Biogas Energy Generation Project for Sustainable Rural Development in Egypt, Qena Governorate (ENSAN AID Foundation)

CASE STUDY

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PLAIN-LANGUAGE SUMMARY

Animal Waste Challenge

Rural Egyptian communities face environmental problems from improper livestock waste disposal, leading to soil pollution, unpleasant odors, and groundwater contamination.

Biogas Solution

ENSAN Aid Foundation developed a project to convert animal waste into clean biogas energy and organic fertilizer through biogas digester units in Al-Taramsa village.

Community Benefits

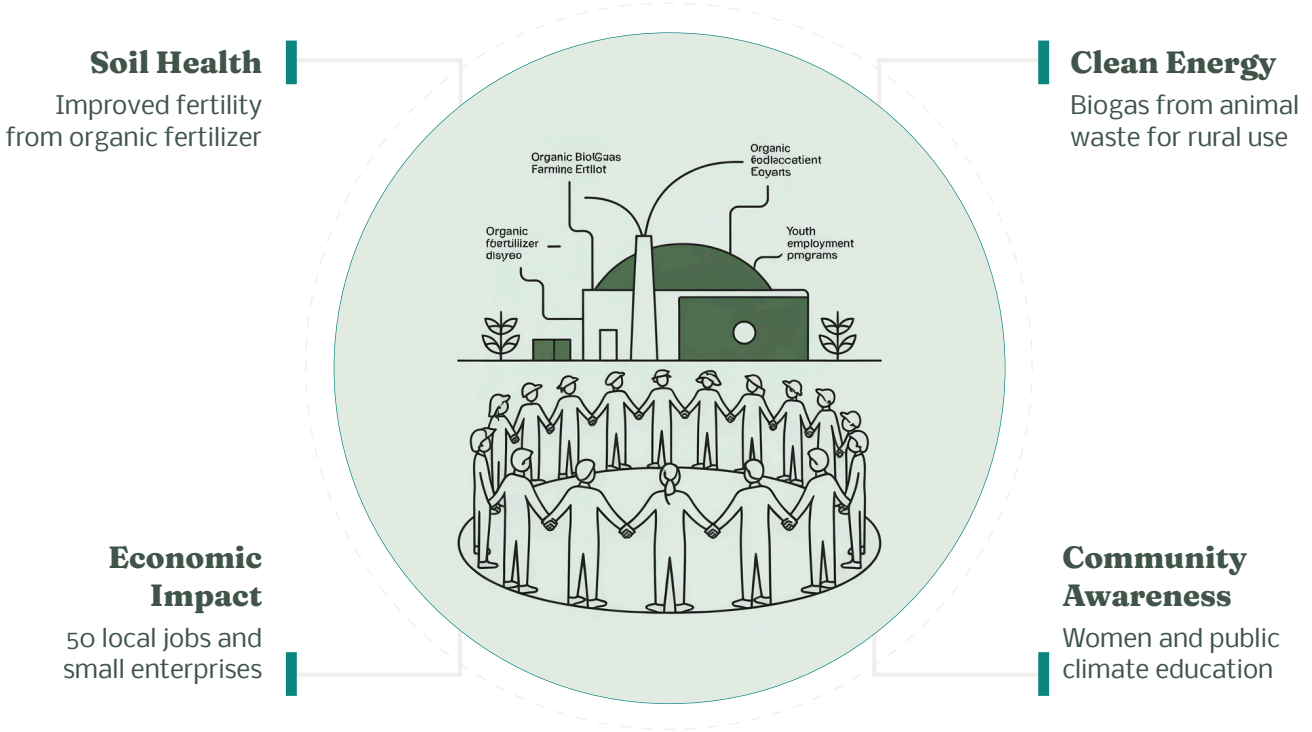
The project created 50 job opportunities for youth, improved soil fertility through organic fertilizers, and raised awareness about climate change challenges.

Sustainable Impact

This initiative demonstrates how civil society organizations can address environmental challenges while promoting economic development and community empowerment in rural Egypt.

