natural Gas Corporation Ltd (ONGC), Ministry of New and Renewable Energy (MNRE), Govt. of India

Map credits: Bing Map

#### Executive summary

This BioCNG project located in Haridwar, Uttarakhand is being managed by Shri Krishnayan Desi Gauraksha and Golok Dham Sewa Samiti. The plant is spread across an area of 0.28 ha and feedstock for the plant is collected from three cow shelters. The raw biogas generated is stored and compressed to produce Compressed Biogas (CBG). The purified CBG is stored in cascades and supplied to the Ayurveda factory in Sidcul, Haridwar. The slurry is separated into solid and liquid parts. The solid part is fortified and converted to biofertilizers, while the liquid part is used by the samiti on their own farm. Biofertilizers are packed in bags of 5 kg, 10 kg, & 50 kg capacities and sold under the brand name Surabhi Sudha. 36 different products such as into bio-pesticide, growth promoter, PROM and fungicide have been developed after enriching biofertilizer with microbes.

#### Value chain and stakeholders' involvement

ONGC undertook an initiative to convert cow manure (cow dung) into useful fuel and value-added products by setting up a Bio-CNG cum Fertilizer & Bottling Plant at Haridwar. Presently, the plant is being run by the cow shelter for carrying out waste management in a clean and hygienic manner in the cow shelter premises. The project received a subsidy from the Government of India through the Ministry of New and Renewable Energy (MNRE). The plant produces biogas, which is self-consumed, while the organic solid and liquid fertilizers produced are distributed among the local farmers, thereby promoting organic farming.

## Financial outlook

Table 21. Financials of Bio-CNG Plant at Krishnayan Gaushala

Item	Amount
Investment cost (in thousand USD)	250.0
Annual operation and maintenance cost (in thousand USD)	87.5
Total annual revenue (in thousand USD)	83.0
Payback period (in years)	3

Source: Authors' creation

## SWOT Analysis

Table 22. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"><li>• Strong partnership with government and ONGC</li><li>• Environment friendly technology</li></ul>	<ul style="list-style-type: none"><li>• Limited market for bio-fertilizers</li><li>• Difficulty in transporting CBG</li><li>• Low price of slurry</li><li>• Unhygienic methods used in the collection of manure</li></ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"><li>• Potential for up-scaling</li><li>• Favorable Govt. policy both at the state level as well as the national level</li><li>• Rising LPG price in India.</li></ul>	<ul style="list-style-type: none"><li>• Lack of awareness of biogas production</li><li>• Solar-power is more favoured.</li></ul>

Source: Authors' creation

## Scalability and replicability potential

There is potential for biogas plants at nearby cow shelter, with a minimum of 2000 cows and can be a viable business model through the revenue from sale of CBG and bio slurry. The same can be replicated in other cow shelter, where milch and non-milch cattle are sheltered. However, an effective Information, Education and Communication (IEC) strategy is needed for popularizing and propagating the adoption of biogas/CBG production.

The creation of a conducive environment for the use of organic manure/bio-fertilizers will be a boon to the environment and farmers which reduce dependence on imported chemical fertilizers. Moreover, this is an eco-friendly waste management system supporting the circular economy in villages and providing additional income to the farmers which shows higher potential for replication.

## Socio-economic, health and environmental benefits

The government of India launched a nationwide programme called Gobardhan. The primary objective of Gobardhan is to ensure cleanliness in villages by converting bio-waste, including cattle waste, kitchen leftovers, crop residue and market waste, to improve the lives of villagers. This will provide economic and resource benefits to farmers and households.

In the ethos of Gobardhan, this project is a good example of an environmental-friendly approach to cow manure management. The relationship between biogas with cows and its manure (dung) is pretty old in India. Biogas is commonly known as Gobar Gas. Having cattle, mainly cows in India is quite common in village areas, which assures the availability of ample manure for biogas plants.

On the other hand, cow shelters (having milk or non-milking cows) have a high amount of manure available and are more suited for setting up large-scale biogas plants. The large-scale biogas plants also provide an alternative revenue source to the cow shelter and help manage their waste. The by-product of this project, i.e. bio-fertilizers, also helps to achieve Paramparagat Krishi Vikas Yojana (PKVY), the mission of organic farming by the government of India.

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## Business case



<b>Case name</b>	Gandaki Urja Pvt. Ltd.
<b>Location:</b>	Pokhara, Nepal (Rural)
<b>Waste input type:</b>	Livestock manure and municipal solid waste
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2017
<b>Scale of business/case:</b>	<i>Amount of waste used:</i> 45 tonnes. <i>Quantity of output:</i> 1,600 kgs of high-quality compressed natural gas and 11,000 kgs of organic fertiliser.
<b>Major partners:</b>	Windpower Nepal Pvt Ltd and Pokhara Himalayan Meats Pvt Ltd

Map credits: Bing Map

## Executive summary

The Gandaki Urja, Nepal's largest commercial-scale BioCNG plant, is located in Pokhara, Nepal, in the foothills of the Annapurna range. The project is focused on conserving fragile mountain ecosystems by managing organic waste, replacing fossil fuels and chemical fertilizers, and supporting the mountain communities' livelihoods in the Annapurna range. Converting organic waste to generate compressed biogas and organic fertiliser is an innovative clean-tech project which generates revenue while saving the environment and improving the health of the local mountain communities in Nepal. The project uses 45,000 kgs of organic waste matter to generate 100 cylinders of biogas and 2 tonnes of fertilizer per day. Nepal's energy purchase from India is around 2.5 per cent of the total trade, and the business aids Nepal to reduce the trade deficit.

## Value chain and stakeholders' involvement

Gandaki Urja is collaborating with both local and national authorities. It collects waste externally from nearby livestock farms and municipality. The customer segments of biogas and biofertilizers include the local community and farmers. In late 2019, it received USD 389813.80 from International Finance corporation (IFC)-backed Business Oxygen (BO2). The project has also received a partial subsidy (40%) from the Government of Nepal's Alternative Energy Promotion Center under the Ministry of Energy, Water Resources and Irrigation (MoEWRI).

## Financial outlook

Table 23. Financials of Gandaki Urja Private Limited

Item	Amount
Investment cost (in thousand USD)	1937.4
Annual operation and maintenance cost (in thousand USD)	2.2
Total annual revenue (in thousand USD)	459.9
Payback period (in years)	6.5

Source: Authors' creation

## SWOT Analysis

Table 24. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"><li>• Strong partnerships with government and international organizations</li><li>• Environment-friendly technology</li></ul>	<ul style="list-style-type: none"><li>• Limited market for bio-fertilizers</li><li>• Unhygienic methods are used to collect manure.</li><li>• COVID-19 severely impacted the business</li></ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"><li>• Potential for up-scaling</li><li>• Favourable Govt. Policy</li><li>• Raising fund from other sources</li><li>• Rising LPG price in India and which impacts Nepal's energy price.</li></ul>	<ul style="list-style-type: none"><li>• Lack of awareness of biogas production</li><li>• Solar-power is more favoured.</li></ul>

Source: Authors' creation

## Socio-economic, health and environmental benefits

The main benefits of this business are:

- The project is estimated to cut 14,000 tonnes of methane emissions annually.
- The project would supply 528,000 kg/year of compressed biogas substituting around 37,183 LPG cylinders annually.
- The project is expected to save 15,000 tonnes of organic waste going to landfills annually.
- It offers 20 full-time employments for local youth.

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# Mulu Senessa Farm

## Business case



<b>Case name</b>	Mulu Senessa Farm Biogas
<b>Location:</b>	Modjo town, East Shoa Zone, Oromia region, Ethiopia
<b>Waste input type:</b>	Livestock manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2020
<b>Scale of business/case:</b>	250 kg per day of waste, 5 m <sup>3</sup> of biogas per day, and 15 m <sup>3</sup> of organic matter
<b>Major partners:</b>	SNV, National Biogas programme

Map credits: Bing Map

## Executive summary

The business case was established in 2022 to cover the own energy demands of the Mulu Senessa dairy farm. It was implemented with the technical support from SNV, and Dutch Development Organization. The waste used in the business case is cow manure which comes internally from the dairy farm, so no further transportation needed. The outputs are biogas and organic soil nutrient. Nearly 250 kg of manure is fed to the digester every day through a channelized conveyance system. The biogas produced (about 10 m<sup>3</sup> per day) is piped to the different utilities of the farm, including milk and cheese processing units, cooking and lighting. The organic matter is recovered from the basin on a regular basis (around 150 kg per day). Though the biogas is currently not commercialized, there is a large demand for cooking gas within the community, which could be tapped. The organic fertilizer meets the fertilizer needs of local farmers, which contributes to both organic farming as well as in reducing costs of crop production by replacing expensive synthetic fertilizers.

## Value chain and stakeholders' involvement

Major stakeholders:

- Planning, technical design, infrastructure development and construction, monitoring - SNV
- Financing, operation and maintenance - Dairy farm
- R&D - SNV, National Biogas Programme
- Customer segments - Community and farmers

## Financial outlook

Table 25. Financials of Mulu Senessa farm biogas plant

Item	Amount
Investment cost (in thousand USD)	4.5
Annual operation and maintenance cost (in thousand USD)	1.0
Total annual revenue (in thousand USD)	4.0
Payback period (in years)	4

Source: Authors' creation

## SWOT Analysis

Table 26. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Relatively simple technology</li> <li>• Cow manure from own farm</li> <li>• Waste disposal cost savings</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of adequate training on management of the business case</li> <li>• Lack of commercialization concepts and motivation</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• High demand for clean energy</li> <li>• Demand for organic soil nutrient due to high costs of imported synthetic fertilizers.</li> <li>• In line with the government's plan for clean energy and green development</li> <li>• Increasing demand for organic products among consumers</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of adequate awareness on biogas among communities</li> <li>• Limited awareness on the possibility of replacing chemical fertilizers with organic soil nutrients among farmers</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

This is a relatively simple case that has a high scalability and replicability potential particularly for livestock farm owners. The investment costs are relatively lower, and the O&M costs are minimal. The business can be scaled up and scaled out, not only for self-energy demand coverage, but also for commercialization of both biogas and organic soil nutrients.

## Socio-economic, health and environmental benefits

- Sustainable development, creation of a clean environment, greenhouse gas emission reduction, ecological footprints reduction.
- Improved pollution and hence human health
- Cost savings, economic returns and employment creation

## References

SNV. 2024. *National Biogas Programme - Ethiopia*. Available at <https://www.snv.org/project/national-biogas-programme-ethiopia> (accessed on August 13, 2024).

