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Inventory of domestic biodigesters for the Guinea Biogas-Project in N'Zérékoré (Republic of Guinea)

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Abstract: This research focuses on assessing the benefits of biodigesters in the biogas project in the N'Zérékoré prefecture in the Republic of Guinea. The methodological approach of this study consisted in geolocating biodigester installation sites, followed by a survey of biodigester users. A total of 50/60 users were surveyed. It was shown that 8% of biodigester owners are women. It was also a question of taking stock of the state of operation of the biodigesters, and it was found that 82% (or 41) of the biodigesters installed between 2015 and 2018 are non-functional and are currently abandoned for several reasons, including unsanitary conditions on the premises. However, the subjects surveyed had access to biogas for the entire duration of the project before 2020. 31.82% stated that biodigester technology, in addition to providing access to renewable energies, helps to reduce household chores, mainly related to the long journeys made by women and girls in search of firewood. 29.55% emphasized the aspect of access to renewable energy, but also addressed the management of organic waste. 15.91% use digestate as agricultural fertilizer, and 22.73% specify that in addition to access to energy, the use of Biogas reduces cooking time. This technology not only contributes to the management of organic waste, but also to the reduction of greenhouse gas emissions, making biodigesters a valuable tool for environmental and energy sustainability.

1. Introduction

The energy deficit is a constraint to the development of rural households, particularly when it comes to cooking energy (Avadikyan *and Mainguy* 1, 2016; Totouom, 2018). Worldwide, more than half the population uses solid biomass fuels (wood) for domestic energy needs, such as cooking and lighting (Bangirinama *et al.* 2016). In sub-Saharan Africa, over 70% of the total population depends on wood for fuel (Sulaiman *et al*. 2017). Lack of access to modern energy sources also has negative social consequences (poor health conditions, low school enrolment rates for girls, etc.) (Ngarava, 2024; Shupler *et al*. 2024). It's also important to point out that developing countries like those in Africa face a very crucial problem when it comes to managing the waste they generate through agriculture and

livestock farming. In some places, the huge quantities of waste produced are creating serious environmental and health problems (Yena, 2023). According to a study carried out by the Netherlands Development Organization (SNV) and the International Institute of Tropical Agriculture, 18.5 million households (around 93 million people) in 24 African countries can technically envisage switching to biogas (Clemens *et al*. 2018). Domestic biogas was introduced in Africa around forty years ago (Gbangbo et al., 2023). However, significant commitment came a little later, around 2008 (Roopnarain *and Adeleke*. 2017). Numerous organizations joined the initiative to accelerate awareness and dissemination of biodigester technologies (Bond *and Templeton*. 2011). Results from private initiatives and national programs showed a significant increase in the number of digesters installed and technicians trained (Asheal Mutungwazi *et al.* 2018; Kaifa & Parawira, 2019). This increase was noted in 9 countries supported by SNV, where a total of 17,000 digesters were installed in 5 years between 2007 and 2012.

In Guinea, the history of biogas goes back to 1977, when experiments were carried out with 3 small 0.2 m3 steel digesters in Kindia and Macenta. In 1981/1982, 7 additional 10 m^3 Chinese-designed fixed-dome digesters were installed, one in Conakry, one in Boké, one in Dalaba, one in Beyla, one in Kankan and two in Forécariah. Between 1983 and 1999, a further 80 fixed-dome digesters were installed, with volumes ranging from 6 m3 to 23 m3. All were installed as part of programs funded by the Guinean government and/or donors to produce biogas for communities. As the aid program came to an end, the digesters began to be neglected due to a lack of funds (PNUD-Guinée. 2019).

In 2001, a team of researchers from the Faculty of Science at Gamal Abdel Nasser University in Conakry carried out a study and built two Chinese-type digesters at the National School of Agriculture and Animal Husbandry (ENAE) de Tolo in Mamou (Boubacar SOW. 2004).

Guinea's energy potential is immense, with 612,000 TOE of biomass, 6,000 MW of hydroelectricity and an average solar irradiation of 4.8 kWh/m2, but its power generation capacity is still insufficient to cover national needs and meet growth acceleration targets (Ohunakin *et al*. 2023; Sakouvogui *et al*., 2023).

