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## RESEARCH ARTICLE

### ASSESSMENT OF THE TECHNICAL POTENTIAL AND ENVIRONMENTAL IMPACTS OF DOMESTIC BIODIGESTERS IN THE URBAN COMMUNE OF FARANAH - REPUBLIC OF GUINEA

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#### ABSTRACT

This study assesses the technical potential and environmental impacts of domestic biodigesters in the urban commune of Faranah, Republic of Guinea. The main objective is to promote the use and sustainable management of biodigesters with a view to valorizing local biomass for biogas production and environmental protection. The methodology adopted is based on socio-economic surveys, field observations and a sampling of 75 households distributed in 15 enumeration areas, supplemented by interviews with technical services and biogas project focal points. The results show the existence of 15 installed biodigesters, 12 of which are functional, and reveal that 42% of the households surveyed have at least 8 cattle and 3% at least 8 pigs, which constitutes a favorable potential for the supply of biodigesters. The study also highlights that the majority of households still rely on wood and charcoal for cooking, contributing to deforestation and greenhouse gas emissions. The widespread use of biodigesters could reduce pressure on forest resources, improve people's living conditions, and promote a circular and ecological economy adapted to the local context.

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## INTRODUCTION

Access to clean, sustainable and affordable energy is a major global challenge, particularly for developing countries. Since the energy crisis of the 1970s, many authors have highlighted the urgent need to diversify sources of supply and reduce dependence on oil. Lagrange (1979a) points out that this crisis led states to adopt policies aimed at improving energy efficiency and promoting alternatives. In the same perspective, Lagrange (1979b) specifies that UNESCO, under the leadership of Boris Berkovski, launched the "World Solar Summit" program, bringing together decision-makers, institutions and users to promote the integration of renewable energies into the global energy system. Today, despite these efforts, renewable energies still only represent around 20% of global electricity consumption, dominated by hydropower (90%), while biomass (5.5%), geothermal (1.5%), wind (0.5%) and solar (0.05%) remain marginal (CEA, 2017). This imbalance demonstrates the distance still to be traveled for a true global energy transition. In sub-Saharan Africa, the adoption of alternative technologies, such as biodigesters, remains limited. Several technical, economic, and social constraints hinder their diffusion: high initial investment costs, lack of user training, maintenance difficulties, and low cultural acceptability (Tolessa et al., 2024). Guinea is a good example of these challenges. More than 80% of household energy needs still rely on firewood and charcoal, leading to deforestation, soil degradation, and greenhouse gas (GHG) emissions. This heavy reliance on traditional biomass exacerbates the effects of climate change and undermines living conditions, particularly in rural and peri-urban areas. However, the country has

significant potential in animal and plant biomass, which is still underutilized for modern energy purposes. In this context, domestic biodigesters appear to be a promising solution. They transform animal waste and organic residues into biogas that can be used for cooking and lighting, while producing digestate that can be used as agricultural fertilizer. These installations are part of national strategies for energy diversification and the promotion of renewable energies, in line with Guinea's climate commitments and international recommendations (GTZ, 2007).

However, despite national initiatives supported in particular by the United Nations Development Programme (UNDP), which has identified biogas technology as a priority for reducing pressure on forests and GHG emissions (UNFCCC/UNEP, 2021), local empirical knowledge remains limited. In the urban commune of Faranah, the actual functionality, diffusion potential and environmental impacts of biodigesters remain unknown due to a lack of scientific evaluations. This lack of data raises questions about the availability of inputs (animal biomass, water), the operating status of existing facilities and their potential contribution to reducing pressure on forests and improving living conditions. The study is justified by the size of the cattle and pig herds, the relative accessibility of water, the growing energy needs and the need to find sustainable alternatives to wood energy. It aims to provide reliable data to guide public decision-making, strengthen the promotion of renewable energies and support a circular economy adapted to the Guinean context.

## MATERIALS AND METHODS

### Material

**Brief description of the study area:** Faranah is a city in Guinea located on the banks of the Niger River and on the country's main road axis, between Conakry and Kissidougou. It is located in the natural region of Upper Guinea. It is the capital of the Faranah prefecture and the capital of the Faranah region. The Urban Commune of Faranah was created in 1991 on the decentralized administrative level. It is located 460 km from the capital Conakry, it is one of the Sixteen (16) communities that make up the prefecture of Faranah (2024 Directory). It covers an area of 47 km<sup>2</sup> and is classified in the category of type B municipalities. It covers a population of 95,784 inhabitants, including 45,976 men and 49,808 women, i.e. an average density of 10 inhabitants per km<sup>2</sup> (Prefectural Directorate of the Faranah Plan 2020). It is made up of twelve (12) urban districts, twelve (12) rural districts and 117 sectors, the city is expanding thanks to urban planning and demographics.