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Data for the case study were obtained from the business entity through personal discussions.

## S & S Farm

### Business case



<b>Case name</b>	S & S Farm Biogas
<b>Location:</b>	Modjo town, East Shoa Zone, Oromia region, Ethiopia
<b>Waste input type:</b>	Livestock manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2021
<b>Scale of business/case:</b>	500 kg per day of waste, 20 m <sup>3</sup> of biogas per day, 2 m <sup>3</sup> organic matter per day
<b>Major partners:</b>	SNV

Map credits: Bing Map

### Executive summary

The biogas digester for this farm was developed with the technical support from SNV in 2021. The model uses cow manure from its own dairy farm. The bio-digester is an underground 60 m<sup>3</sup> digester to which the cow manure slurry is channelled for anaerobic decomposition. The outputs are biogas and organic soil nutrients. Nearly 500 kg of manure is fed to the digester every day. The biogas produced (about 20 m<sup>3</sup> per day) is channelled to be used in different utilities of the farm, including dairy processing units, cooking and lighting. The organic matter is recovered from the basin on a regular basis (on average about 2 m<sup>3</sup> organic matter per day). The organic matter is used for gardening purposes within the farm compound.

### Value chain and stakeholders' involvement

Major stakeholders:

- Planning, technical design, infrastructure development and construction, monitoring - SNV
- Financing, operation and maintenance - Dairy farm
- R&D - SNV, National Biogas Programme
- Customer segments - Dairy farm (self-consumption)

## Financial outlook

Table 27. Financials of S&S farm biogas plant

Item	Amount
Investment cost (in thousand USD)	10.0
Annual operation and maintenance cost (in thousand USD)	1.5
Total annual revenue (in thousand USD)	2.5
Payback period (in years)	5

Source: Authors' creation

## SWOT Analysis

Table 28. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"><li>• Relatively simple technology</li><li>• Cow manure from own farm</li><li>• Waste disposal cost savings</li></ul>	<ul style="list-style-type: none"><li>• Lack of complete knowledge on management and operation of biogas system.</li><li>• Lack of adequate training on the technical aspects of the system.</li><li>• Lack of commercialization concepts/motivation</li></ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"><li>• High demand for clean energy</li><li>• Demand for organic soil nutrient due to high costs of imported synthetic fertilizers.</li><li>• In line with the government's plan for clean energy and green development</li><li>• Increasing demand for organic products among consumers</li></ul>	<ul style="list-style-type: none"><li>• Limited awareness on biogas among communities</li><li>• Limited awareness on the possibility of replacing chemical fertilizers with organic soil nutrients among farmers</li></ul>

Source: Authors' creation

## Scalability and replicability potential

This business case uses a relatively simple technology that has a high scalability and replicability potential particularly for commercial livestock farm owners. The investment costs are relatively low, and the O&M costs are minimal. The business case can be scaled up and scaled out, not only for self-energy demand coverage, but also for commercialization of both the biogas and organic soil nutrients. According to the Ethiopian cases, this 60m<sup>3</sup> bio-digester is a medium scale plant, developed for beneficial uses within the farm utility, other than just cooking. The system can be easily adapted by farmers who own dairy cattle with steady supply of cow manure.

## Socio-economic, health and environmental benefits

- The business case plays a crucial role in creating a clean environment within the farm's compound as well as in the surroundings. Moreover, it has benefits in reducing greenhouse gas emission, reducing ecological footprints thereby reducing pollution of land and water bodies.
- It contributes to improved human health. Moreover, food safety could also be achieved through expansion of organic farming practices.
- It reduces the use of expensive synthetic fertilizers and hence increases yield for farmers.
- It improves the economic returns of the dairy farm through the income generated from main and secondary products.
- It offers employment opportunities for local community.

## References

Data for the case study was obtained from the business entity through personal discussions.

# Melkam Endale Dairy Farm PLC

## Business case



<b>Case name</b>	Melkam Endale Dairy Farm PLC
<b>Location:</b>	Sululta, Sheger Ketema, Oromia region, Ethiopia
<b>Waste input type:</b>	Livestock manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2020
<b>Scale of business/case:</b>	6000 kg per day of cow dung, 32 m <sup>3</sup> of biogas per day, 2 m <sup>3</sup> organic nutrient per day
<b>Major partners:</b>	SNV, Biogas Dissemination Scale-Up Programme (NBPE+)

Map credits: Bing Map

## Executive summary

Melkam Endale Dairy Farm is located in Oromia region, Sheger Ketema, Sululta town. This business model is a pioneer model in Ethiopia generating electricity from biogas using biogas generator. It was developed in 2020 under the Biogas Dissemination Scale-Up Programme (NBPE+) managed by SNV in collaboration with the government of Ethiopia. It is an 80 m<sup>3</sup> bio-digester system using cow manure from its own dairy farm. A 16-Kilowatt (KW) biogas generator and a 30 m<sup>3</sup> biogas storage balloon were installed at the biodigester. The biodigester produces about 32 m<sup>3</sup> of biogas and about 2 m<sup>3</sup> of bio-slurry. Part of the biogas is used in the dairy farm for other utilities. This generator converts the biogas produced from the biodigester into electricity (8-Kilowatt per day) for use in both the cold chain and the incubation room of the farm. The farm now has a more reliable source of energy from the biogas generator, which has not only reduced its electricity costs from the grid, but also avoided loss of dairy products due to power outage. The business has lower O&M costs and is a reliable design for supply of off-grid clean electricity for a business.

## Value chain and stakeholders' involvement

Major stakeholders:

- Planning, technical design, infrastructure development and construction, monitoring, R&D - SNV (NBPE+)
- Financing, operation and maintenance - Dairy farm
- Customer segments - Dairy farm and farmers

## Financial outlook

Table 29. Financials of Melkam Endale dairy farm biogas plant

Item	Amount
Investment cost (in million USD)	15.0
Annual operation and maintenance cost (in million USD)	2.2
Total annual revenue (in million USD)	6.7
Payback period (in years)	5

Source: Authors' creation

## SWOT Analysis

Table 30. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>Affordable business case for livestock farms</li> <li>Relatively simple technology</li> <li>Cow manure is readily supplied at the site.</li> </ul>	<ul style="list-style-type: none"> <li>Lack of commercialization of the soil nutrients</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>Increasing demand for clean and affordable energy</li> <li>Demand for organic soil nutrient due to high costs of imported synthetic fertilizers.</li> <li>In line with the government's plan for clean energy and green development, hence strong support from the government</li> <li>Increasing demand for organic agricultural products among consumers</li> </ul>	<ul style="list-style-type: none"> <li>Limited awareness on biogas among communities</li> <li>Limited awareness on the possibility of replacing chemical fertilizers with organic soil nutrients among farmers</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

This is a large-scale bio-gas digester system which is a pioneer model for electricity generation from biogas. The model is suitable for commercial livestock farms with large animal manure output. It is a standard design for biogas production and electricity using biogas generators. The investment cost is affordably low, and the biogas generator can serve for at least 10 years, provided that operational guidelines are adhered to, and regular servicing is provided. The business case has a feasible potential for scaling up and out. It can also be easily replicated to any geographical location. As this is a model for electricity generation from biogas, it is highly suitable for businesses facing challenges due to power outages.

## Socio-economic, health and environmental benefits

- The business contributes to GHG emission reduction, food safety, energy safety, prevention of land and water pollution, hence improves human health.
- It has created job opportunities along its value processes. Moreover, the production of electricity has enabled quality products and productivity of the dairy business, which will enhance the profitability of the business. On the other hand, the soil nutrients can be helpful in replacing expensive synthetic fertilizers by farmers and hence increased economic returns.

## References

SNV. 2021. *Pioneering green electricity from bio-digesters in Ethiopia*. Available at <https://www.snv.org/update/pioneering-green-electricity-bio-digesters-ethiopia> (accessed on August 13, 2024).

Data for the case study were obtained from the business entity through personal discussions.

# Uilenkraal dairy farm

## Business case



<b>Case name</b>	Uilenkraal Dairy Farm
<b>Location:</b>	Western Cape, South Africa
<b>Waste input type:</b>	Cattle manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2015
<b>Scale of business/case:</b>	23 tons of manure per day (200 m <sup>3</sup> of slurry per day), 400 kWh of electricity per day
<b>Major partners:</b>	Cape Advanced Engineering (CAE)

Map credits: Bing Map

## Executive summary

Uilenkraal is a dairy farm located in Western Cape, South Africa, and has a dairy herd of 2,350 cows. The biogas plant at the farm was developed by a local engineering company, Cape Advanced Engineering (CAE). The volume of the bio-digester is 7,000 m<sup>3</sup> and a heating system keeps the interior temperature at 37°C. A total of 200 m<sup>3</sup> of slurry is pumped a day into the bio-digester from the central dung-collector. The resulting biogas is used for generating 400 kWh electricity per day which is consumed internally. The production of electricity from biogas has cut down the farm's monthly electricity bill cost USD 6800 to USD 750 (90% reduction). The biogas system covers, on average, 75% of farm's electricity requirement, while importing, around 25% of its electricity from Eskom (South African Electricity Company). In addition to biogas, bio-fertilizer is produced from the bio-slurry which is used for crop cultivation and as bedding material.

## Value chain and stakeholders' involvement

The main stakeholders of the business are the Cape Advanced Engineering (CAE) and Southern African Biogas Industry Association, who brings together independent biogas producers. CAE plays an important role in planning, technical design, infrastructure development, construction, monitoring and R&D. The roles of the dairy farm include financing, operation and maintenance, monitoring and evaluation.

## Financial outlook

Table 31. Financials of Uilenkraal dairy farm biogas plant

Item	Amount
Investment cost (in thousand USD)	120.0
Annual operation and maintenance cost (in thousand USD)	4.2
Total annual revenue (in thousand USD)	625.0
Payback period (in years)	10

Source: Authors' creation

## SWOT Analysis

Table 32. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Lower O&amp;M costs</li> <li>• Readily availability of cow manure</li> <li>• Use of local technology</li> <li>• Strong technological backup</li> </ul>	<ul style="list-style-type: none"> <li>• Larger initial cost of installation</li> <li>• Inefficient use of the biogas produced due barriers in connecting the national power grid</li> <li>• Large land requirement</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Cost effective electricity generation and replacement of grid electricity</li> <li>• Possibility for increasing production of electricity and hence revenue</li> <li>• Demand for organic fertilizers</li> </ul>	<ul style="list-style-type: none"> <li>• Insufficient revenue due to lack of sales to the national power grid</li> <li>• Relatively longer payback period</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

South Africa has about 300 biogas plants from household levels to large factories, and these facilities largely use the energy for their own needs. South Africa has a potential to replace around 2,500 MW of electricity by biogas. The biogas technology used in the Uilenkraal dairy farm is a cost-effective system and has a large potential to be scaled out and replicated in facilities with steady supply of organic waste. The maintenance costs of the plant are minimal and has a potential to be commercialized.