ABSTRACT

This case study aims to highlight how the ENSAN Aid Foundation for Development has contributed to improving environmental, economic, and social sustainability in rural areas through its biogas energy generation project. It also explores the possibility of expanding the project implemented by the foundation to other similar areas in Qena Governorate in particular, and Upper Egypt in general, within the framework of ENSAN Aid's project, which aims to convert animal waste into clean energy and organic fertilizer. A mixed-method research approach was adopted, combining primary data from the field (questionnaires, focus groups, participatory assessments) conducted by ENSAN Aid, with secondary data from government reports and previous studies on bioenergy and rural development in Upper Egypt. The study concluded that: The fertility of agricultural soil increased after using organic fertilizers produced from biogas. Providing 50 job opportunities for youth in Qena Governorate, Egypt, including employment in the construction of biogas units and employment in small projects such as mushroom cultivation, recycling solid waste such as organic materials, producing organic fertilizer, and planting rooftops. Raising awareness among women and society as a whole about the challenges posed by climate change and how to address them.



Keywords: ENSAN Aid Foundation, Sustainable Development, Circular Economy, Biogas

INTRODUCTION

Livestock plays a significant and pivotal role in the global economy and food production. According to the OECD and FAO in 2017, livestock contributed approximately 40% of agricultural output in developed countries and 20% in developing countries, this sector has grown rapidly in developing countries, averaging 2.5% annually over the past two decades (Building Resilience in the Egyptian Livestock Subsector, 2025). Domestically, food security is undoubtedly one of the most important pillars of national strategic security, Livestock is an integral part of agricultural activity and one of Egypt's most important agricultural capital resources due to the contribution of its various products (primary and secondary) to agricultural production. This gives it a prominent position in the economic structure in general, and the agricultural economy in particular (GAFI, 2024).

The number of livestock (buffalo, cows, camels, sheep, and goats) reached 16.3 million in 2018, compared to 17.3 million in 2017, representing a decrease of 5.5%. The number of cattle reached 4,379,000 heads in 2018, compared to 4,387,000 heads in 2017, a decrease of 0.2%. However, the number of buffaloes reached 3,445,000 heads in 2018, compared to 3,433,000 heads in 2017 (Figure 1) (Annual Bulletin of Livestock Statistics 2019, 2019).

Figure 1: Egyptian livestock representing the significant role of cattle and buffalo in the country's agricultural economy

LIVESTOCK STATISTICS AND WASTE MANAGEMENT CHALLENGES

Table 1: Evolution of the Estimated No. of Cattle and Animals Heads During the period (2014-2018) (in thousands).

Type	2014	2015	2016	2017	2018
Cows	4762	4883	5012	4387	4379
Buffaloes	3949	3702	3437	3433	3445
Sheep	5503	3463	5556	5305	4830
Goats	4186	4046	4260	3974	3572
Camels	158	153	157	156	85

Source: (Annual Bulletin of Livestock Statistics 2019, 2019).

As illustrated in Table 1, although livestock is a source of capital and income, providing essential nutrients and additional benefits such as draught power, transportation, and organic fertilizer for soil fertilization, the increasing number of livestock has led to the production of more waste (animal manure), which leads to the spread of diseases, unpleasant odors, and groundwater pollution. However, the disposal and management of this waste is poor, resulting in serious environmental problems and significant burdens on the state. However, it could represent a hidden treasure if properly and efficiently exploited. There is an urgent need to address this problem and find scientific and practical solutions to the tragic environmental, social, and economic situation facing rural villages due to this waste and its burning. This is to preserve the environment and make communities more sustainable. This is what civil society organizations in Upper Egypt have sought to achieve, especially the ENSAN Aid Foundation, the case study we are focusing on. The Foundation aims to help rural communities achieve zero pollution, which has led to interest and support for biogas production as a renewable and environmentally sustainable resource.

BIOGAS PRODUCTION AS A MECHANISM FOR TRANSITIONING TO A CIRCULAR ECONOMY

The circular economy is based on the concept of the 3Rs (reduce, reuse, and recycle). "Reduce" refers to reducing the amount of waste in the economy, "reuse" refers to using products again as part of new products, and "recycle" refers to using the product again after processing it (Ratten, 2024). The circular economy is a way of understanding how resources are used and then reused. This means that after a product becomes waste, it is transformed into something else that can be used. This means that the relationship between production and consumption is no longer linear (that is, a product is no longer used and then discarded), but rather circular, where the product is produced, remanufactured, and then reused in a continuous cycle (Ratten, 2024).

In this context, biogas production goes through several stages (Figure 2 & 3). The process begins with hydrolysis, where large proteins, carbohydrates, and fats are converted into amino acids and long-chain fatty acids. These compounds are then converted into volatile fatty acids through acidogenesis. This is followed by secondary acidogenesis, where the volatile fatty acids are converted into acetic acid (vinegar), carbon dioxide, and hydrogen. Bacteria then consume these products to produce methane (CH_4), the main component of the biogas. This gas is highly flammable, with the methane content typically ranging from 50% to 75% (Naihma, 2017).