Per capita energy consumption is 0.5 toe/year, giving an energy access rate of between 8% and 12%. According to data available for 2012, almost 100% of rural households rely exclusively on firewood, and 20% of urban households use firewood and/or charcoal for cooking. This massive reliance on biomass is contributing to the rapid depletion of the country's forest resources, encouraging deforestation and global warming. So, to resolve the difficulties of access to firewood by rural households and reduce the harmful effects on the environment, the idea of creating a market for the development and use of biogas resources in Guinea has emerged (Alawenon *et al*. 2023). This idea was transformed into a project called Guinea Biogas Project, financed by the Global Environment Facility (GEF).

The aim of this project was to create a viable and efficient market for the widespread production, marketing and use of biogas technologies in Guinea. Its implementation plan called for the construction of 2,000 biodigesters in all regions of Guinea. However, in the field, two (2) of the ten planned semi-industrial biodigesters and 1,440 domestic biodigesters have been built, 75% (Ansoumane Sakouvogu *et al.* 2021). Environmental, cultural and socio-economic conditions are conducive to livestock farming in Forest Guinea, producing large quantities of animal waste every year, the recovery of which remains a major problem. N'Zérékoré is the region in which most biodigesters (43%) have been installed. The aim of the present activity is to list the advantages of using the biodigesters of the biogas project in the prefecture of N'Zérékoré, and to assess their current status.

2. Methodology

2.1 Materials

Presentation of the study area

The Prefecture of N'Zérékoré is a subdivision of Guinea. Located in the N'Zérékoré region, it lies between 7°45' North 8° 49' West. According to the 2014 General Census of Population and Housing (RGPH), the population was 396,949 with a density of 92hab/ Km2 and covers an area of 4625km2. The N'Zérékoré prefecture is bordered to the north by the Beyla prefecture, to the east by the Lola prefecture, to the west by the Macenta prefecture and to the south by the Yomou prefecture. It has ten (11) sub-prefectures: N'Zérékoré Centre, Bounouma, Gouécké, Kobéla, Koropara, Koulé Samoé, Soulouta, Womey, Palé, Yalenzou see **Figure 1**.