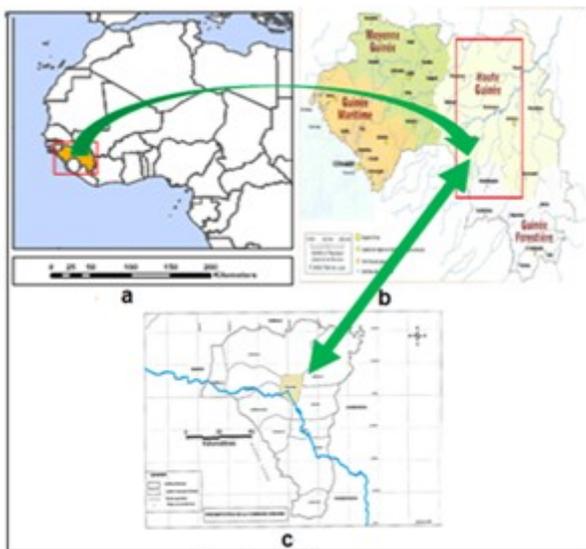
### It is limited.

- To the North by the Rural Commune (CR) of Passayah ;
- To the South by the CR of Songoyah and that of Tindo ;
- To the West by the CR of Dantilia ;
- To the East by the CR of Bantou

### The ethnic composition of the Urban Commune

#### Faranah presents itself as follows:

The Malinke, the Djallonke, the Kouranko  
The Sankarankas ,the Peulhs, the Soussou;  
The Kissians , the Guerzés , the Thomases; Etc. . . . .  
This explains the cultural mix that the urban commune of Faranah has.



### The socio-economic activity principles of the urban municipality are

- **Agriculture:** The main activity of the population; depending on the means of the farmer, there are mechanized, animal-drawn and manual forms of agriculture. All crops are grown: rice, fonio, corn, millet, yams; vegetable crops, citrus fruits.
- **Breeding:** the prefecture in general and the urban commune in particular are in favour of breeding,

Thanks to its climate, its plains, its lowlands and grassy and wooded savannahs. Livestock farming occupies second place after agriculture.

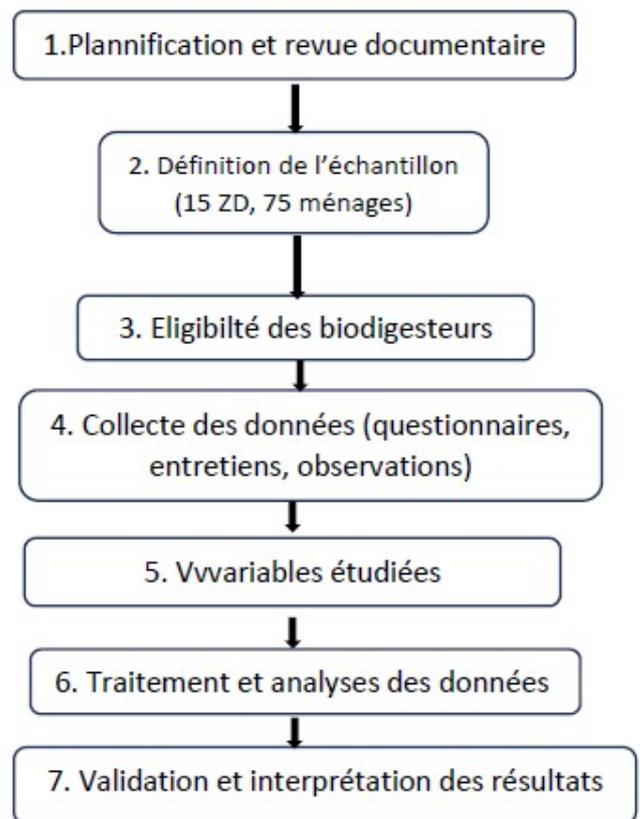
It is characterized by a traditional mode of exploitation; housing is limited to night penning, reproduction is free, but a followed health control is ensured by certain breeders. According to the Prefectural Section of Animal Resources of Faranah SPRA/F (2024) livestock farming is mainly focused on cattle (8,078b heads), sheep (1,931 heads), goats (1,184 heads), and poultry (17,500 heads).