## Socio-economic, health and environmental benefits

Cow dung causes a serious threat to the environment if it is not managed properly. The improper disposal of cow dung pollutes the environment and can be a vector of disease. Therefore, proper management of cow dung is essential for maximizing its benefits while minimizing environmental impact. The benefits include:

- Full time and part time employment creation,
- Reduced grid electricity costs for the dairy farm
- Potential to supply electricity at lower prices to users.
- Promotes organic farming practices with the use of organic fertilizer
- Pollution and GHG emissions reduction

- Improves human health, food and energy safety

## References

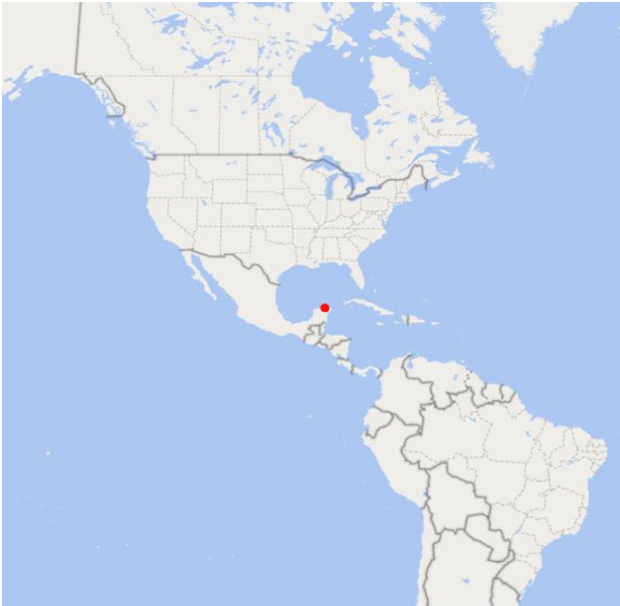
Claassen, J. 2015. Affordable SA bio-digester powers local dairy farm. *Farmer's weekly*, June 26, 2015. Available at: <https://www.farmersweekly.co.za/agri%20technology/farming-for-tomorrow/affordable-sa-bio-digester-powers-local-dairy-farm/> (accessed on April 17, 2024).

NIRAS-LTS. 2021. *Bioenergy for sustainable local energy services and energy access in Africa: Summary report*. Denmark: NIRAS A/S. 23p.

Wang, H; Aguirre-Villegas, H.A.; Larson, R.A.; Alkan-Ozkaynak, A. 2019. Physical properties of dairy manure pre- and post-anaerobic digestion. *Applied Sciences* 9 (13): 2703. <https://doi.org/10.3390/app9132703>

# LA MONTAÑA dairy farm

## Business case



<b>Case name</b>	LA MONTAÑA dairy farm
<b>Location:</b>	Tizimín, Yucatán Península region, South Mexico
<b>Waste input type:</b>	Cow manure
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Scale of business/case:</b>	<i>Amount of waste used:</i> 10 tons/day <i>Quantity of product recovered:</i> 650 m <sup>3</sup> /day of biogas, 7 tons/day of liquid biofertilizer and 2 tons/day of solid biofertilizer
<b>Major partners:</b>	Secretary of Agriculture, Livestock, Rural Development, Fishing and Food (SAGARPA)

Map credits: Bing Map

## Executive summary

LA MONTAÑA, a dairy farm with 82 cows, is located in Tizimín, Yucatán Península region in the south of Mexico, which is the lowest milk production area in the country. The farm was facing enormous challenges with floods and damaged feeding crops, interrupted milking process and regular electricity supply shortages. Therefore, the dairy farm, with the help of the Secretariat of Agriculture, Livestock, Rural Development, Fishing, and Food (SAGARPA), initiated a biogas plant to address the annually accumulating tons of cow manure through this waste-to-energy project. In the process, the system provides two value propositions: a) biogas/CBG to industry and b) bio-slurry, both solid and liquid, as a residue from biogas plants which are used as organic compost. Biogas replaces fossil fuels, while the bio-slurry turned into bio-fertilisers is used by farmers and communities. Both these value propositions provide an alternative revenue source to the farm and help manage their waste.

## Value chain and stakeholders' involvement

The Secretariat of Agriculture, Livestock, Rural Development, Fishing, and Food (SAGARPA) is the governmental organization that supports policies directed to overall sector development, growing production, financial protection for farmers, and promoting collaboration between government and producers. SAGARPA serves as the major stakeholder of the business case providing technical transfer and subsidy for the installation of the biogas system at LA MONTAÑA dairy farm.

## Financial outlook

Table 33. Financials of LA MONTAÑA dairy farm biogas plant

Item	Amount
Investment cost (in thousand USD)	298.0
Annual operation and maintenance cost (in thousand USD)	7.0
Total annual revenue (in thousand USD)	52.0
Payback period (in years)	5.7

Source: Authors' creation

## SWOT Analysis

Table 34. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Relatively simple technology</li> <li>• Cow manure from own farm</li> <li>• Waste disposal cost savings</li> </ul>	<ul style="list-style-type: none"> <li>• High initial investment</li> <li>• Large land requirements</li> <li>• Lack of commercialization concepts and motivation</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Increasing demand for clean and affordable energy</li> <li>• Demand for organic soil nutrient due to high costs of imported synthetic fertilizers.</li> </ul>	<ul style="list-style-type: none"> <li>• Potential human health impacts due to biogas leakage</li> <li>• Capacity gaps for scaling</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

Biogas energy is an attractive and beneficial option for decreasing the dependence on fossil fuels and increasing energy safety in rural areas. The readily availability of feedstock for biogas production due to the significance of livestock production in the country increases the replicability potential of the business case. Furthermore, appropriate ambient air temperature leads to optimum conditions where biogas can be produced throughout the year with a relatively low addition of heating energy to the process.

## Socio-economic, health and environmental benefits

Besides the production of clean energy, organic fertilizer and employment creation, another critical aspect is greenhouse gas emissions reduction. Being a bioenergy project, Greenhouse gases are not emitted, leading to a negative carbon footprint. It also prevents land and water pollution, leading to improved human health.

## References

Koldisevs, J. 2014. *Biogas production in rural areas of Mexico*. Mexico: KTH Industrial Engineering and Management. 53p.

# Agropecuaria Aliar S.A.

## Business case



<b>Case name</b>	Agropecuaria Aliar S.A.
<b>Location:</b>	Puerto Gaitán, Meta, Colombia
<b>Waste input type:</b>	Pig waste
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	Anaerobic digestion since 2017 Fertilizer production since 2017 Energy production from biogas since 2021
<b>Scale of business/case:</b>	<i>Product recovered:</i> <i>Biogas:</i> 2022: 2,614,048 m <sup>3</sup> /year <i>Liquid organic fertilizer (Biol):</i> 2022: 1,032,734 m <sup>3</sup> /year <i>Solid organic fertilizer:</i> 2021: 1,260.26 tons/year 2022: 6,063.60 tons/year
<b>Major partners:</b>	Rural and indigenous communities

Map credits: Bing Map

## Executive summary

At Agropecuaria Aliar S.A, the productive chain begins with agriculture, which provides the main raw material for animal feed production, followed by pig production cycle, animal processing and the production of meat products for marketing. Liquid and solid organic waste, pig waste and meat by-products (blood, bones and hair, handled in an animal meal processing plant) are obtained from these processes. Pig waste is treated through anaerobic digestion, where it is transformed into fertilizer and biogas. In one of the main pig centers at Machijure, Aliar has installed a biogas to energy generation plant, with the capacity to supply up to 80% of the center's energy demand. In 2022, 56.30% of the total biogas produced (2,614,048 m<sup>3</sup>) was used as fuel for electricity generation and the remaining 43.70% was piped to a flare for the transformation of methane into carbon dioxide, where it is finally released into the atmosphere. Furthermore, Aliar transforms 88.5% of the wastewater into liquid and solid fertilizers, which are used as inputs for the irrigation of pastures and forages for cattle, where they feed around of 5,000 animals, while preventing the use of synthetic fertilizers.

## Value chain and stakeholders' involvement

The major stakeholders include rural and indigenous communities of the region to whom Aliar S.A. offers part of the solid fertilizer as a donation for the development of crop cultivation.

## Financial outlook

Table 35. Financials of Agropecuaria Aliar S.A.

Item	Amount
Investment cost (in thousand USD)	66.7
Annual operation and maintenance cost (in thousand USD)	146.9
Total annual revenue (in thousand USD)	1523.9
Payback period (in years)	N/A

Source: Authors' creation

## SWOT Analysis

Table 36. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"><li>• Treatment of organic waste internally, without payment to third parties.</li><li>• Use of renewable energy (biogas).</li><li>• Use of organic fertilizers</li><li>• Decrease in the carbon footprint.</li><li>• Improvement in environmental indicators.</li></ul>	<ul style="list-style-type: none"><li>• Need to import technology for installation and maintenance of biogas plants and generation of electrical energy from biogas.</li></ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"><li>• Reduction in the impact of bad odors from improper waste disposal.</li><li>• Increase in the use of biogas for electricity generation from 56% to 100%.</li></ul>	<ul style="list-style-type: none"><li>• Limitations by regulatory institutions for the use of digestate as fertilizer.</li></ul>

Source: Authors' creation

## Scalability and replicability potential

In Colombia there is a high potential for biogas production from livestock waste. However, high investment cost and technology imports limit the development of large-scale biogas plants in the country.