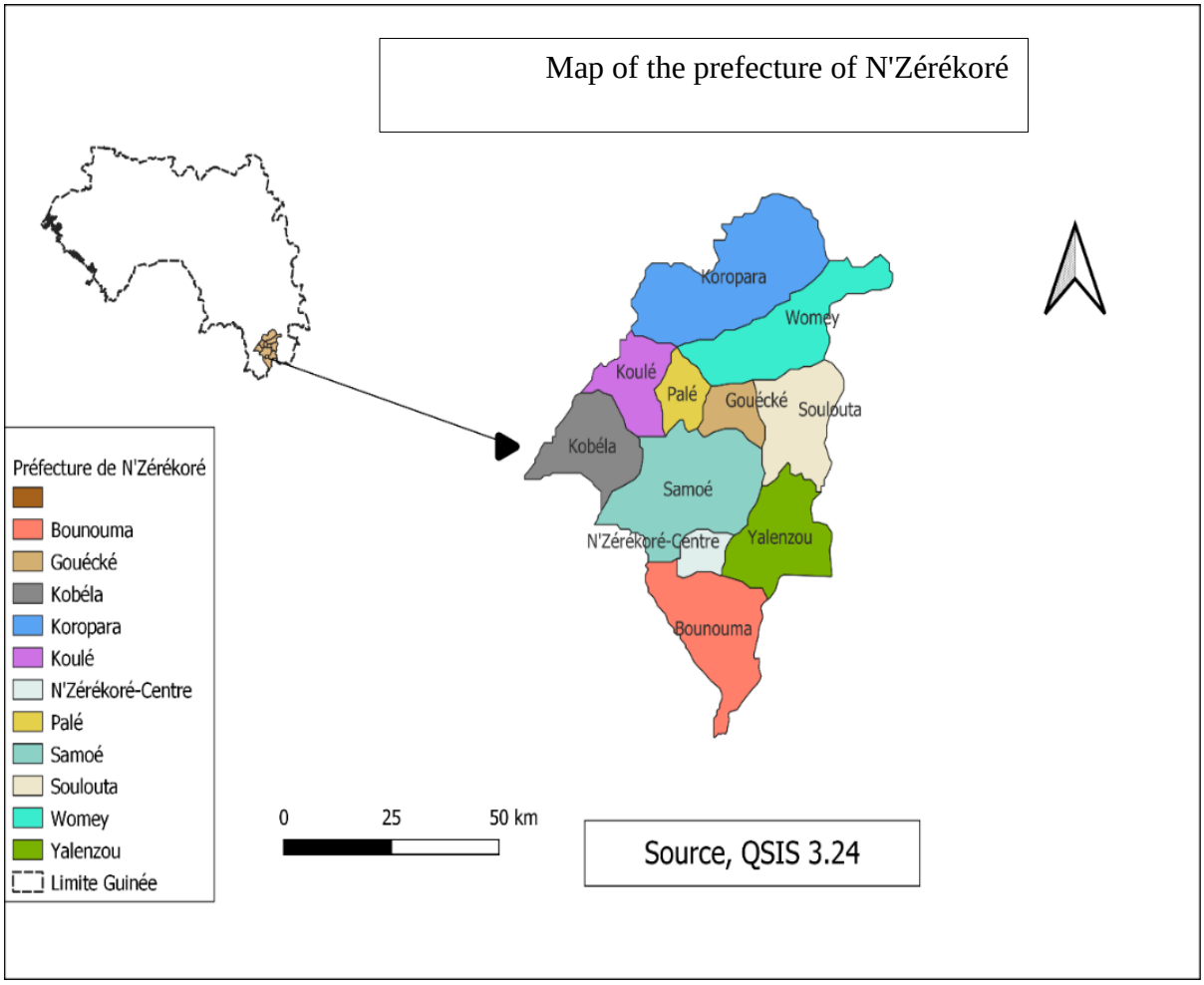

Figure 1. Presentation of the study area

2.2 Data collection equipment

Survey forms, a GPS, a digital camera and Kobocollect software were used to collect data. Data were collected over a period of 3 months, and the method used in this research consisted in geo-referencing the areas where bio-digesters are installed, followed by a survey of bio-digester users based on a structured questionnaire comprising closed and open-ended questions. Of the 66 bio-digesters built in the N'Zérékoré prefecture, 75% were surveyed, 50 bio-digesters. Using Kobocollect, SPSS 21 and QSIS 3.24 software, we were able to collect, process and analyze the data from this study.

3. Results and Discussion

3.1 Pourcentage des nombres femmes et d'hommes possédant les biodigesteurs

This result shows that 8% of biodigester-owning respondents are women and 92% are men. This large discrepancy does not express that men are responsible for biodigester management, but simply means that they are the heads of household. The 8% of women who own biodigesters are either widowed, unmarried or divorced see **Figure 2**.

3.2 Statistics of biodigesters surveyed in N'Zérékoré prefecture

This table shows that most of the biodigesters built are located in the peri-urban areas of the town of N'Zérékoré, 50%. This large number determines the interest these beneficiaries have shown by agreeing to contribute 40% of the cost of building the biodigester see **Table 1**.

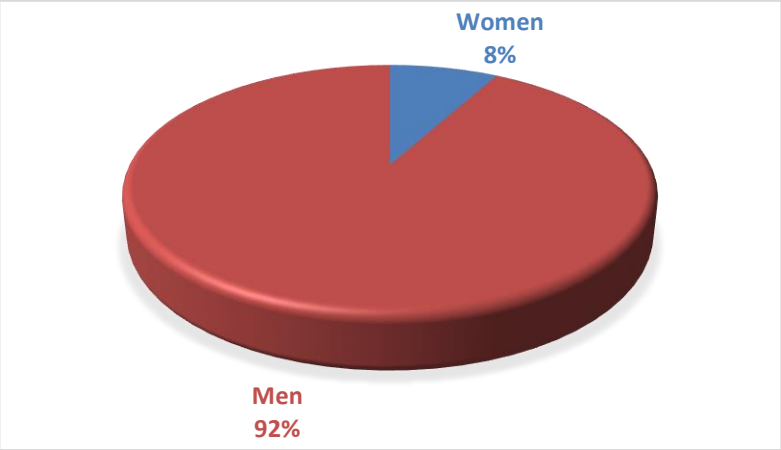

Figure 2. Number of male and female biodigester owners

Table 1. Statistics of biodigesters surveyed in N'Zérékoré

	Workforce	%	% Valid	% Cumulated
Boma sud	4	8	8	8
Bounouma	3	6	6	14
Gouécké	5	10	10	24
Kéréma	2	4	4	28
Kobéla	4	8	8	36
Koulé	3	6	6	42
N'Zérékoré	25	50	50	92
Samoé	4	8	8	100