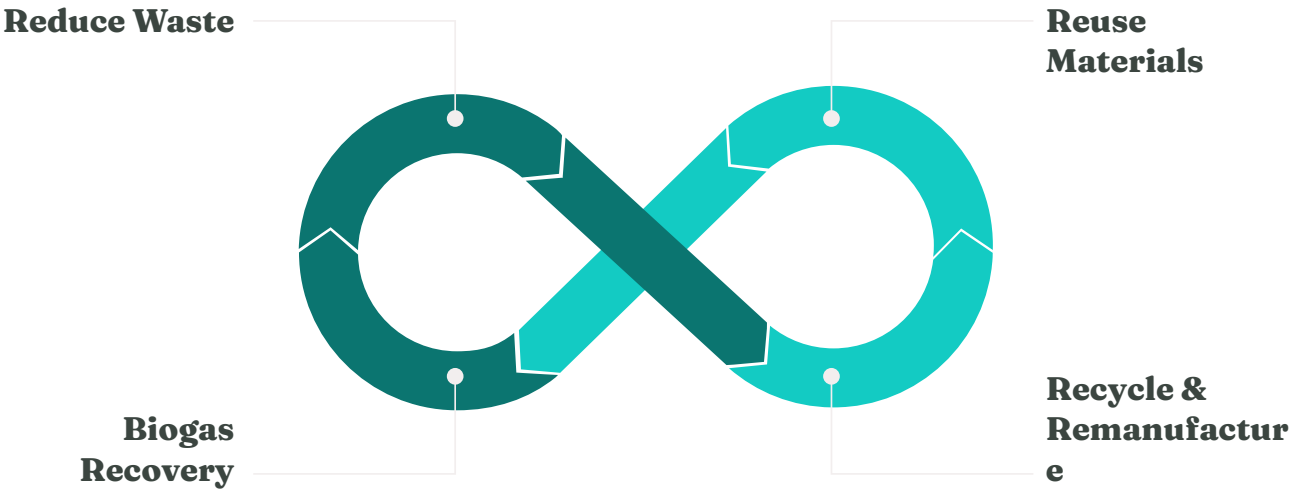


Figure 2: Production process

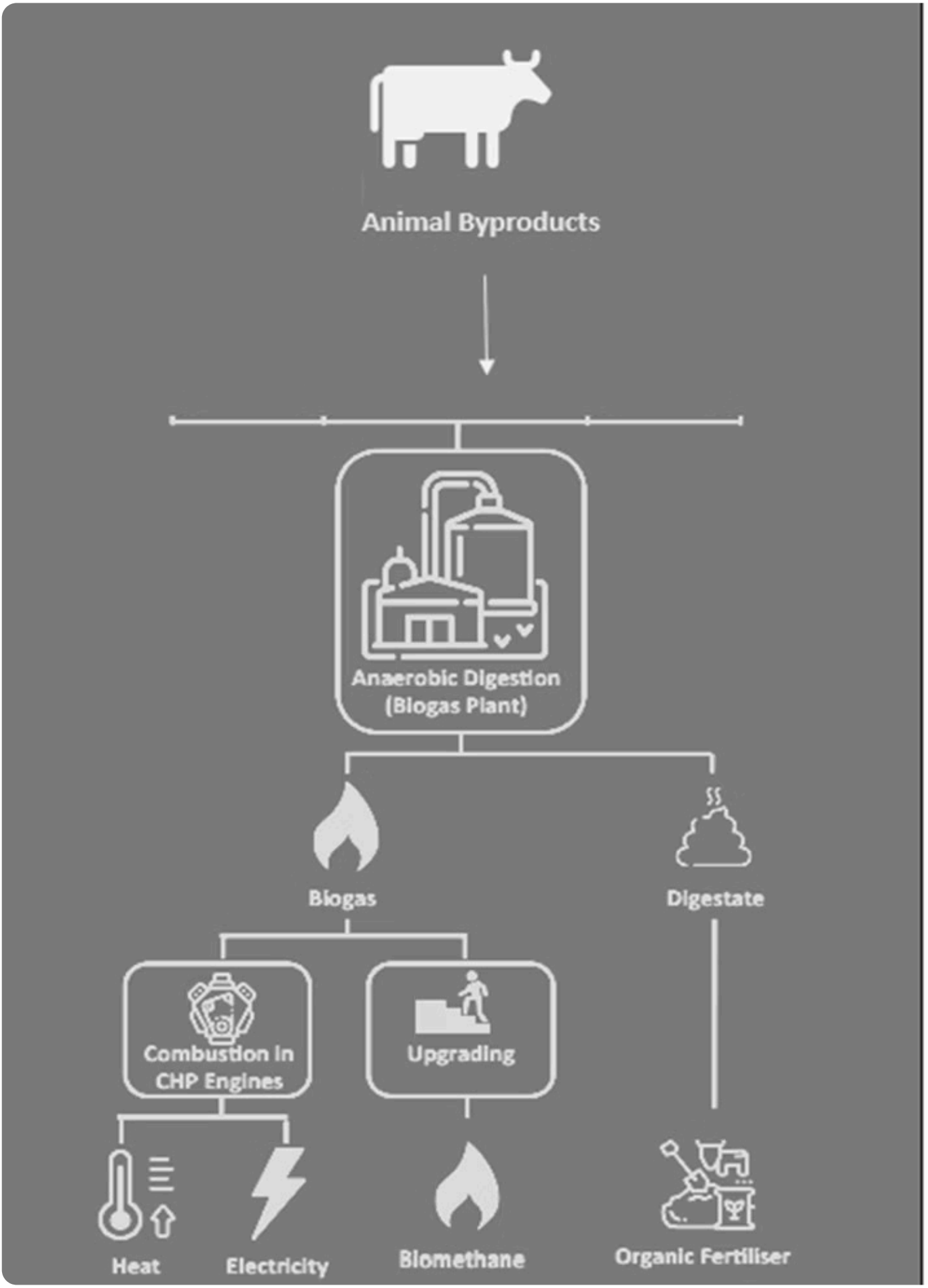


Figure 3. Biogas energy generation process

BIOGAS APPLICATIONS AND BENEFITS

01

Direct Use for Cooking and Lighting

The combustion of biogas produces lower emissions than the combustion of other biomass species, contributing to improved indoor air quality.

02

Electricity and Heat Generation

The calorific value of natural gas ranges from 50% to 70%. Burning biogas in gas generators or gas boilers can produce electricity and heat.

03

Vehicle Fuel Alternative

Biogas can be used as an alternative fuel for vehicles after being purified of impurities and modifying its properties to meet standards.

04

Natural Gas Network Integration

Purified biogas is fed into natural gas distribution networks for wider use as an alternative and sustainable energy source.

To maximize the benefits of biogas and its uses, practical solutions must be found to address the problem of waste and the management of agricultural organic waste. This problem can be attributed to several factors: Rapid population growth, Increased economic and industrial activity, Urban expansion and the spread of unregulated informal settlements, Lack of awareness and illiteracy, Absence of clear policies, and Inadequate waste management systems (Nassar et al., 2023).

CASE STUDY: ENSAN AID FOUNDATION AND ITS ROLE IN BIOGAS GENERATION IN UPPER EGYPT

ENSAN Aid implemented a biogas energy generation project in rural Egypt, specifically in Al-Taramsa village in Qena Governorate. Based on a field study conducted by the foundation in the village, focus groups revealed a pressing issue of environmental pollution. This problem is attributed to the large number of livestock in the agricultural village, where families owning these animals dispose of the waste indiscriminately, resulting in multiple environmentally harmful consequences.

ENSAN Aid relied on the following methodology to implement the biogas generation project:

Integrated Analysis

Understanding the village's production system, including the value chains of agriculture and livestock, focusing on opportunities for private sector involvement in establishing biogas units and waste recycling.

Comprehensive Assessment

Data collection on the economic, social, and environmental conditions of each household participating in the project, monitoring agricultural practices related to livestock rearing and organic waste management.

Household Resilience

Evaluating the household's ability to benefit from biogas units, generate additional income from organic compost production, and resilience to climate change and resource scarcity.

Participatory Approach

Involving farmers and youth in evaluating agricultural practices and contributing to planning environmental initiatives within the village, such as rooftop gardening and recycling.