## Socio-economic, health and environmental benefits

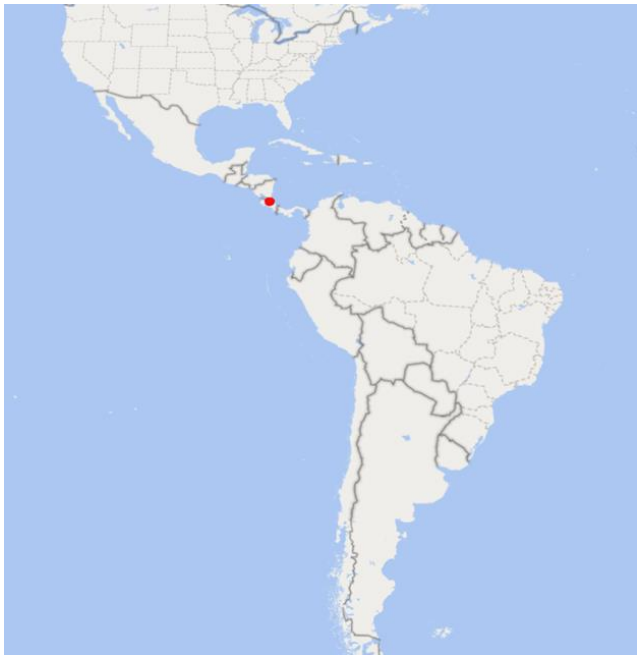
- Generates a low carbon economy.
- Reduces the need for forest exploitation and consumption of fossil fuels.
- Reduction of energy costs due to the use of biogas as a source of electrical and thermal energy.
- Savings on the purchase of fertilizers.
- Energy independence and flexibility in remote rural areas.

## References

The information contained in this form was provided by Agropecuaria Aliar S.A. staff and extracted from the company's public document 'Informe de sostenibilidad 2022'. The information was adjusted, summarized, or completed by Rosa Cecilia Ruiz-Bastidas and reviewed by Guillermo Peña.

# Centro Internacional de Inversiones S.A (CIISA)

## Business case



<b>Case name</b>	Centro Internacional de Inversiones S.A (CIISA)
<b>Location:</b>	La Ribera de Belén, Heredia, Costa Rica
<b>Waste input type:</b>	Slaughterhouse waste and meat by products
<b>Value offer:</b>	Energy, soil nutrients and organic matter
<b>Organization type:</b>	Private
<b>Status of organization:</b>	Since 2016
<b>Scale of business/case:</b>	<i>Amount of waste used:</i> 59 tons/day <i>Product recovered:</i> Biogas: 2973 m <sup>3</sup> /day Dehydrated biosolid: 9.5 tons/day
<b>Major partners:</b>	Alianza en Energía y Ambiente con Centroamérica (AEA) AD-SOLUTION UG- Germany INDEREN (Ingeniería y desarrollos renovables, S.L.), Spain. SISMOCOM. J y C Las Laderas de Occidente SRL (Authorized manager for the production of certified fertilizer from biosolids). LIMPSA S.A (Waste transportation, authorized manager).

Map credits: Bing Map

## Executive summary

The main activity of the company Centro Internacional de Inversiones S.A (CIISA), in "El Arreo" slaughterhouse, is the slaughter of pigs and cattle, as well as the sale of meat, value-added food products and other products. The activity is associated with the generation of 59 tons/day of waste such as blood, animal fatty tissues, fats trapped in separation traps, pig manure, manure from livestock, rumen content, primary sludge generated in the plant wastewater treatment and food waste. The waste is treated through anaerobic digestion to produce biogas (2973 m<sup>3</sup>/day) for internal consumption and resulting dehydrated biosolid (9.5 tons/day) delivered to an external party, J y C Las Laderas de Occidente SRL, to produce fertilizer.

## Value chain and stakeholders' involvement

Major stakeholders:

- Financial support: Alianza en Energía y Ambiente con Centroamérica (AEA)
- Feasibility study and Biodigester design: Anaerobic Digestions Solutions - AD-SOLUTION UG-Germany
- Construction of the biodigester: INDEREN (Ingeniería y desarrollos renovables, S.L.), Spain
- Biosolid receptor: J y C Las Laderas de Occidente SRL (Authorized manager for the production of certified fertilizer from biosolids).
- Waste transportation: LIMPSA S.A (Authorized manager).

## Financial outlook

Table 37. Financials of CIISA biogas plant

Item	Amount
Investment cost (in thousand USD)	2658.0
Annual operation and maintenance cost (in thousand USD)	294.6
Total annual revenue (in thousand USD)	737.6
Payback period (in years)	5.6

Source: Authors' creation

## SWOT Analysis

Table 38. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Treatment of organic waste internally, without payment to third parties.</li> <li>• Use of renewable energy (biogas) for the boiler.</li> <li>• Use of organic fertilizers</li> <li>• Decrease in the carbon footprint.</li> <li>• Improvement in environmental indicators.</li> </ul>	<ul style="list-style-type: none"> <li>• Reengineering of processes due to lack of experience in handling the type of substrate.</li> <li>• Lack of training at the national level for biogas plants.</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Reduction in the impact of bad odors from improper waste disposal.</li> </ul>	<ul style="list-style-type: none"> <li>• Challenges in production due to extreme weather events (climate change). Intensification of winds and lightning.</li> <li>• Decrease in economic returns due to drops in the price of fossil fuels (bunker).</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

There is a high potential for biogas production from livestock waste. However, high investment cost and technology imports limit the development of large-scale biogas plants in the country.

## Socio-economic, health and environmental benefits

The implementation and management of the biodigester requires the hiring of additional personnel, which contributes to the creation of local jobs. 4 direct jobs and 5 indirect jobs were created. Furthermore, operating sustainable technologies may necessitate specialized skills, providing workers with opportunities for training and skill development. The company contributes to the reduction of greenhouse gas emissions by treating slaughterhouse waste and using biogas to replace fossil fuels, avoiding CO<sub>2</sub> emissions of 1949 tons/year, promoting environmental sustainability and compliance with environmental regulations. The biodigester also helps to reduce bad odors and disease transmission due to improper disposal of waste, while also improving community relations and potentially avoiding legal issues related to complaints about unpleasant odors.

## References

All information contained in this form was provided by CIISA - Centro Internacional de Inversiones S.A. Part of the information was adjusted, summarized or completed by Rosa Cecilia Ruiz-Bastidas and reviewed by Guillermo Peña according to the information provided.

# Recovery of soil nutrients and organic matter for agriculture from animal manure and abattoir waste

To obtain better agricultural yields and mitigate environmental damage, developing nations have been focusing on promoting organic farming by replacing the use of expensive chemical fertilizers with biofertilizers which not only increase yield but also reduce the cost of production, especially for small and marginal farmers. This paves the way for sustainable management of livestock waste, primarily animal manure, for recovery of nutrients and production of organic fertilizers.

Animal manure can be converted into biofertilizer through several processes such as stripping, scrubbing, anaerobic digestion, liquid-solid separation, bio drying and composting. The fertilizer produced from manure is rich in essential nutrients such as N, P, K, Ca, Mg, which improves soil nutrient content, thereby favors plant uptake, and elevates crop productivity (Loss et al. 2019). The chemical and nutrient composition of animal manure based biofertilizers can vary depending on several factors such as environmental factors, animal species, feeding patterns and storage time of manure. In addition to animal manure, dried slaughterhouse waste or wastewater and slurry generated from biogas units are also used as raw materials for fertilizer production.

These livestock based-organic fertilizers, being an affordable alternative for synthetic fertilizers, not only provides organic carbon and valuable nutrients to the soil, but also supply desirable microbes which play a crucial role in improving soil and crop health. However, the use of these fertilizers is associated with major drawbacks such as ammonia vaporization, nutrient leaching and pathogen contamination which could be prevented by further treatment and removal of undesirable compounds and minerals. Moreover, other concerns such as operational problems, regulatory constraints and fluctuations in market prices also exist with the production of biofertilizers (Dadrastia et al. 2021). Despite the obstacles, organic fertilizer production from livestock waste is still considered as a profitable business model in most developing nations.

This section covers cases that involve the production of granulated organic fertilizers and liquid fertilizers from fully decomposed animal manure, slaughterhouse waste or biogas slurry. It includes business cases incorporating a) investments through public-private partnerships, and b) investments from the private sector (as shown in figure 3).

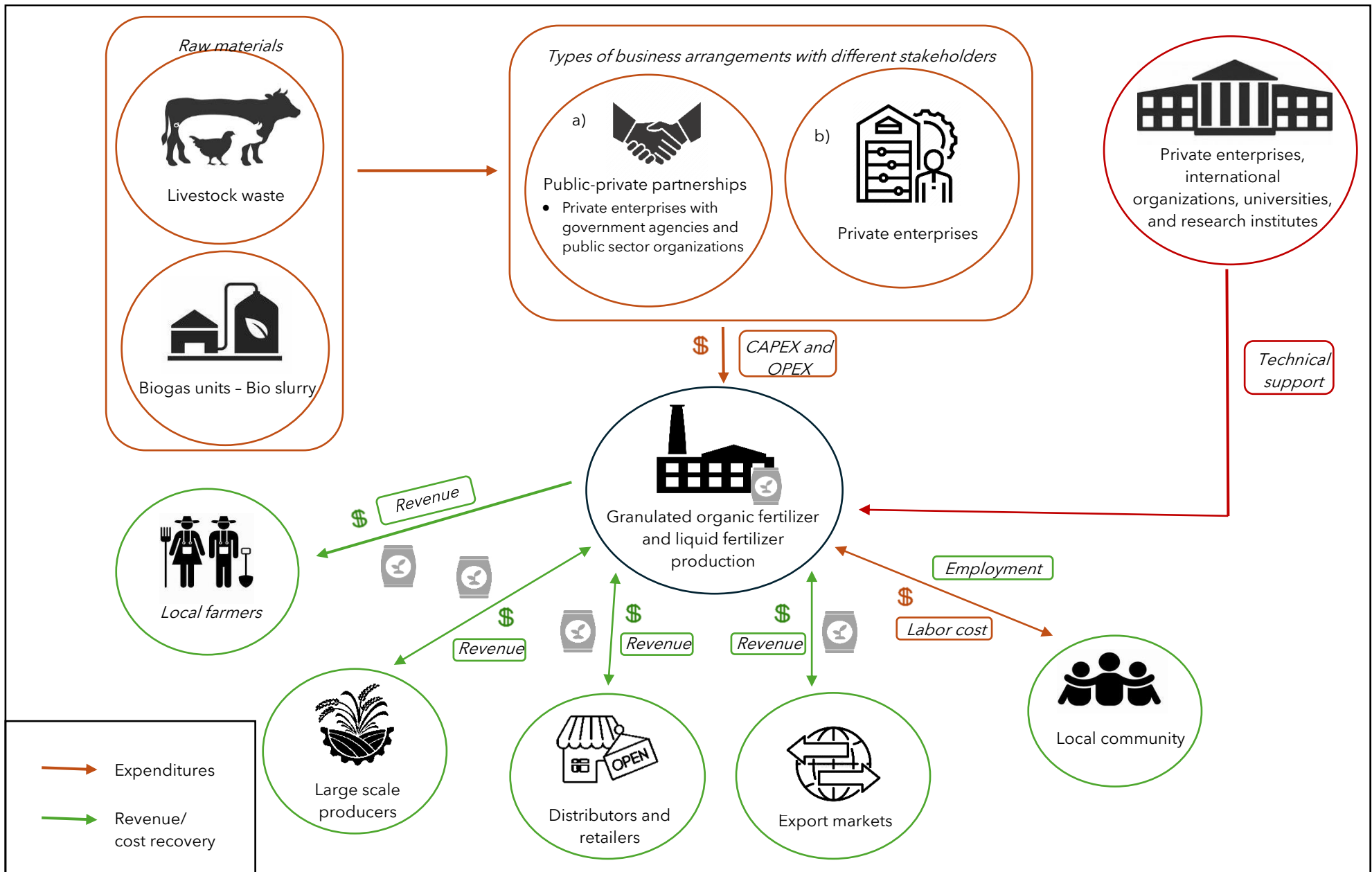


Figure 3. Value chain of soil nutrients and organic matter recovery business cases  
 Source: Authors' creation