3.3 Functionality of biodigesters during the project period

The diagram shows that 44 of the 50 biodigesters surveyed were operational during the project period, compared with 6 that were never operational. The reasons for the non-functioning of the 6 biodigesters, representing 12%, are due to difficulties in mobilizing family labor and environmental problems linked to the location of the biodigesters. The 88% of owners of functional biodigesters confirm that biogas has enabled them to reduce their use of wood and charcoal. So we can conclude that during these periods there is a reduction in greenhouse gases due to the valorization of organic waste, which also contributes to the emission of these gases see **Figure 3**.

3.4 Functional status of biodigesters after the project period

Figure 4 shows that of the 50 bio-digesters surveyed in the N'Zérékoré prefecture, only 9 were functional, compared with 41 that were non-functional, with percentages equal to 18% and 82% respectively. These results are similar to those found by Diop et al. in 2015 in Senegal, where out of 58 bio-digesters, 19 were functional, generally full-time, 2 were seasonal and 37 are no longer functioning. This high number of biodigester abandonments is due to several factors outlined by the respondents see **Figure 4**.

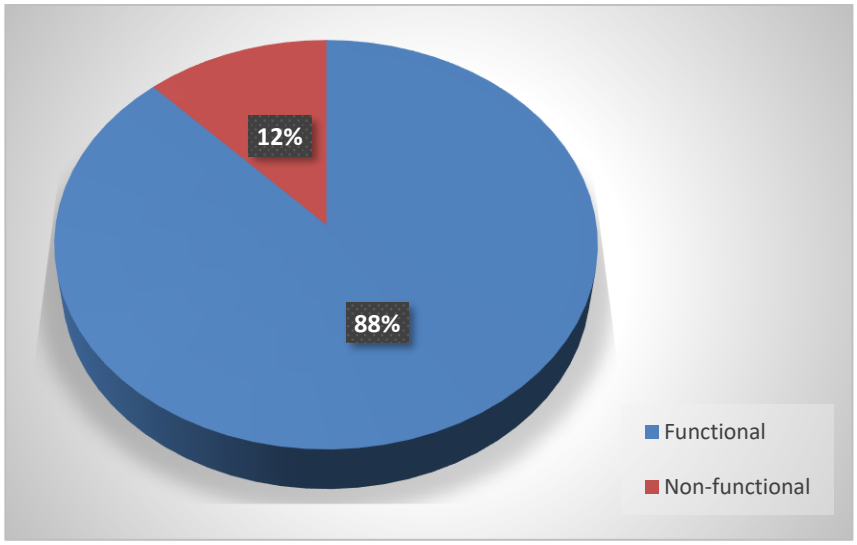

Figure 3. biodigester functionality during the project period

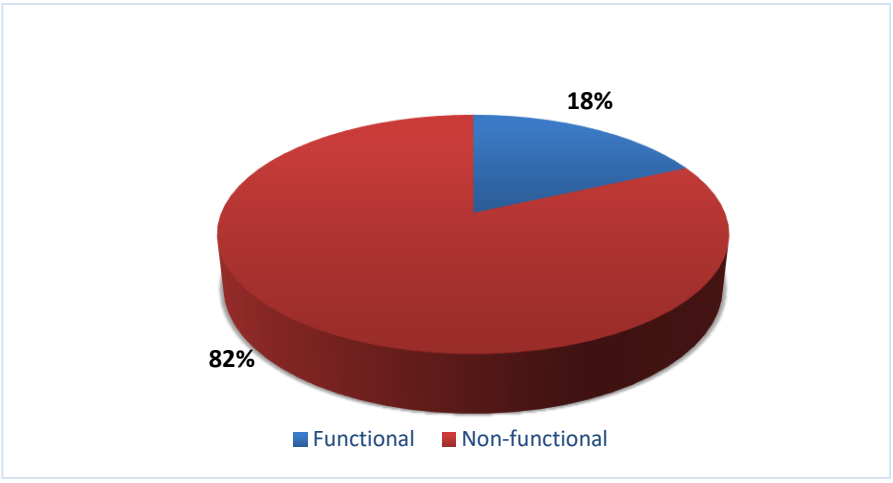

Figure 4. Functionality of biodigesters during the project

3.5 Reasons why bio-digesters don't work

The non-functionality of bio-digesters in the N'Zérékoré prefecture is attributed to several factors. From this figure we can see that the highest number of bio-digester abandonments (39.02%) is linked to odors when mixing pig manure, a total of 16 bio-digesters out of 41. This situation can be explained by. The non-operation of bio-digesters in the N'Zérékoré prefecture is attributed to several factors. From this figure, we can see that the largest number of abandoned bio-digesters (39.02%) is linked to odors when mixing pig manure, a total of 16 bio-digesters out of 41. These results are contrary to those

found by Diop et al. in 2015 in Senegal, where 37 bio-digesters were found to be non-functional; the reasons were due to bio-digester feeding, 20 bio-digesters, followed by problems linked to bio-digester construction (12), insufficient gas (5) and breakdowns (3) see **Figure 5**.

Fuels used by biodigester owners before the project

From this figure, firewood is the fuel most used by the households surveyed. Of the 50 bio-digester owners surveyed, 40 said they used wood for cooking before the project, 8 used charcoal and 2 butanes, corresponding to 80%, 16% and 4% respectively. These results are in line with studies carried out by Diawara D. 2001 on the situation of forest genetic resources in Guinea, where household consumption of firewood is between 80 and 90%. This heavy reliance on wood resources contributes to deforestation and soil erosion see **Figure 6**.