TARGET COMMUNITY: AL-TARAMSA VILLAGE

The field sample size required to study the impact of the biogas project in Al-Taramsa–a village with a population of 33,000–was determined using approved statistical methods. The sample size was calculated at 380 individuals. This sample was subsequently distributed across the ten neighborhoods of the village according to the relative population weight of each neighborhood (as detailed in Table 2). This was carried out using a proportional stratified sampling method, ensuring accurate and fair representation of all segments of the local community.

Table 2: Number of Hamlets in the village of Tramsa in Qena Governorate in Egypt. Source: (ENSAN AID Foundation)

Hamlets	Percentage (%)	Sample Size (out of 380)
Hajer Al-Jabal	15%	58
Adhbat Al-Zahalit	14%	54
Jazirat Al-Taramsa	12%	45
Nagaa Al-Arab	9%	33
Adhbat Jad	11%	42
Nagaa Al-Sheikh Naggar	10%	38
Nagaa Al-Maghariba	7%	30
Sheikh Hassan	11%	40
Nagaa Beit Abdel Nabi	11%	40
Total	100%	380

VILLAGE CHARACTERISTICS AND PROJECT SCOPE

33K	10	8	70%
Population	**Hamlets**	**Project Duration**	**Target Girls**
55% males and 45% females	Including the mother village	Months	Of youth aged 18-29

About the target community: (Al-Taramsa Village) Its population is 33 thousand people, 55% males and 45% females. The village depends on agriculture and livestock, and a number of young people work in various professions by managing projects specific to the village and outside the village (in Qena Governorate). The mother village (Al-Taramsa) has 9 hamlets, including: 1. Hajer Al-Jabal 2- Adhbat Al-Zahalit 3- Jazirat Al-Taramsa 4- Nagaa Al-Arab 5- Adhbat Jad 6- Nagaa Al-Sheikh Naggar 7- Nagaa Al-Maghariba 8- Sheikh Hassan 9- Nagaa Beit Abdel Nabi (Figure 4).