## a) Public-private partnerships

### Grupo Terra Zan S.A.S. E.S.P.

#### Business case



<b>Case name</b>	Grupo Terra Zan S.A.S. E.S.P.
<b>Location:</b>	Bogotá, D.C., Colombia
<b>Waste input type:</b>	Poultry waste, pig waste, manure from livestock, crop waste, abattoir waste, plant waste, industrial sludge, food waste and wastewater
<b>Value offer:</b>	Soil nutrients and organic matter for agriculture
<b>Organization type:</b>	Public-private partnerships
<b>Status of organization:</b>	4 years of operation (since 2019)
<b>Scale of business/case:</b>	<i>Amount of waste used for resource recovery: 50 m<sup>3</sup>/day</i> <i>Quantity of product recovered: 46 m<sup>3</sup>/day</i>
<b>Major partners:</b>	Colombian financial entities such as Bancolombia, Leasing Bancolombia, Renting Bancolombia.  <i>Key partners. (the intermediaries):</i> Investors, associations of producers and merchants, Government agencies, logistics managers, organic waste generators and collectors, municipal, departmental and national governments, universities, financial entities and multilateral organizations

Map credits: Bing Map

#### Executive summary

Terra Zan Group manufactures environmentally friendly fertilizers. The fertilizers provide nutrients, organic matter, and microorganisms to the soil, which aids in the protection of ecosystems and the mitigation of climate change by fixing carbon in the soil and avoiding greenhouse gas emissions. The products are made up of organic materials derived from various sources (agriculture, livestock, wastewater, food industry, and agribusiness, among others), making them nutrient-rich and valuable to soil and plants. Terra Zan Grupo collects organic waste from both large- and small-scale generators. The waste is transported to composting facilities. The initial storage is performed within the composting plant, followed by conditioning stages for the transformation of the waste into the corresponding final products. Following that, the commercial link and technical support to farmers are established so that the products can be used as soil regenerators. The fertilizer is highly suitable for farmers who aim to

improve their crops while promoting organic farming, and gain access to new and better markets. The reduction in production costs and increase in production of 17% to 40% results in an estimated increase in profits of 64% to 88% for the farmers.

### Value chain and stakeholders' involvement

- Colombian financial entities such as Bancolombia, Leasing Bancolombia, Renting Bancolombia
- Private sector collaborators such as Corporación 9R sostenible
- Universities such as Universidad de La Salle, Universidad Central, Fundación Universitaria Cafam (UNICAFAM)
- Public sector collaborators such as AGROSAVIA, Tecnoparques SENA.
- Different working groups such as Mesa Nacional Para el aprovechamiento de Biomasa Residual, Consejo Departamental de Ciencia, Tecnología e Innovación (CODECTI) of Cundinamarca, and the associations of recyclers.

### Financial outlook

Table 39. Financials of Grupo Terra Zan

Item	Amount
Investment cost (in thousand USD)	89.4
Annual operation and maintenance cost (in thousand USD)	633.4
Total annual revenue (in thousand USD)	2044.9
Payback period (in years)	N/A

Source: Authors' creation

### SWOT Analysis

Table 40. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Terra Zan Group has a solid positioning as a company whose business model is based on the circular economy</li> <li>• It has a differential advantage related to being the only national company to produce liquid fertilizers based on wastewater.</li> <li>• The product is perceived as the best organic fertilizer available the market.</li> <li>• The company's income is growing steadily, at an annual rate of 30%.</li> </ul>	<ul style="list-style-type: none"> <li>• There are difficulties in managing the company's funds, which leads to solvency and liquidity problems.</li> <li>• The company does not have a reliable cost structure that allows it to effectively determine its prices.</li> <li>• Collection policies make it difficult to receive financial resources.</li> <li>• The location and access routes to the production plant are complex and discouraging for customers.</li> <li>• The sales team in the organic fertilizers division is insufficient.</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Strong regulations on waste management.</li> <li>• 51% of the solid waste generated in Bogotá is organic.</li> <li>• Conflict between Ukraine and Russia that increases prices of conventional fertilizers.</li> <li>• The economic expectations of the sector are positive.</li> </ul>	<ul style="list-style-type: none"> <li>• Threatening culture of inorganic agriculture.</li> <li>• Chemical, non-organic fertilizers dominate the fertilizer market.</li> <li>• Competitions due to other entrants in the business.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

The national government of Colombia issued Law 274 of the National Development Plan 2023-2026, which presents the Basura Cero program that promotes the reuse of waste in the value chain of industrial and agricultural production. The production process of Grupo Terra Zan aligns with Basura Cero program which increases the demand and replicability potential of the business case. Furthermore, the company has planned the implementation of 20 organic fertilizer manufacturing units over the next 5 years.

## Socio-economic, health and environmental benefits

Grupo Terra Zan's innovative business model based on the circular economy has far-reaching socioeconomic, health, and environmental consequences. The company addresses issues such as landfill collapse, groundwater contamination, and greenhouse gas emissions by addressing the pressing issue of inadequate organic waste disposal. Simultaneously, the degradation of productive soils due to organic matter loss is countered, reducing pollution and adverse health effects caused by chemical fertilizers.

Grupo Terra Zan's initiatives have a significant socioeconomic impact. It can reduce costs through efficient waste management, resource utilization and energy production. Implementing sustainable practices improves the image of the industry, attracting consumers who value responsible and sustainable consumption.

Furthermore, proper waste management results in indirect social benefits such as improved public health, better working conditions for recyclers, the creation of green jobs, and a reduction in the negative impacts of improper waste disposal on communities.

## References

All information contained in this form was provided by Grupo Terra Zan. Part of the information was adjusted, summarized, or completed by Rosa Cecilia Ruiz-Bastidas and reviewed by Guillermo Peña according to the information provided.

## b) Private enterprises

### Agri Flora Organic Solutions

#### Business case



<b>Case name</b>	Agri Flora Organic Solutions
<b>Location:</b>	Nyahururu, Kenya
<b>Waste input type:</b>	Animal manure and fruit waste
<b>Value offer:</b>	Soil nutrients and organic matter for agriculture
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2016
<b>Scale of business/case:</b>	Medium scale, reaching 3 counties in Kenya <i>Amount of waste used: 15 tons/day</i>
<b>Major partners:</b>	Kenya Climate Innovation Centre (KCIC), Kenya Climate Ventures, Retailers

Map credits: Bing Map

#### Executive summary

Agri-Flora Organic Solutions is a company established in 2016. The company manufactures organic fertilizer by the trademark, Asili, which is made of carbon-based compounds that increase productivity and growth of healthy plants. The company provides clients with quality organic fertilizers in a safe, reliable, efficient, and an environmentally sound manner. The granulated fertilizer is prepared from organic materials such as fruit waste and decomposition of animal waste. The Asili organic fertilizer is a slow release fortified organic fertilizer with balanced nutrients such as Calcium, Zinc, Manganese, Magnesium, Iron, Molybdenum, Selenium that help improve plants quality, increased productivity and healthy soil. Moreover, the company is making efforts to reduce the impacts of synthetic fertilizers in soil health including soil acidification. Farmers' demands for organic fertilizers is now increasing that makes the company a game-changer in promoting green development.

#### Value chain and stakeholders' involvement

Agri-Flora Organic sources its organic materials from suppliers, including animal raiser households (such as pig, cattle, and poultry raisers) and commercial cattle farmers. The organic fertilizer outputs are Asili Granulated Fertilizer and liquid fertilizer. The organic fertilizer produced is mainly distributed to small scale and large-scale farmers in Nyandarua, Baringo, and Samburu regions of Kenya. The primary focus of the company was potato farmers, and gradually the demand has increased among other farmers. The company reaches its customers via the following channels: (i) direct sales to farmers, (ii) collaborates with local agro-input retailers to make their fertilizers accessible to farmers, and (iii) utilizes online platforms to reach a wider audience. The company also engages in awareness creation activities

and training to promote the use of organic fertilizers. To address the increases in demand for organic fertilizers, the company has partnered with Kenya Climate Innovation Center (KCIC), which provides business advisory services, financial support, and guidance. The company is also supported by Kenya Climate Ventures (KCV), an independent subsidiary of KCIC, and the support is geared towards accelerating the transition to sustainable food and agricultural systems.

Major stakeholders:

- Technical design – Agri Flora Organic Solutions
- Financing, infrastructure development, construction, monitoring and evaluation – KCIC
- R&D and awareness – KCV
- Operation and maintenance – Local service providers
- Policy supports – Government
- Customer segments – Farmers

## Financial outlook

Table 41. Financials of Agri Flora Organic Solutions

Item	Amount
Investment cost (in thousand USD)	590.0
Annual operation and maintenance cost (in thousand USD)	10.0
Total annual revenue (in thousand USD)	250.0
Payback period (in years)	5

Source: Authors' creation

## SWOT Analysis

Table 42. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Granulated fertilizer, making it suitable for farmers.</li> <li>• Production of high quality slow-releasing organic fertilizer with balanced nutrients</li> <li>• Strong quality control system</li> <li>• Soil testing and production of special recipe fertilizers</li> <li>• Employment creation and good customer handling</li> </ul>	<ul style="list-style-type: none"> <li>• Technological dependence</li> <li>• Limited production capacity</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Increasing demand for organic fertilizers and potential increases in revenue</li> <li>• Improving soil health and sustainable productivity, which enables it to access further opportunities.</li> <li>• Potential opportunities for export if certified by international quality organizations.</li> <li>• Potential for scaling and replication</li> </ul>	<ul style="list-style-type: none"> <li>• Raw material sourcing challenges</li> <li>• Demand fluctuations for organic fertilizers.</li> <li>• Market competition from other producers could be a challenge.</li> <li>• Scaling production, while at the same time keeping quality, could be a challenge.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

The demand for organic fertilizers has been growing, given the benefits of organic fertilizers, which increase yield up to 50% on average. The company, with its present capacity reaches farmers in three regions, but there is a potential to further grow their production capacity. Due to increasing demand of organic fertilizers, Agri-Flora recently signed a financial agreement with the Kenya Climate Innovation Centre (KCIC). With KCIC's support, it plans to expand their manufacturing plant to meet the growing needs of farmers. This business is therefore potentially scalable to meet demands. There is also a high replicability potential for the business across Africa, where raw materials are readily available, and demands are high.