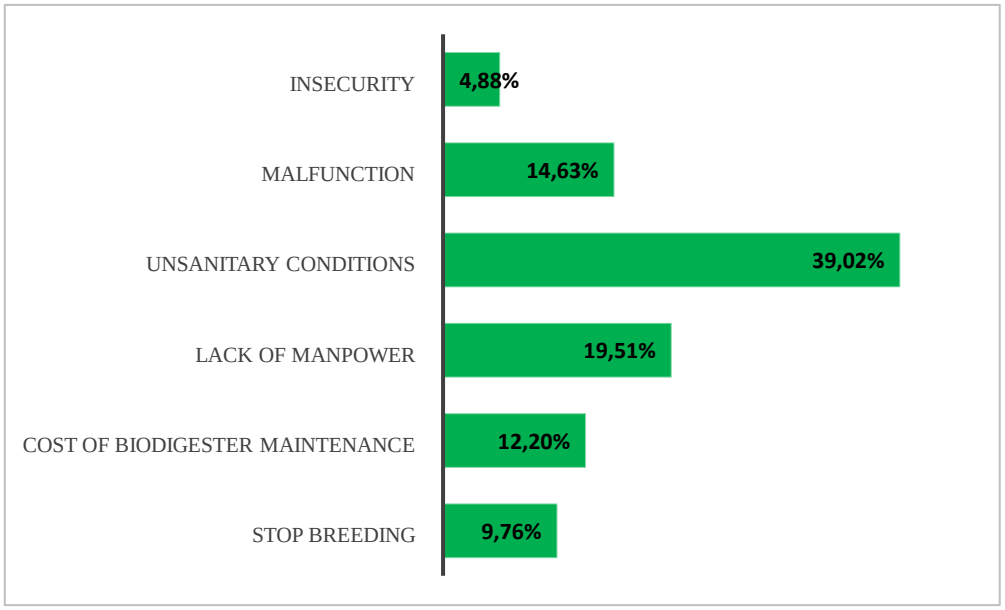

Figure 5. Reasons for biodigester non-functionality

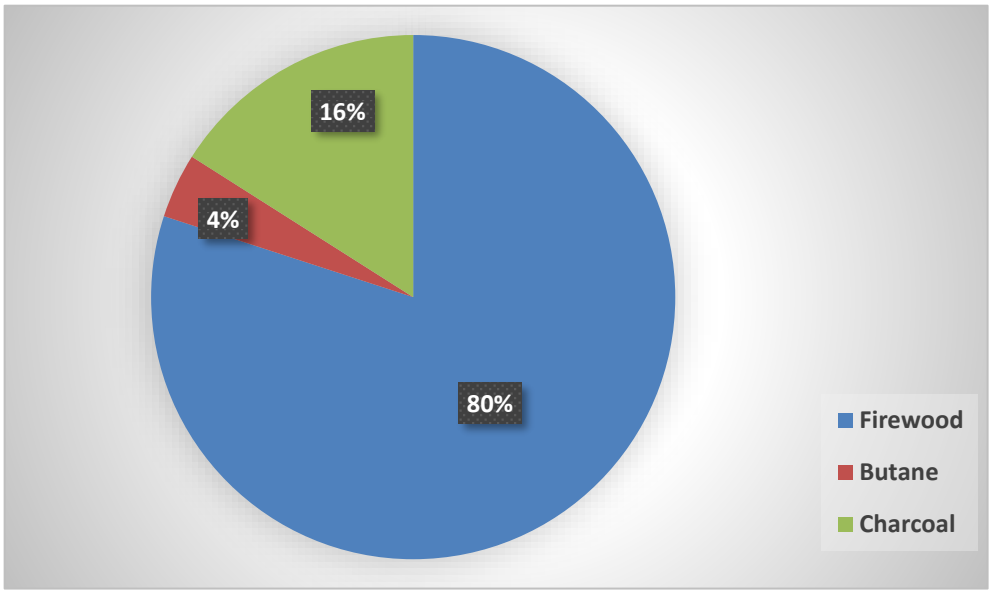

Figure 6. Fuels used before the project

Household firewood collectors

This figure shows that of the 40 bio-digester owners who claimed to use only firewood in their households before the project, 30 were women and girls responsible for collecting wood in the fields, representing 30 (75%). As for boys collecting wood, they numbered 10 (25%). We note that the search for firewood for cooking needs falls to women. These results are in line with studies carried out by the World Food Programme (WFP) and IOM in 2023 in the Goma camp in Congo, where 63% of women and 60% of girls were responsible for collecting firewood. This search for wood takes up time that the women could have devoted to social or