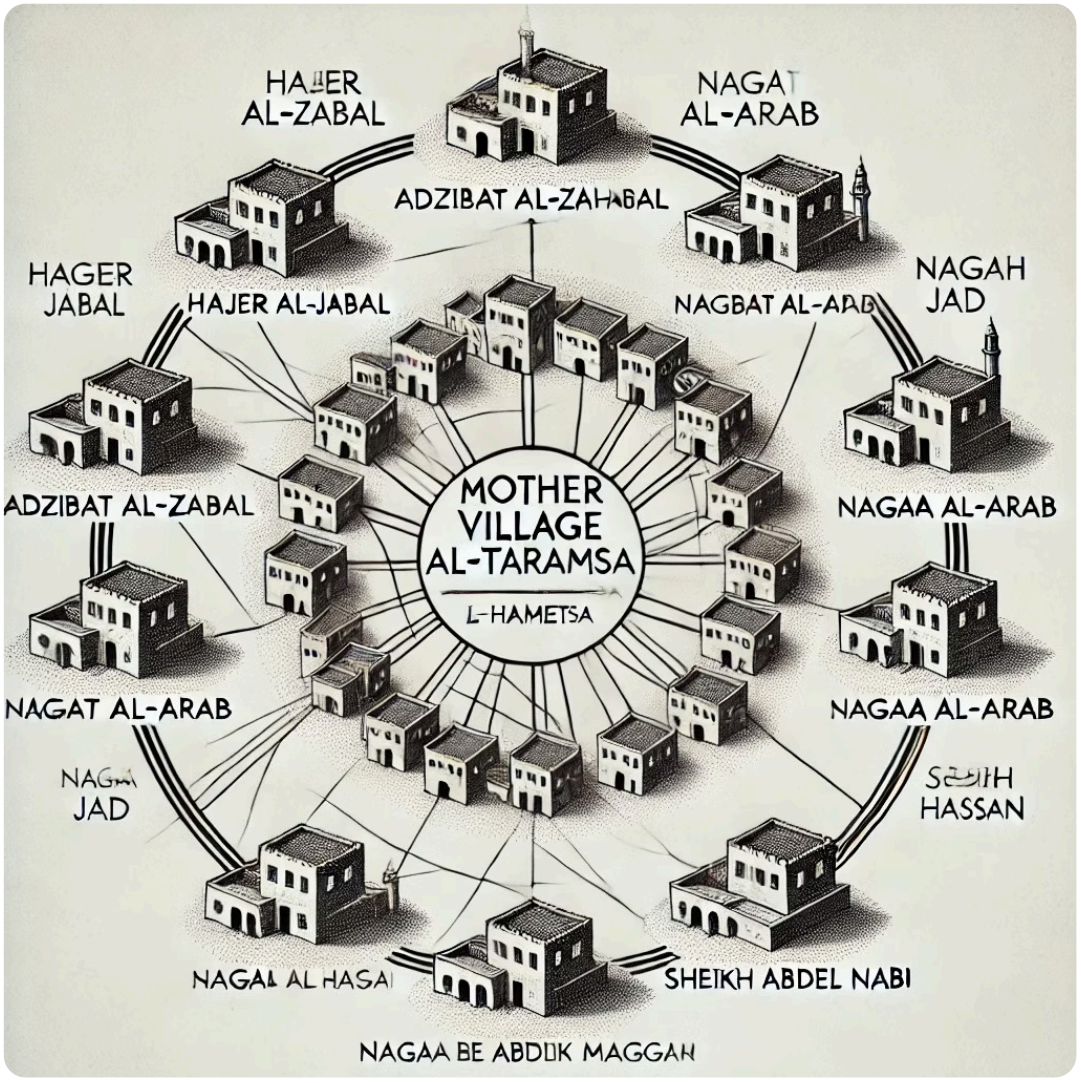


Figure 4: Map or diagram showing the layout of Al-Taramsa village and its surrounding hamlets.

Project implementation in Al-Taramseh leveraged a deep understanding of local social and economic structures. Biogas units were designed based on local knowledge of livestock waste handling, ensuring they are simple, user-friendly, and maintainable by local farmers, aligning with agricultural practices without requiring complex external support. Unit models matched community educational levels and available resources. Active involvement of diverse residents (including women and youth) in management enhanced acceptance, making local knowledge key to implementation and long-term sustainability. As an agriculture and livestock-dependent village serving as a hub for ten surrounding villages, Al-Taramseh positions this project as a scalable model for similar communities.

TARGET GROUP AND GENDER-RESPONSIVE APPROACH

Geographical scope: Al-Taramsa village in Qena Center, encompassing 10 villages. Target group: Youth aged 18-29 (70% girls, 30% boys). Seventy percent of girls in Al-Taramsa lack active community involvement, employment, and skill development opportunities. This demographic reality presents a strategic opportunity for gender-sensitive development interventions, aligning with the following objectives:

Integrating Youth into Rural Climate Action

The biogas project provides a practical training platform for youth—not only in the operation and maintenance of units, but also in resource management and recycling—thereby enhancing their role as active contributors to environmental transformation.

Economic and Social Empowerment of Girls

Project activities were specifically designed to ensure the participation of girls and young women through training on household biogas unit operations, environmental awareness sessions, and capacity building in life skills and decision-making.

Gender-Responsive Climate Action

Targeting this group ensures that climate response strategies are comprehensive and equitable, recognizing women's distinct roles in household management, energy consumption, and waste handling.

Contributing to Sustainable Development Goals

The project directly supports the achievement of several SDGs, particularly those related to gender equality, clean energy, climate action, and inclusive economic growth.

Local partnerships include the Environmental Protection Fund, Bioenergy Foundation, and Al-Taramsa Community Development Association. Project duration: 8 months.

IDENTIFYING THE PROBLEM

Based on a field study conducted by the Ensan Aid Foundation through seven focus groups in the village of Al-Taramsa, located in Qena Governorate, Egypt–with the participation of youth, women, farmers, and representatives from governmental and non-governmental agencies (Figure 5)–the study concluded that the problem of environmental pollution stems from the abundance of livestock and the indiscriminate disposal of waste by families who own these animals. This practice leads to numerous environmental and public health issues. Considering the village's priorities and the number of individuals affected, the study identified the environmental and economic crisis as the most pressing concern, impacting approximately 90% of the community. This situation contributes to environmental degradation, the spread of disease, and high rates of unemployment among youth, which collectively undermine economic, social, and health outcomes.