## Socio-economic, health and environmental benefits

Agri Flora Organic Solutions has numerous socio-economic and environmental benefits that support sustainable crop production, soil health and livelihoods, which include:

- Employment creation by providing direct and indirect full-time and part-time job opportunities. The jobs involve various roles, from raw material sourcing, production and quality control and marketing. As a result of increased crop yields, food security is enhanced, and livelihoods are improved. Organic fertilizers can also be more affordable due to their natural origin.
- Organic fertilizers enhance soil health due to slow-release nutrient availability. It also reduces the use of synthetic fertilizers, thereby avoiding the negative impacts on soil and water.
- The business contributes to waste reduction and environmental safety.

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## Organic Fertilizer Manufacturers Botswana (OFMB)

### Business case



<b>Case name</b>	Organic Fertilizer Manufacturers Botswana
<b>Location:</b>	Gaborone, Botswana
<b>Waste input type:</b>	Cattle manure
<b>Value offer:</b>	Soil nutrients and organic matter for agriculture
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2016
<b>Scale of business/case:</b>	20,000 tons of organic fertilizer per year
<b>Major partners:</b>	The United States Agency for International Development (USAID), Regenerative Agriculture Association of South Africa (Regen Ag SA), Slow Food South Africa, Mpumalanga Economic Growth Agency (MEGA)

Map credits: Bing Map

### Executive summary

Organic Fertilizer Manufacturers Botswana (OFMB) is pioneering Joint Venture Company in Botswana producing organic blended fertilizer from animal waste. OFMB has invested in and installed a state-of-the-art blending and bagging plant with a capacity of 60,000 tons per annum and installed a packing and sealing plant primarily for its organic products with a capacity of 20,000 tons per annum, as well as a fertilizer granulation plant with a capacity of 30,000 tons per annum. The organic fertilizers are manufactured from composted cattle manure, with Gypsum and Carbon and other products added depending on the fertilizer being produced. OFMB is currently supplying Botswana and surrounding countries such as Zambia, DRC and Zimbabwe with organic and organically blended fertilizer (20,000 tons annually) in a granulated form. The Ecocert certified organic fertilizer can be exported to the European Union (EU) and America through the African Growth and Opportunity Act (AGOA). OFMB is continuously investing in the new groundbreaking technologies, products, research and development to ensure that it is keeping pace with changes in the agricultural sector and climate and to ultimately provide most suitable service and product to the farmers in the country and the region.

### Value chain and stakeholders' involvement

The major stakeholders include the United States Agency for International Development (USAID), Regenerative Agriculture Association of South Africa (Regen Ag SA), Slow Food South Africa, Mpumalanga Economic Growth Agency (MEGA), research institutes, the Ministry of Agriculture, Botswana, and the customer segments including farmers, processors, distributors, and retailers within Botswana and other countries.

The following are the roles of the different stakeholders:

- Surveying, strategies and planning - Government and international shareholders
- Technical design - International shareholders
- Financing and administrative approvals - Private investment/ international shareholders
- Infrastructure development and construction - Private investment
- Monitoring, operation and maintenance - The enterprise (OFMB)
- R&D - Research institutes

## Financial outlook

Table 43. Financials of Organic Fertilizer Manufacturers Botswana

Item	Amount
Investment cost (in thousand USD)	5000.0
Annual operation and maintenance cost (in thousand USD)	100.0
Total annual revenue (in thousand USD)	2600.0
Payback period (in years)	6

Source: Authors' creation

## SWOT Analysis

Table 44. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Ecocert certification that ensures that products meet stringent organic standards, emphasizing environmental sustainability and safety</li> <li>• Large production capacity</li> <li>• Good quality control</li> <li>• Production of fertilizers suitable for particular soil type</li> <li>• Direct and indirect employment creation</li> <li>• Soil testing and agronomic services</li> </ul>	<ul style="list-style-type: none"> <li>• High initial cost of installation</li> <li>• External technology requirements, need for import</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Increasing demand for organic fertilizers, hence increase in revenue</li> <li>• Improved soil health</li> <li>• Increased productivity and crop yields</li> <li>• Opportunities for export and foreign currency gains</li> <li>• Potential for scaling and replication</li> </ul>	<ul style="list-style-type: none"> <li>• Raw material sourcing challenges</li> <li>• Demand fluctuations for organic fertilizers</li> <li>• Customer attitudes and perceptions on organic fertilizers</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

OFMB has a capacity to produce over 30,00 tons of organic fertilizers annually. However, only 15% of this is currently utilized in the country. It is a large-scale producer, having large potentials for export markets. It is a pioneer company whose success could be potentially replicated in other regions as well. Factors for replicability including Ecocert certification (highlighting commitment to environmentally friendly practices) are key. Still, best practices, knowledge, and experiences in collaboration can be learned for replication of similar business elsewhere.

## Socio-economic, health and environmental benefits

OFMB provides various socio-economic and environmental benefits locally and beyond. The company collaborates with local farmers, agricultural organizations, and research institutions to promote eco-friendly practices and enhance soil health. Some of these benefits are:

- Enhances soil health
- Improves nutrient availability and food safety
- Effective alternative for expensive synthetic fertilizers
- Reduces human health risks due to improper waste disposal
- Reduces land and water pollution, and GHG emissions
- Job creation (Full-time and part-time)

## References

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# Bio-Prom by BAIF

## Business case



<b>Case name</b>	Bio-Prom Organic Manure by BAIF
<b>Location:</b>	Sindhudurg, Nashik and Nandurbar of Maharashtra, Navsari of South Gujarat
<b>Waste input type:</b>	Biogas residue (cow dung)
<b>Value offer:</b>	Soil nutrients and organic matter for agriculture
<b>Organization type:</b>	Private
<b>Status of organization:</b>	2023
<b>Scale of business/case:</b>	<i>Amount of waste used: 277 MT of dry cake (Biogas residue) per year. Product recovered: 462 MT of Bio-PROM per year</i>
<b>Major partners</b>	BAIF Development Research Foundation, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, German Federal Ministry for Economic Cooperation and Development (BMZ), National Bank for Agriculture and Rural Development (NABARD)

Map credits: Bing Map

## Executive summary

GIZ India in collaboration with BAIF Development Research Foundation, is supporting an initiative to produce 'Bio-PROM', an organic fertilizer produced using residue from biogas plants which aligns with the government strategy on promoting organic farming. This project is based on the Integrated Sustainable Energy and Sustainable Agriculture (IRESA) model of BAIF Development Research Foundation through which it has supported several farmers to setup biogas plants within the region. The farmers/ farmer households having a pre-installed biogas plant serve as a supplier of dry cake (biogas residue) for production of Bio-PROM. The Bio-PROM produced is supplied back to the farmers for improving soil health and crop productivity, while the surplus biofertilizer is sold outside. Thereby, the project aims to integrate livestock systems with agricultural crop production and create new job opportunities for the local community. As for now, 6 Bio-PROM manufacturing units had been successfully inaugurated in districts, namely Sindhudurg, Nashik and Nandurbar of Maharashtra, Navsari of South Gujarat and 3 new Bio-PROM units will be commenced shortly. Moreover, field trials have been conducted to compare the results of Bio-PROM with chemical fertilizers on multiple crops at farmers level, as well as at Government universities.

## Value chain and stakeholders' involvement

The Soil Protection and Rehabilitation of Degraded Soil for Food Security in India (ProSoil) is an Indo-German development cooperation project implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) in partnership with the National Bank for Agriculture and Rural Development (NABARD) which is part of a global programme under BMZ's Special Initiative 'Transformation of Agricultural and Food Systems'. Under this project, GIZ India in collaborates with BAIF Development Research Foundation to install Bio-PROM units. BAIF Development Research Foundation is majorly responsible for initiation of the project through capacity building. The Farmer Producer Organization (FPO) play a major intervening role in purchasing dry cakes from biogas producing farmers for the production of Bio-PROM and selling it back to the farmers at a reasonable price.

## Financial outlook

Table 45. Financials of Bio-PROM by BAIF

Item	Amount
Investment cost (in thousand USD)	20.3
Annual operation and maintenance cost (in thousand USD)	23.7
Total annual revenue (in thousand USD)	78.6
Payback period (in years)	5.1

Source: Authors' creation

## SWOT Analysis

Table 46. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Low cost and environment friendly technology</li> <li>• Improves soil health and crop productivity.</li> <li>• Eco-friendly alternative for synthetic phosphate fertilizers</li> </ul>	<ul style="list-style-type: none"> <li>• Labor intensive</li> <li>• Needs continuous supply of raw material from household level biogas plants</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Growing demand for biofertilizers to promote organic farming.</li> <li>• High price of phosphate based chemical fertilizers.</li> <li>• More subsidies and funds from the government and financial agencies</li> </ul>	<ul style="list-style-type: none"> <li>• Dissatisfaction with the quality of other organic fertilizers</li> <li>• Lack of awareness on the use of slurry (from biogas plants) for the production of organic manure</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

A transition towards organic farming is being emphasised throughout the world, especially in India, which remains as a key factor for increasing the use of biofertilizers such as Bio-PROM in agricultural production. Indian PROM market was valued at USD 203.2 million in 2020 and it is projected to reach USD 419.6 million by 2030, since it is a cheaper alternative for phosphate fertilizers such as DAP, while improving crop yields. The yield of crops such as paddy has been reported to increase by 15-26% when replacing DAP and SSP with PROM. The investment of private enterprises towards PROM manufacturing have increased in recent years, namely Jaipur Bio Fertilisers, Gujarat Pavan Fertiliser Company, Bhoomi Phosphate Private Ltd. and Biogen Fertilisers India Private Ltd. Moreover, dry cake prepared from the residue of biogas plant is readily available for Bio-PROM manufacturing due to increase in animal manure production from livestock farms and promotion of biogas production at household level by the Ministry of New and Renewable Energy (MNRE), Government of India through its National Biogas and Manure Management Programme (NBMMP). NBMMP has promoted the installation of around 5 million household size biogas plants within 2017-2018. The notable increase in biogas production and growing demand for biofertilizers act as key drivers for promoting Bio-PROM initiatives.