income-generating activities. When wood is used, women are exposed to combustion fumes, which can lead to respiratory illnesses see **Figure 7**.

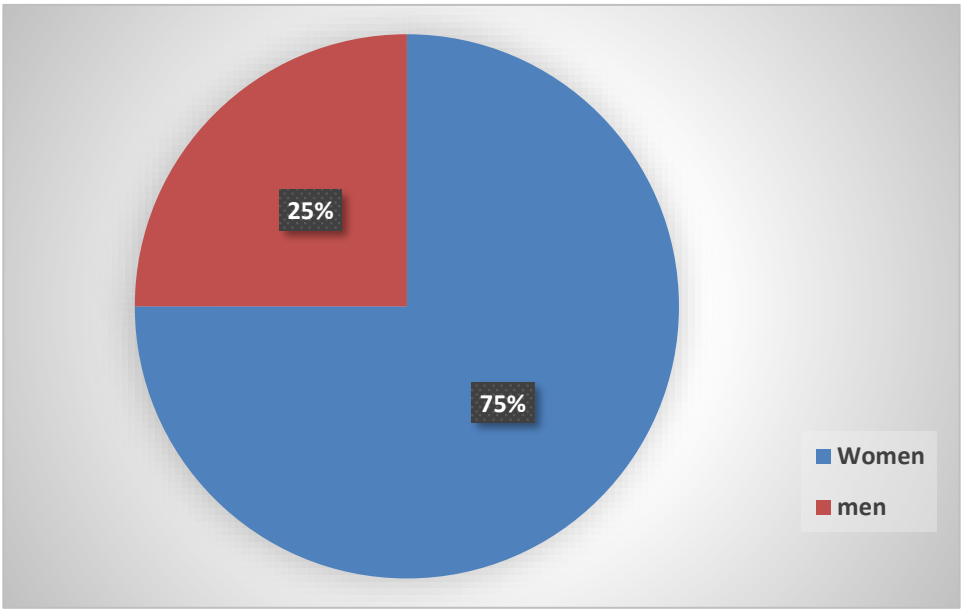

Figure 7. People responsible for collecting firewood

Cooking times for households using wood

Of the 40 firewood users, 23 said it took 2 hours to cook, 10 said 3 hours and 7 said 4 hours, giving an average of 3 hours. These results are in line with those of studies carried out by F. T. DIOP and colleagues in 2015, in which they found 3 hours of cooking for households cooking with wood see **figure 8**. The different variations in hours depend on the type of food cooked or the type of wood and collection periods. Indeed, wood collected during the rainy season does not have the same cooking times as wood collected during the dry season see **Figure 8**.

