Hindawi
Journal of Energy
Volume 2022, Article ID 1165136, 9 pages
https://doi.org/10.1155/2022/1165136

Research Article

Institutional Involvement and Collaboration in Disseminating Biogas Technology in Ghana

Martha Osei-Marfo,[1,2] **Albert Ebo Duncan**,[1] **Samuel Barnie**,[1] **Sampson Nyame Owusu**,[1] **Esi Awuah**,[3] **and Nanne de Vries**[2]

[1]*Department of Water and Sanitation, University of Cape Coast, Ghana*
[2]*Department of Health Promotion, Maastricht University, Netherlands*
[3]*Department of Civil Engineering, Kwame Nkrumah University of Science and Technology, Ghana*

Correspondence should be addressed to Albert Ebo Duncan; aduncan@ucc.edu.gh

Received 23 May 2022; Revised 10 August 2022; Accepted 11 October 2022; Published 21 November 2022

Academic Editor: Yukesh Kannah Ravi

Globally, biogas technology has been touted by academics, international organizations, United Nations, and pressure groups, among others, as an effective tool for protecting the planet against degradation. As such, stakeholders in the biogas technology sector have made some policy recommendations toward that goal. These include a global campaign in support of energy for sustainable development, climate financing by the international community, all countries adopting appropriate national strategies, innovative financial mechanisms, and encouraging private-sector participation in achieving the goal. Clearly, for countries to promote accessibility and create favorable perceptions on the adoption of biogas technology requires institutional involvement and collaboration. That is, institutions need to participate and contribute in terms of ideas and expertise as well as work together to ensure the dissemination and uptake of biogas technology in Ghana. This study is aimed at assessing the level of institutional involvement and collaboration and barriers to biogas technology dissemination in Ghana. A qualitative method was employed, and data were collected from 101 respondents through interviewing. The results indicated that the involvement of government and financial institutions in disseminating biogas technology was low, while biogas service providers showed moderate involvement. With regard to collaboration, it was revealed that institutions moderately collaborate in awareness creation but had low collaborations for promotion, monitoring, and evaluation. Furthermore, the lack of a national biogas policy, low government commitment towards biogas technology, and low financial support were key barriers to effective institutional involvement and collaboration in disseminating biogas technology in Ghana. It is recommended that the government shows a high commitment by providing the needed resources for dissemination activities and task the Ghana Energy Commission to formulate a national biogas policy to facilitate dissemination and adoption. Finally, a national biogas steering committee composed of all relevant stakeholders, including the Finance Minister or a representative from the Finance Ministry would create a good platform to help champion the dissemination of biogas technology in Ghana.

1. Introduction

The use of biogas technology for the production of clean energy has been touted by academics, international nongovernmental organizations (NGOs), United Nations, and pressure groups, among others, all around the world. In the United Nations (UN) sustainable agenda for 2030, the UN has expressed a strong determination to protect the planet from degradation through sustainable consumption and production, sustainable management of natural resources, and taking urgent actions in response to climate change with the ultimate goal of supporting the needs of the present and future generations [1]. According to WHO [2], about 3 billion people worldwide rely on traditional biomass for cooking and heating, which is alarming to the sustainability of the planet.

In Sub-Saharan Africa, extant research indicates that a very high proportion of the population relies on traditional

biomass (firewood) for domestic energy, citing Burkina Faso, Liberia, and Tanzania where over 95% of the population rely on firewood for cooking and heating [3]. The felling of trees for firewood without corresponding tree planting projects does not only degrade the planet but also it has great implications for climate change. For example, the use of firewood is a significant source of greenhouse gas emissions with its attendant health problems as a result of exposure to smoke [4].

In Ghana, almost 50% of the nation's energy consumption is for residential purposes, with about 76% of residents using firewood for cooking and related purposes [5]. This high use of biomass has been associated with the country's rising levels of atmospheric carbon dioxide. For instance, studies show that carbon dioxide emissions rose from 7.7 million tonnes in 2000 to 16.8 million tonnes in 2019 due to biomass energy usage (World Data Atlas) [5]. These statistics suggest that a considerable proportion of the Ghanaian population does not use sustainable energy and thus clearly indicates how unregulated means of energy consumption could have adverse consequences on the economy as well as the environment.

In view of this, the Advisory Group on Energy and Climate Change (AGECC) has proposed that the global community should focus on providing access to modern energy services by 2030 [6]. Accordingly, some actions have been recommended to help achieve this goal, including a global campaign in support of energy for sustainable development. All countries prioritize this goal through the adoption of appropriate national strategies, providing innovative financial mechanisms, climate financing by the international community, and encouraging private-sector participation in achieving the goal, etc. [6].

To address energy and related socioeconomic and environmental challenges, the development and dissemination of biogas technology (BT) offer a promising intervention. Nonetheless, the use of BT is still at its infant stage in Ghana despite the fact that the technology was introduced some three decades ago [7]. According to Bensah et al. [7], there is a market potential for the installation of 16,207 household biogas plants in Ghana. Meanwhile, Hanekamp and Ahiekpor [8] have noted that at least 400 biogas installations have been constructed throughout Ghana, thus calling on the government to establish a national biogas programme. Evidence from the above empirical studies clearly indicates that biogas technology has been underutilized in Ghana.