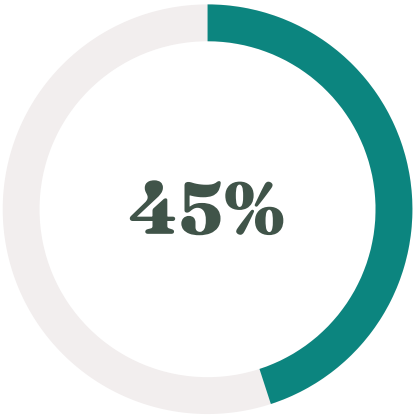
Figure 5. Youth participation in the Al-Taramsa village in the biogas generation project. Source: ENSAN Aid Foundation

Causes of the problem: Large quantities of accumulated animal waste, including solid farm materials, contribute to surface pollution, often compounded by pesticide contamination. While effective against harmful insects, pesticides severely harm soil bacteria necessary for organic matter decomposition and nutrient absorption, leading to a progressive decline in soil fertility. This reliance on chemical pest control poses a major ecological concern, as insects develop resistance and more resilient species capable of devastating crops emerge. Furthermore, chemical substances used in modern pest control contaminate food (grains, fruits, vegetables) and soil, posing significant human health risks. In Al-Taramsa, weakened soil and reduced fertility are directly linked to excessive pesticide and chemical fertilizer use; approximately 90% of village farmers rely on chemical fertilizers.

DEMOGRAPHIC ANALYSIS AND PARTICIPATION

Village Population Distribution

Males



Females

AL- Taramsa Village Gender Distribution Total Population: 33000. Source: ENSAN Aid Foundation

Youth Target Distribution

Females

Males

Youth Target (aged 18- 29) Distribution Gender. Source: ENSAN Aid Foundation

Capacity Building Participation

Females

Males

Capacity Building Participation (aged 18- 29) 50 youth: 70% Females, 30% Males. Source: ENSAN Aid Foundation

ENVIRONMENTAL AND SOCIAL IMPACTS

Furthermore, the unregulated accumulation of animal waste contributes to both visual and environmental degradation, creating significant public health risks such as respiratory issues from airborne pollutants and waterborne diseases from contaminated sources. This also imposes economic costs through increased healthcare burdens and reduced agricultural yields. Additional challenges facing the village include: The high cost and scarcity of gas cylinders, which has led many women to burn waste in traditional ovens to secure income–further exacerbating environmental pollution. Limited employment opportunities for both young men and women, leading to economic stagnation. A general lack of awareness among residents regarding the importance of waste recycling, the value of organic fertilizers, the impacts of climate change, and basic public health practices. Limited awareness among women about their role in decision-making processes and community engagement, hindering social development.

Environmental Effects

- The spread of diseases and harmful insects from the accumulation of waste
- Environmental pollution from the use of local ovens in the village
- Groundwater contamination and soil degradation
- Increased incidence of respiratory illnesses due to air pollution
- Loss of local biodiversity and ecosystem health
- Unpleasant odors impacting daily life and well-being

Social Impacts

- The lack of job opportunities for young men and women
- The absence of the role of women in society
- Limited awareness about environmental conservation
- Out-migration of youth seeking better economic prospects
- Increased strain on household incomes due to health expenditures
- Reduced community participation and social cohesion

These environmental and social challenges are deeply interconnected, forming a complex cycle of poverty and ill-health. Environmental degradation directly undermines the economic stability of the community, particularly affecting farmers and women who rely on natural resources. In turn, social issues like unemployment and lack of awareness perpetuate unsustainable practices, making it harder to address the root causes of pollution and achieve sustainable development for Al-Taramsa.

Description of the groups affected by the problem: Youth aged (18-29) 70% girls, 30% males (University graduates and intermediate qualifications).

PROJECT OBJECTIVE AND INTERVENTIONS

The project aims to provide biogas by using cattle manure to produce safe methane gas (does not cause fires or suffocation) which goes directly as clean fuel to the gas stoves in farmers' homes through clean energy in addition to producing organic fertilizer that improves the quality of agricultural soil and increases the productive capacity of the acre and provides the farmer with the financial equivalent of gas and agricultural fertilizers as an ideal way to support the Egyptian farmer economically and reduce the burden on him, and the interventions:

Establishing and Operating Biogas Units

4 biogas units (biogas) & producing new and renewable energy as a permanent and clean alternative and providing a source of high-quality municipal fertilizer.

Raising Awareness Among Girls

Through the Women and Life program, enhancing understanding of women's roles in environmental sustainability and community development.

Environmental Investment Education

Raising awareness among villagers about environmental investment and climate change challenges and opportunities.

Capacity Building for Youth

Building the capacity of youth to implement biogas units and develop skills for sustainable waste management projects.