Cooking times for households using biogas

From this figure we can see that the average cooking time is 1.75 hours, which corresponds to 1h 45min min, compared with 3 hours for wood. In addition to the reduction in cooking time, the women surveyed stated that the use of biogas in cooking eliminates smoke and smoke-related illnesses see **Figure 9**.

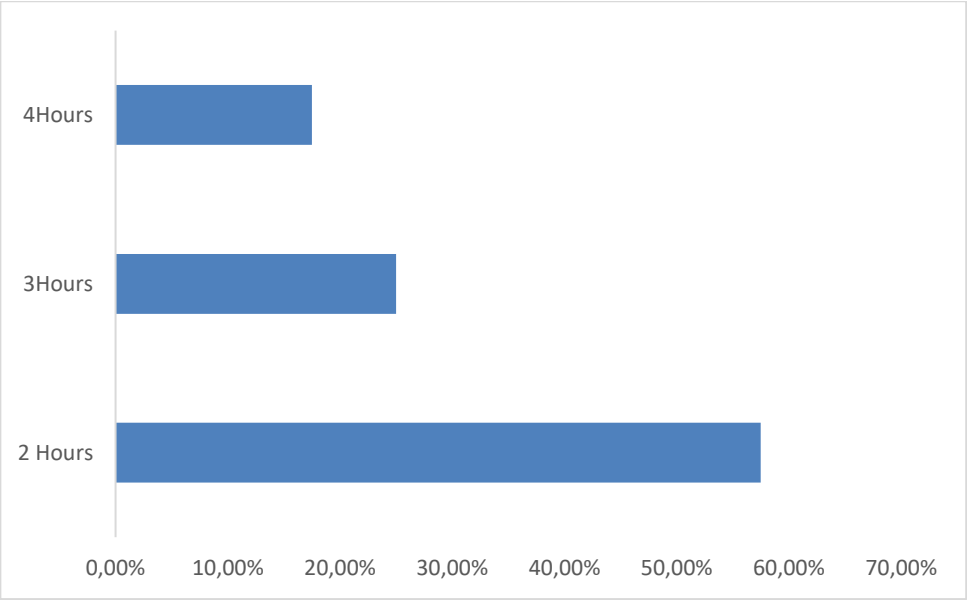

Figure 8. People responsible for collecting firewood

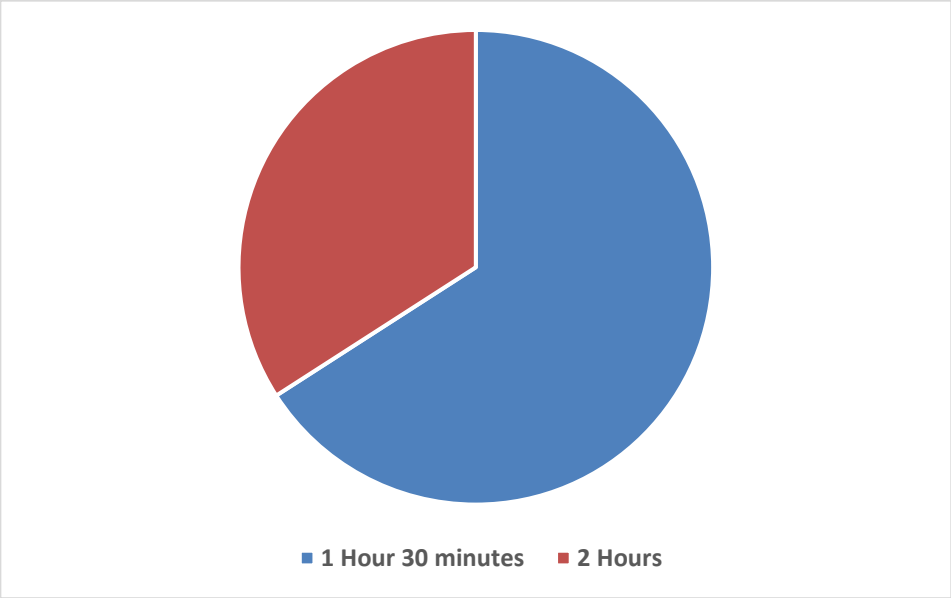

Figure 9. Cooking times for households using biogas

Advantages of biodigester use cited by owners

Despite the abandonment of biodigesters by their owners, we can see from this figure that biodigester owners are not unaware of the benefits associated with using this technology. Surveys have shown that the 44 owners of biodigesters in operation during the project period had access to biogas for cooking. 31.82% of owners stated that biodigester technology, in addition to providing access to renewable energy, helped to reduce household chores, especially those related to long-distance walking by women and girls in search of wood for cooking. 29.55% of owners mentioned access to renewable energy, but also the management of organic waste. The 15.91% of owners allude to the use of biogas in cooking, but also to the use of digestates as agricultural fertilizer for market garden crops. This use of