- **Climate :** The urban commune of Faranah is bathed in a sub-Saharan climate strongly influenced by the harmattan characterized by the alternation of 2 distinct seasons:
  - A dry season of 7 months from October to April;
  - A 5-month rainy season from May to September.

This wind is mostly felt around the months of December, January, and February.

### Method

To achieve the objectives, the following methodological approach was adopted



**Planning of activities and documentary reviews:** for the development of our research work we designed and adopted a timetable of activities in time and space. This phase allowed us to collect official information on the subject . At this level, we consulted documents related to the subject and we also carried out research on the internet referring to the subject.

**Sampling and sample size:** Sampling was conducted in clusters, based on 15 enumeration areas (EAs). Five households were selected per EA, for a total of 75 households. Technical eligibility criteria included the presence of at least 8 cattle or 8 pigs and regular access to a water source (well, borehole, pond, or tap). A comprehensive inventory identified 15 domestic biogas plants, 12 of which were functional at the time of the study.

**Eligibility criteria for households to install biogas plants:** The following table summarizes the criteria used to determine the eligibility of households to install a biogas plant

**Table 1. Identification of biodigesters in the urban commune of Faranah**

No.	Neighborhoods/Districts	Sectors	Number of biodigesters	Observations
1	Market II	Gbenikoro	1	Non-functional
2	Faranah Koura	F. Koura College	2	Non-functional
3	Dandaya	Heremakono	2	Functional
		Modia	1	Functional
4	Sirikoloni II	Sagbaya	3	Functional
5	Aviation	Diarra	2	Functional
6	Slaughterhouse 2	III	1	Functional
7	Slaughterhouse 2	Bonifè	2	Functional
8	Soulemania	Center	1	Functional
<b>Total</b>			<b>15</b>	<b>12 functional (80%) – 3 non-functional (20%)</b>

**Table 2. Eligibility criteria for households to install biodigesters**

Technical criteria	Eligibility threshold	Result (n=75 households)	Proportion (%)
Bovine (heads $\geq$ 8)	Yes/No	32	42
Porcine (heads $\geq$ 8)	Yes/No	2	3
Cattle + pigs ( $\geq$ 8 each)	Yes/No	1	2
Regular access to water	Yes/No	65	87

Source: Field surveys, 2024

### Tools and data collection

- Structured household questionnaires: socio-economic data, livestock practices, access to water, energy uses and perception of biogas.
- Technical sheets for the inventory of biodigesters (location, capacity, functional status, supply, maintenance). - Semi-directive interview guides: with technical services and biogas project focal points. - Direct observation: verification of the state of the installations, water availability and observation of cooking and lighting methods.

### Variables studied

#### The variables studied include

- Independent variables: livestock size, water availability, household size, energy practices, distance to water points.
- Dependent variables: technical market potential, functional status of biodigesters, uses of biogas, energy substitution, recovery of digestate.

#### Data processing and analysis:

**The data were processed using:** descriptive statistics (frequencies, means, standard deviations). The inventory of biodigesters is presented in table form. The technical potential was estimated as a proportion of eligible households. Logistic regressions and statistical tests ( $\chi^2$ , Fisher, Wilcoxon) were used to analyze the determinants and compare energy consumption.

## RESULTS AND DISCUSSION

### Results

**Inventory of biodigesters:** The inventory carried out in the urban commune of Faranah made it possible to identify fifteen (15) domestic biodigesters installed in different neighborhoods and districts.

Table 1 presents their distribution and operating status. At the time of the survey, 12 biodigesters (80%) were operational, while 3 (20%) were out of service. The main causes of malfunction were related to the lack of raw materials (cow dung) and the lack of technical monitoring.

### Technical adoption potential and access to resources

#### Among the 75 households surveyed:

- **42%** owned at least 8 heads of cattle;
- **3%** had at least 8 heads of pigs;
- **2%** combined both types of farming.

Thus, nearly 47% of households are technically eligible to install a biodigester. Regarding access to water, 87% of households have a water source all year round, mainly: wells (20%), natural ponds (14%), boreholes (38%), SEG taps (28%). In terms of domestic energy: wood (30% collected in the bush, 28% purchased), coal (38%),

#### Butane gas (4%) and electricity from EDG (35%)

In total, **47 households (62.3%)** meet all the technical conditions (available manure, sufficient space and access to water) to install a biodigester.