## Socio-economic, health and environmental benefits

The use of organic fertilizer for agricultural production prevents the entry of harmful chemicals into the human body and the ecosystem. Use of Bio-PROM reduces air, water and soil pollution resulting from the use of chemical fertilizers. In rural areas, promotion of biogas production reduces health risks associated with the use of biomass-based fuels in women and children and ensures forest conservation. Bio-PROM initiatives create new job opportunities to the local community and promote the development of sustainable community-based organizations at village level. Use of organic manure reduces input cost of chemical fertilizers and creates additional revenue for small holder farmers through the sale of bio cakes.

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# Recovery of feed for aquaculture from animal manure and abattoir waste

Presently, aquaculture is one of the fastest growing food systems, especially in developing countries due to rising demand for fish consumption. The aquaculture sector is dominated by small scale fish farmers who face several challenges such as shortage of fish feed, lack of technology and investment capital which remain as obstacles in improving fish productivity. At the same time, integration of livestock farming, and aquaculture serves as one of the most effective strategies for sustainable development of aquaculture systems both economically and ecologically (Yadav et al. 2023 and FAO 2003).

High potential and most conventionally recognized type of integrated livestock-fish farming involves the direct use of livestock waste such as manure, urine and spill-feed in aquaculture ponds. The nutrients such as nitrogen (N) and phosphorous (P) present in the livestock waste function as fertilizers providing nutrients directly or by stimulating the growth of natural food sources such as zooplankton, phytoplankton and periphyton (Raman 2018). Besides manure being used as fertilizers, in some cases, sterilized slaughterhouse wastes are utilized to produce high quality fish feed which meets the nutritional requirements for optimal growth and health of fish (Outlook Planet 2023). Moreover, several livestock-based integrated farming systems (IFS) also involve the interconnection of crop cultivation (vegetables crops) with livestock farming and aquaculture. This allows the use of livestock manure and fish waste as fertilizer for healthy plant growth, in turn, crop cultivation enables the use of vegetable residues as fish feed.

Thereby, Livestock-based integrated farming systems aims to overcome the dependency on expensive supplementary feed and fertilizer, while promoting considerable increase in fish productivity. It aims to provide food with high nutritional value, increase income and employment generation, improve sustainable resource management, and promote organic farming, thereby contributing to alleviation of poverty, food insecurity and malnutrition (FAO 2003).

IFS is predominant in several Asian countries including China, Malaysia, India, Indonesia, Philippines, and African countries including South Africa, Ethiopia, Kenya, Malawi, and Tanzania. The following section covers three cases from India of South Asia and Tanzania of Sub-Saharan Africa which are reported with livestock-based integrated farming systems handled by small-scale rural farmers (Figure 4).

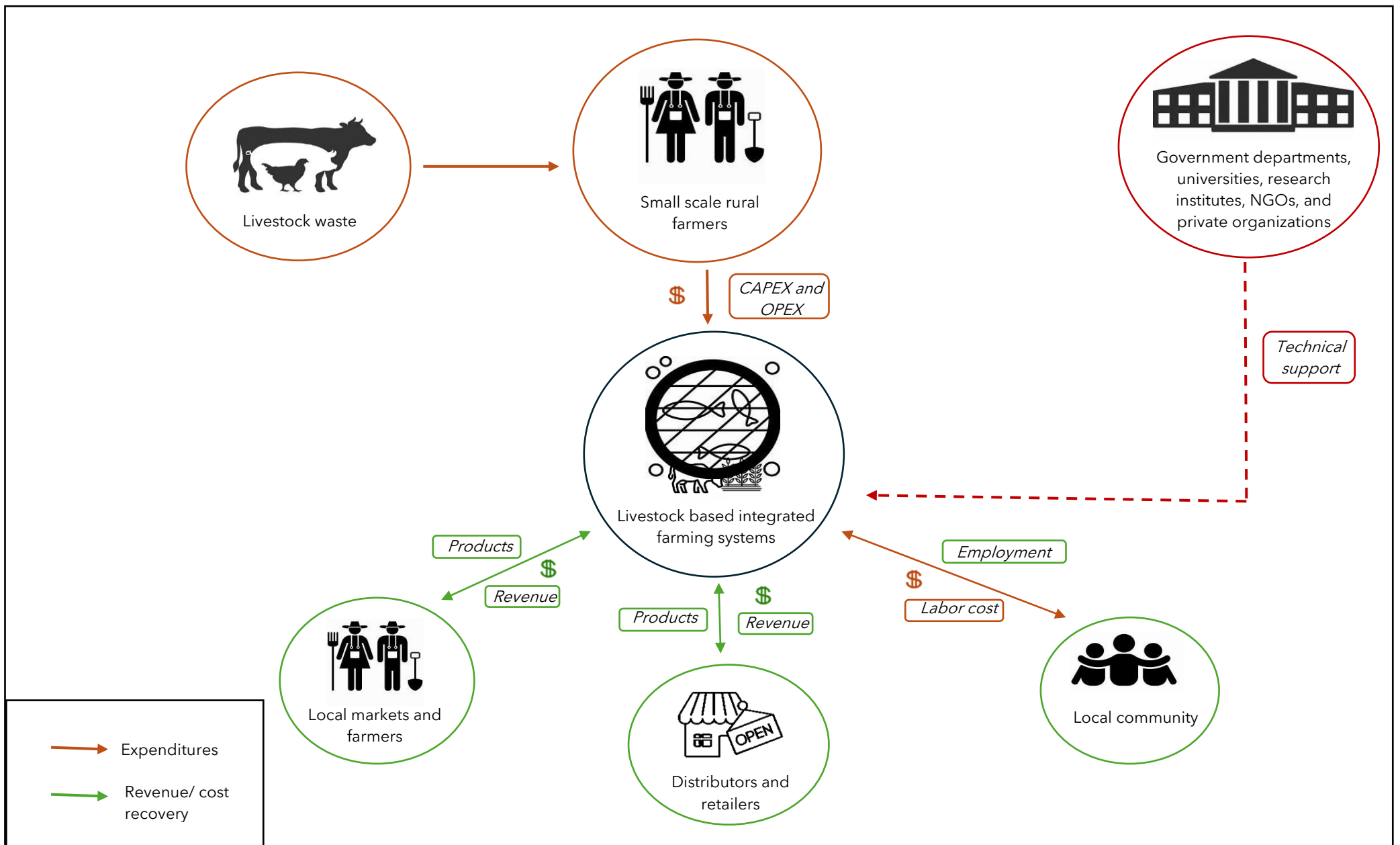


Figure 4. Value chain of fish feed recovery business cases  
 Source: Authors' creation

# Integrated Farming System (IFS), Assam, India

## Business case



<b>Case name</b>	Integrated Farming System in Assam, India: Pig and fish
<b>Location:</b>	Jorhat District, Assam, India
<b>Waste input type:</b>	Pig waste
<b>Value offer:</b>	Fish feed recovery
<b>Organization type:</b>	Private (Small scale farmers)
<b>Status of organization:</b>	2023
<b>Scale of business/case:</b>	<i>Amount of waste used: 20kg/day. Product recovered: 150kg of fish and vegetables</i>
<b>Major partners</b>	Seven Sisters Development Assistance and Rastriya Krishi Vikash Yojana (RKVY), Govt. of Assam

Map credits: Bing Map

## Executive summary

Assam is home to many smallholder farmers who practice subsistence farming. Therefore, integrating pig, fish, and vegetable production helps to improve their livelihoods. The operational ratio of the business is two female indigenous breed pigs, one male exotic (Hampshire) breed pig, and a homestead pond. Two-month-old piglets are raised for six months, resulting in two batches of pigs being reared in conjunction with one batch of fish per year. The fish species released into the pond include catla, rohu, mrigal, grass carp, and silver carp. The fertilised pond water, enriched with blue-green algae due to the addition of pigsty sludge, is used to irrigate horticultural crops such as okra in the Kharif season and cabbage in Rabi season. A control mechanism is also installed in the drain to regulate the flow of pig sludge and prevent water quality degradation in the fishpond. While pigs receive intensive care regarding feed and health, fish are not fed, and the fishpond does not receive any external fertilizers. Pig sludge is recycled to meet the fish's feed requirements.

## Value chain and stakeholders' involvement

The Indian government has launched several programs and initiatives to promote integrated farming practices, including the National Agricultural Development Scheme, National Fisheries Development Board, and National Horticulture Mission. In addition, various research institutions, universities, and agricultural extension agencies in India provide technical support and training to farmers on integrated farming practices. These institutions and agencies also conduct research and development activities to improve the efficiency and sustainability of integrated farming systems. Several NGOs and private sector organisations also actively promote integrated farming practices in India. They provide training and capacity-building support, establish linkages between farmers and markets, and facilitate access to credit and other financial services. Furthermore, India has a well-established network of Farmer Producer Organizations (FPOs) that promote collective marketing and bargaining for smallholder

farmers. These FPOs also facilitate access to input and output markets, enabling farmers to obtain better product prices.

Major stakeholders of the business:

- Farmers
- Seven Sisters Development Assistance (SeSTA)
- Rastriya Krishi Vikash Yojana (RKVY), Govt. of Assam
- Assam Agricultural University

## Financial outlook

Table 47. Financials of IFS, Assam

Item	Amount
Investment cost (in thousand USD)	20.8
Annual operation and maintenance cost (in thousand USD)	1.7
Total annual revenue (in thousand USD)	2.1
Benefit cost ratio	3.5:1

Source: Authors' creation

## SWOT Analysis

Table 48. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Integrating pig, fish, and vegetable production can provide a diversified income source, reducing the risk of crop failure or market fluctuations.</li> <li>• Waste from one system can be used as a resource for the others, reducing waste and maximizing efficiency.</li> <li>• The integration of pig, fish, and vegetable production can result in increased productivity</li> </ul>	<ul style="list-style-type: none"> <li>• Integrating different species can increase the risk of disease transmission, which can negatively impact the production system.</li> <li>• The different species have different nutrient requirements, and imbalances can occur if not managed carefully.</li> <li>• May require significant upfront investment in infrastructure and equipment.</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Farmers may be able to access new markets.</li> <li>• Reduces waste accumulation and improves resource use.</li> <li>• Provide a diverse range of nutrient-rich foods, improving the nutritional status of communities.</li> </ul>	<ul style="list-style-type: none"> <li>• Competition for resources</li> <li>• Fluctuations in market demand and prices can negatively impact the income.</li> <li>• Changes in weather patterns and extreme weather events can impact production.</li> <li>• Alternative source of food preference, local people prefer boiler chicken or imported pork than local fish or pork.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

According to a study conducted by Assam Agriculture University between 2008 and 2014, the integrated farming system (IFS) of pig-fish-vegetable, consisting of one male Hampshire and two female local pigs, a fish pond of 450 m, and vegetable cultivation of cabbage and Okra on 1000 m of land, resulted in an increased income, benefit cost ratio, and an additional labour requirement of 159 man-days compared to the traditional practice of piggery using local pig breeds. Given the nature of the agricultural activity in Assam, there is great potential for this business model to replicate across Assam and other parts of India.