biofertilizer (digestate) reduces the use of chemical fertilizers. 22.73% specify that, in addition to access to energy, the use of biogas reduces cooking time see **Figure 10**.

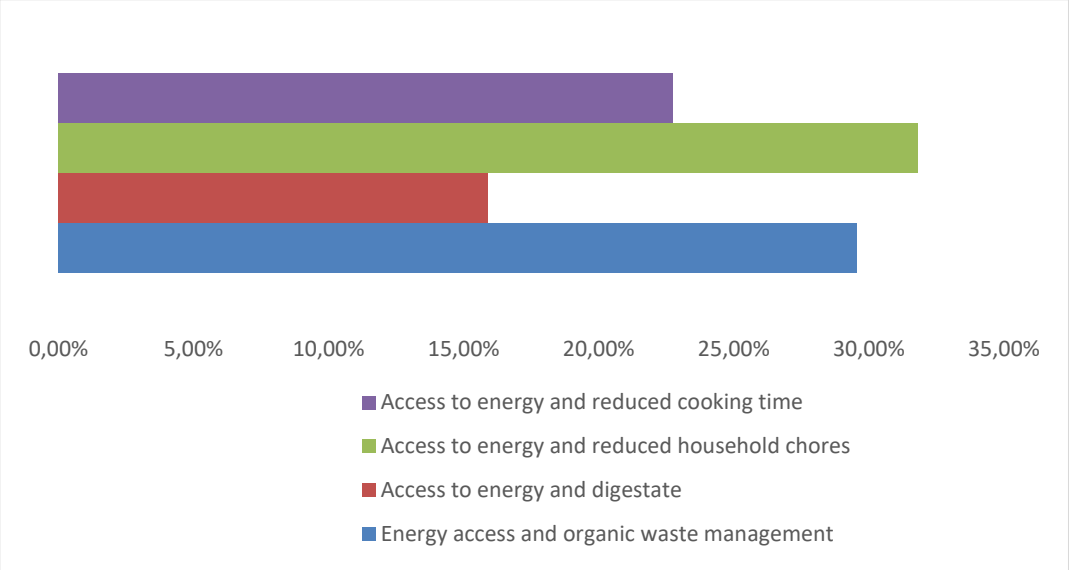

Figure 10. The advantages of using biodigesters

Conclusion

This study enabled us to highlight the fact that many biodigesters in N'Zérékoré prefecture are non-functional and even abandoned. The reasons for abandonment are linked to odors when mixing pig waste, 39.02% of a total of 16 non-functional biodigesters out of 41. However, the 44 owners of functional biodigesters had access to biogas during the project period for cooking. 31.82% said that biodigester technology, in addition to providing access to renewable energy, helped reduce household chores, particularly those associated with women and girls travelling long distances in search of firewood. 29.55% mentioned access to renewable energy, but also organic waste management. The 15.91% used digestate as agricultural fertilizer. 22.73% stated that, in addition to access to energy, the use of biogas reduces cooking time.

Biogas contributes to the management of organic waste, the production of green energy and the reduction of greenhouse gas emissions, making biodigesters a valuable tool for environmental and energy sustainability. However, the situation remains alarming, as biodigesters built in the forest region are being abandoned due to a lack of financial support and a lack of willingness on the part of biodigester owners.

We recommend state involvement in the support and popularization of bio-digesters;

extending the awareness campaign by promoters; financial support for farmers with bio-digesters; providing equipment to dilute waste during mixing; intensifying the sources of organic matter used as substrates for bio-digesters; strengthening the bio-digester control unit; training bio-digester owners in the management and use of digestates and effluents from waste treatment in agriculture.

Disclosure statement: *Conflict of Interest:* The authors declare that there are no conflicts of interest.
Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

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