### Environmental and socio-economic effects

#### In households equipped with a biodigester, the main changes observed are:

- Significant reduction in wood and coal consumption,
- Improved cooking speed and cleanliness,
- Valorization of digestate as organic fertilizer.

#### The main constraints noted are:

- Irregular availability of inputs (cow dung, water),
- Lack of technical training,
- Cultural reluctance to use animal waste.

#### Statistical analyses confirm these observations:

- **Cattle herd size:** determining factor of adoption (OR = 3.25;  $p < 0.001$ ).
- **Monthly income :** significant influence (OR = 2.14;  $p = 0.004$ ).
- **Educational level :** not significant ( $p = 0.214$ ).
- **Wood energy consumption :**  $1.8 \pm 0.7$  cubic meters/month (users) vs.  $4.2 \pm 1.3$  cubic meters/month (non-users) (Wilcoxon,  $p < 0.001$ ).
- **Wood collection time :** 2.4 h/day (users) vs. 5.1 h/day (non-users) (Fisher,  $p < 0.01$ ).
- **Reduction of forest pressure** linked to the use of biogas ( $\chi^2 = 21.54$ ;  $p < 0.001$ ).

## DISCUSSION

The results show that the urban commune of Faranah has a strong technical potential for the adoption of biodigesters, with almost half of the households eligible.

This finding is in line with observations made in other African contexts, where the availability of animal biomass and access to water are the main determinants of the diffusion of this technology ( Tolessa , 2024; Gbadeyan et al., 2024). The results obtained confirm that the diffusion of biodigesters in the commune of Faranah presents a high potential (62.3% of eligible households), but that sustainability depends on material and economic conditions. The inventory of biodigesters shows that nearly a third of the installations are non-functional, a phenomenon already observed in Ghana where approximately 28% of the units listed were abandoned due to lack of technical monitoring ( Kemausuor et al., 2018). This underlines the importance of a maintenance and continuous training system to ensure the sustainability of the technology. The analysis of determinants reveals that herd size and income are the main factors of adoption, which confirms the observations of Surendra et al. (2014), who highlight the availability of inputs and financial capacity as essential levers. On the other hand, the level of education does not appear to be a determining factor, suggesting that adoption is conditioned more by material means than by human capital. In terms of energy and the environment, the significant differences between equipped and unequipped households (wood consumption reduced by half, collection time halved) corroborate the conclusions of the FAO (2019), according to which biogas makes it possible to reduce wood consumption by 40 to 60%. This reduction in forest pressure contributes directly to the fight against deforestation and the improvement of household living conditions. Thus, the study confirms that biodigesters represent a sustainable and suitable solution to strengthen energy security, reduce deforestation and improve the socio-economic resilience of rural families. The functionality rate (80% of installed biodigesters) is relatively high compared to other experiences in sub-Saharan Africa, where many pieces of equipment quickly break down due to lack of maintenance ( Monzambe, 2007). This suggests that the installations in Faranah benefit from some technical monitoring, although limited. Environmentally, replacing wood and coal with biogas helps reduce deforestation and greenhouse gas emissions. This result corroborates the findings of Dong & Diallo (2018), who highlight the importance of biomethanization in limiting pressure on forest resources. However, adoption remains hampered by socio-economic constraints: low awareness, initial installation costs, and cultural resistance. These obstacles are similar to those identified in Diallo's (2021) work on the limits of sustainable agriculture in Guinea, where technological innovation requires strong institutional support.

## CONCLUSION

This study demonstrates that domestic biodigesters are a viable solution for meeting the energy needs of Faranah households while preserving the environment. With nearly half of households technically eligible and an 80% operational rate among existing installations, the potential for dissemination is considerable. Thanks to the availability of inputs (cow dung, pig manure, water) and the current heavy reliance on wood and coal, their diffusion has strong potential.

The use of biogas reduces deforestation, improves living conditions, and provides an organic fertilizer that can be used in agriculture. However, constraints remain, linked to behavioral changes, health risks, and maintenance requirements. To ensure the sustainability of this technology, it is necessary to strengthen community awareness, provide appropriate technical and financial support, and promote the integration of digestate into agricultural practices. Thus, the widespread adoption of biodigesters offers a real opportunity for a circular economy that reconciles energy, agriculture, and environmental protection.

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