## Socio-economic, health and environmental benefits

This model has various socio-economic, health, and environmental impacts, as follows:

- Increased income and food security
- Employment creation
- Improved nutrition
- Reduced use of antibiotics and reduced exposure to chemicals
- Prevention of water pollution and soil degradation due to improper disposal of waste

## References

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SeSTA (Seven Sisters development Assistance). 2023. Available at <https://sesta.org/livelihood-promotion/> (accessed on August 16, 2024).

# Integrated Farming System (IFS), Meghalaya, India

## Business case



<b>Case name</b>	Integrated Farming System in Meghalaya, India: Pig and fish
<b>Location:</b>	Ri Bhoi District, Meghalaya, India
<b>Waste input type:</b>	Pig waste
<b>Value offer:</b>	Fish feed recovery
<b>Organization type:</b>	Private (Small scale farmers)
<b>Status of organization:</b>	2023
<b>Scale of business/case:</b>	<i>Amount of waste used: 0.09 tons/day</i>
<b>Major partners</b>	Indian Institute of Farming System Research (ICAR)

Map credits: Bing Map

## Executive summary

Combining pig, fish, and vegetable production offers a compelling solution to tackle the region's food security and income challenges, particularly among smallholder farmers engaged in subsistence farming. This integrated approach leverages the symbiotic relationships between these components for mutual benefits, creating a sustainable and efficient agricultural system. Livestock rearing is central to this integrated system, contributing high-quality protein and valuable manure. The livestock manure becomes a dual asset as it serves as fertiliser for fishponds and vegetable crops. Fishponds, in turn, are stocked with fish species that thrive on pig waste, creating a natural cycle of nutrient exchange. Through their waste, the fish provide essential nutrients for the vegetable crops, enhancing overall productivity. Implementing raised beds or integrating vegetable crops with fishponds minimises reliance on external inputs, promoting self-sufficiency in the system.

## Value chain and stakeholders' involvement

The Indian government has launched several programs and initiatives to promote integrated farming practices, including the National Agricultural Development Scheme, National Fisheries Development Board, and National Horticulture Mission. In addition, various research institutions, universities, and agricultural extension agencies in India provide technical support and training to farmers on integrated farming practices. These institutions and agencies also conduct research and development activities to improve the efficiency and sustainability of integrated farming systems. Several NGOs and private sector organisations also actively promote integrated farming practices in India. They provide training and capacity-building support, establish linkages between farmers and markets, and facilitate access to credit and other financial services. Furthermore, India has a well-established network of Farmer Producer Organizations (FPOs) that promote collective marketing and bargaining for smallholder farmers. These FPOs also facilitate access to input and output markets, enabling farmers to obtain better product prices.

Major stakeholders of the business:

- Farmers
- Indian Institute of Farming System Research (ICAR)

## Financial outlook

Table 49. Financials of IFS, Meghalaya

Item	Amount
Investment cost (in thousand USD)	5.5
Annual operation and maintenance cost (in thousand USD)	3.1
Total annual revenue (in thousand USD)	13.4
Benefit cost ratio	1.49

Source: Authors' creation

## SWOT Analysis

Table 50. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>• Generate a steady income through diverse products.</li> <li>• Cost savings due to efficient resource utilization.</li> <li>• Employment creation</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of storage facilities</li> <li>• Lack of availability of input on time.</li> <li>• Lack of awareness among rural farmers</li> <li>• Risk of disease transmission and nutrient imbalance</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>• Farmers may be able to access new markets.</li> <li>• Reduces waste accumulation and improves resource use.</li> <li>• Provide a diverse range of nutrient-rich foods, improving the nutritional status of communities.</li> </ul>	<ul style="list-style-type: none"> <li>• Competition for resources</li> <li>• Fluctuations in market demand and prices can negatively impact the income.</li> <li>• Changes in weather patterns and extreme weather events can impact production.</li> <li>• Alternative source of food preference, local people prefer boiler chicken or imported pork than local fish or pork.</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

This business can be adapted to diverse ecological and climatic conditions and has higher scalability. It is highly flexible and can accommodate variations in soil types, water availability, and other local factors, therefore more likely to be successfully replicated in different regions.

## Socio-economic, health and environmental benefits

The integration of pig, fish, and vegetable production diversifies the farmer's income streams and bolsters financial stability, mitigating reliance on a singular product and contributing to enhanced food security. The diverse production systems generate novel employment avenues, ranging from farm management to processing and marketing. This multifaceted approach elevates the farmer's livelihood and fosters a spirit of entrepreneurship within the community. The harmonious relationship between vegetable and fish production in the integrated system lessens reliance on chemical fertilizers and pesticides and contributes to environmental sustainability and improved human health.

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# Integrated Farming System (IFS), Tanzania

## Business case



<b>Case name</b>	Integrated Aquaculture System of Tanzania
<b>Location:</b>	Six districts of Tanzania (Kilombero, Igunga, Mvomero, Songea rural, Songea urban and Mbarali)
<b>Waste input type:</b>	Cow dung manure, Goat manure, Pig manure, Chicken manure, Duck manure and Combination of manure
<b>Value offer:</b>	Fish feed recovery
<b>Organization type:</b>	Private (Small scale farmers)
<b>Status of organization:</b>	2017
<b>Scale of business/case:</b>	<i>Amount of waste used: 2.1 t ha<sup>-1</sup> yr<sup>-1</sup> Fish yield: 3.24 t ha<sup>-1</sup> yr<sup>-1</sup></i>
<b>Major partners</b>	Small scale farmers

Map credits: Bing Map

## Executive summary

In Tanzania, IFS have been carried out intensively in six districts, namely, Kilombero, Igunga, Mvomero, Songea rural, Songea urban and Mbarali. In these districts, 93% of the IFA ponds were under individual ownership and the majority of fish farmers were males within the age group of 26-45 years while females contribute to other activities such as fish feed preparation and feeding, harvesting and selling to neighbors and local markets. Around 65% of IFS farmers have taken additional training in fish farming along with more than 5 years of practical experience. Most of the fishponds (40%) were constructed between 1996-2005, while 25% of ponds were constructed recently (after 2010). The average pond size and depth were measured as 398.5 m<sup>2</sup> and 1.74 m, respectively. 97% of the fish farms contain earthen ponds stocked with fish sources from local hatcheries, neighbors and restarting. The fish farms were observed to use different types of manure including cow dung manure, goat manure, pig manure, chicken manure, duck manure and combination of manure for fertilization of fishponds. The IFS farms have the capacity to produce 3.24 t of fish yield with the use of 2.1 tons of animal manure per hectare per year, which is directly applied to the ponds without involving any treatment methods. The most prominent type of manure used for fertilization is cow dung (71%), which is followed by chicken manure (11%) and combination of various manure including cow dung manure, goat manure, pig manure, chicken manure and duck manure (6%).

## Value chain and stakeholders' involvement

Major stakeholders include small scale rural farmers, local hatcheries and neighbours who provide fish fingerlings, and customer segments such as local market and local community.

## Financial outlook

Table 51. Financials of IFS, Tanzania

Item	Amount
Investment cost (in thousand USD)	55.2
Annual operation and maintenance cost (in thousand USD)	359.7
Total annual revenue (in thousand USD)	834.2
Benefit cost ratio	1.99

Source: Authors' creation

## SWOT Analysis

Table 52. Business model assessment -SWOT analysis

STRENGTH	WEAKNESS
<ul style="list-style-type: none"> <li>Promotes sustainable agriculture and improves livelihood of farmers.</li> <li>Increases productivity and profitability.</li> </ul>	<ul style="list-style-type: none"> <li>Higher operating expenditures</li> <li>Requires additional labor and technical knowledge.</li> </ul>
OPPORTUNITY	THREAT
<ul style="list-style-type: none"> <li>High input cost for the use of feed and chemical fertilizers</li> <li>Growing demand for fish consumption</li> <li>Opportunity to obtain financial and technical assistance from donors who are involved in promoting sustainable agriculture.</li> <li>More potential for development and up-scaling</li> </ul>	<ul style="list-style-type: none"> <li>Lack of awareness on long-term environmental benefits</li> <li>Health risks due to pathogens and antibiotics from direct use of animal waste</li> </ul>

Source: Authors' creation

## Scalability and replicability potential

Integrating aquaculture with livestock farming provides an opportunity for sustainable use of animal manure. Pond fertilization using animal manure is highly preferable in small scale aquaculture farms of rural areas due to shortage of fish feed. It is significant in reducing expenditure on costly feed and fertilizers which form more than 60% of the total input cost. IFS pond reports 1.54 times higher total revenue and 3 times higher net income compared to non-IFS ponds in Tanzania. 38% of IFS farmers are planning to expand their fish farming activities due to higher farm productivity and profitability when integrating aquaculture with livestock farming and agriculture. Growing demand for fish consumption and higher profitability are considered as the key drivers of scalability and replicability potential of IFS systems.

## Socio-economic, health and environmental benefits

Reuse of animal manure on aquaculture provides an opportunity for sustainable management of livestock waste while offering economic benefits. It reduces GHG emission, environmental pollution and health risks associated with improper disposal of animal waste. It improves biodiversity and the integrity of natural habitats. IFS increases the availability of fish for meeting the growing demand and improves nutrient content of human diet. Skills and knowledge acquired from IFS farming can be used to diversify livelihood strategies and promote sustainable activities. It increases the overall income of fish farmers by increasing productivity and provides additional revenue for livestock farmers from selling manure, thereby reducing financial risk for small-scale farmers.

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