OUTPUTS AND PROJECT RESULTS

The project aimed to provide a renewable source of biogas and high-quality organic fertilizer to improve soil properties through the establishment of four biogas units (see Figure 5 for an image of biogas delivered to homes in the village of Tramsa). It also sought to raise awareness among 250 farming families in the village of Al-Taramseh regarding animal waste recycling and environmental investment. Additionally, the project focused on empowering 50 young women by enhancing their understanding of their roles in society and building the capacity of 50 young men and women (30% male), aged 18 to 29, to implement biogas units and small-scale solid waste recycling projects throughout the project duration.

Figure 5. Biogas delivered to homes in the village of Tramsa in Qena Governorate, Egypt. Source: ENSAN Aid Foundation.

To assess the impact of awareness activities, the project utilized several direct evaluation tools, including: Pre- and post-awareness questionnaires to measure changes in participants' knowledge about the benefits of recycling and biogas. Brief interviews with families to gauge their willingness to adopt more sustainable agricultural and livelihood practices. Field observations, which indicated that a number of families began adopting waste recycling and composting practices following the awareness sessions–an encouraging sign of improved environmental awareness. Behavioral change among farmers, where those who initially resisted the implementation of biogas units at home later expressed a willingness to adopt the technology out of genuine conviction.

PROJECT ACHIEVEMENTS AND IMPACT

Table 3: Outputs and results of the biogas generation project in the village of Tramsa in Qena Governorate, Egypt. Source: ENSAN Aid Foundation

Outputs	Results
Installation of 4 biogas units	Providing a renewable energy source for beneficiary families and reducing dependence on traditional fuels such as natural gas or firewood
Serving 20 farmers in fertilizing agricultural lands and providing 4 families with renewable energy	Improving the properties of agricultural soil and increasing its fertility, which has contributed to enhanced crop quality and reduced reliance on chemical fertilizers
Production of high-quality organic fertilizer from biogas units	Increasing local community awareness of the importance of waste management and its potential to be transformed into sustainable economic resources
Education of 250 farming families on animal waste recycling and environmental investment	Building local capacities capable of implementing similar projects in the future and promoting environmental entrepreneurship among youth
Training of 50 young men and women on implementing biogas units and waste recycling projects	Enhancing the role of women in environmental and development issues and increasing their participation in community and economic activities
Education of 50 young women on the role of women in society	Empowering women to participate more actively in decision-making processes and community leadership roles

CONCLUSION

In light of the national drive towards achieving sustainable development specifically the second and ninth pillars of Egypt's Sustainable Development Strategy (MPED, 2023), which emphasize the efficient use of both traditional and renewable resources, contribution to economic growth, the achievement of social justice and poverty eradication, environmental preservation, and the development of a leading and innovative renewable energy sector and efficient resource management ENSAN Aid has implemented a pilot project to produce clean biogas in the village of Al-Taramsa in Qena Governorate. This project represents a practical application of the waste-to-energy approach by utilizing livestock waste to produce biogas, while also generating high-quality organic fertilizer that contributes to improving the quality of agricultural soil.

The following achievements have been realized: A renewable source of biogas has been provided, along with high-quality organic fertilizer to enhance soil properties, through the establishment of four biogas units. Awareness was raised among 250 farming families in the village of Al-Taramsa regarding animal waste recycling and environmental investment. In addition, 50 young women were sensitized to the role of women in society, and the capacities of 50 young men and women (70% female, 30% male) aged 18-29 were built to implement biogas units and small-scale solid waste recycling projects in the village throughout the project period. Agricultural soil fertility improved following the use of organic fertilizers produced through the biogas process. Fifty job opportunities were created for youth in Qena Governorate, including employment in the construction of biogas units and in small-scale enterprises such as mushroom cultivation, solid waste recycling (particularly organic waste), organic fertilizer production, and rooftop gardening. Community-wide awareness was raised–particularly among women–regarding the challenges of climate change and strategies for addressing them.

To ensure that the above-mentioned outcomes were achieved, several evaluation mechanisms were applied: Pre- and post-intervention surveys were conducted with participants in awareness sessions to assess changes in knowledge and attitudes regarding recycling and biogas. Focus groups were held to discuss the experiences of families and participants in integrating sustainable practices into their daily lives. A participatory evaluation was also carried out with community members to identify both achievements and challenges.

This initiative by ENSAN Aid stands as a tangible response to the social, economic, and environmental challenges facing rural communities, particularly in light of the increasing volume of organic waste.

CONFLICTS OF INTEREST

The author declares no conflict of interest

FUNDING

Not Applicable

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