Additionally, Arthur [9, 10] have stated that about 815,109 m^3 of biogas from sewages of four public universities in Ghana annually, which is equivalent to 4,891 MWh of energy can replace 4,532 tonnes of firewood. While the government of Ghana sought to achieve 2% penetration of biogas for cooking in hotels, restaurants, and institutional kitchens by 2020 [5], Brew-Hammond [3] argues that to get near that target, a significant increase in the number of stakeholders together with more effective institutions in the renewable energy sector will be required. Other empirical studies have indicated that government incentives, long-term financing, and capital grants contribute to the growth/dissemination of BT, especially when the government recognizes BT as a tool for reducing greenhouse gas emissions and a means of using less fossil fuels [11–13].

Specific to Ghana, biogas technology-related research has focused mainly on biogas dissemination in Ghana ([14]), biogas as a potential renewable energy source [9, 10], prospects for household biogas plants [7]; biogas generation from sewage [9, 10], and feasibility study to establish institutional biogas system [8]. There is, however, no empirical study focusing on institutional involvement and collaboration in disseminating BT in Ghana during the period of this work. This study therefore explores the level of institutional involvement and collaboration, and barriers to the dissemination of biogas technology in Ghana.

2. Institutional Arrangement

The term institutional arrangement has been widely defined and used by several researchers in different fields, yet there has not been a full consensus on its definition among scholars. For some researchers, the institutional arrangement is comparable to markets, state, corporate hierarchies, networks, associations, and communities [15]. Similarly, Eaton et al. [16] refer to an institutional arrangements as a set of rules or agreements governing the activities of a specific group of people pursuing a certain objective. In the view of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), institutional arrangement refers to the formal government organizational structures as well as informal norms which a country puts in place for arranging and undertaking its policy work [17].

This organizational structure makes use of informal institutions such as the general public, nongovernment organizations, and private sector groups. According to Hodgson [18], such institutions are characterized by: their own established criteria to define their boundaries of influence, as well as differentiate their members from nonmembers; specific lines of command with clear accountability; defined members responsibilities, rules and regulations to be followed by all members, and a clear set of objectives to be achieved [19].

This study, therefore, defines institutional arrangements as organizational structures, both formal government institutions and private sector groups (biogas service providers and financial institutions) which are in place to facilitate the dissemination of BT in Ghana.

2.1. Government Institutions. Government institutions refer to the relevant government bodies that have been tasked by law to collaboratively see on the development, promotion, management, and utilization of renewable energy [20] in Ghana. These relevant institutions include but are not limited to the Energy Commission (EC); Environmental Protection Agency, Ghana (EPA); Ministry of Food and Agriculture; Ministry of Environment, Science, Technology, and Innovation (MESTI); Metropolitan, Municipal, and District Assemblies (MMDAs) of Local Government; Ministry of Sanitation and Water Resources (MSWR); and Ghana National Cleaner Production Centre (GNCPC).

According to the RE Act 2011, these relevant institutions shall collaborate with the Energy Commission in the exercise of its powers and performance of its functions and dissemination of renewable energy.

2.2. Biogas Service Providers. Biogas service providers refer to individuals and institutions that have registered with Biogas Association of Ghana (BAG). The formation of BAG was initiated by Energy Commission of Ghana, Environmental Protection Agency, Ghana, and Ghana National Cleaner Production Centre (GNCPC) in 2017. The objective is to carry out, encourage, and support research into BT and to ensure the development of quality standards by training actors in the industry based on modern approved practices [21]. The association is also to ensure creating awareness of the benefits of BT in Ghana. Membership of BAG stands at 66 (38 registered members and 28 company members). BAG, which is supposed to be coordinating the activities of its members, is a not-for-profit institution and solely depends on the support of donor agencies to run its activities. However, biogas service providers operate purely on business grounds and are important stakeholders in the dissemination of BT in Ghana.

2.3. Financial Institutions. Research has shown that financial institutions are key stakeholders in the promotion of BT [7, 9, 10, 22, 23] and, for that matter, are considered relevant in assisting in the articulation and functioning of institutions mandated for the deployment of BT. In India, for example, the Ministry of Finance, banks, and other financial institutions form part of the committees responsible for biomass energy policies and strategies for deployment and execution [24]. Similarly, in Burkina Faso, the Ministry of Finance and Economy is an active member of the steering committee for the National Biodigester Programme, which sees to the promotion and construction of biogas plants [25]. The formulation of such committees brings about better collaboration between financial institutions and all BT stakeholders.

However, Ghana is yet to have such a committee on the national biogas programme. It is high time Ghana adopted either Burkina Faso's or India's model of involving the Ministry of Finance in BT steering committee, to get the financial institutions on board to support BT development. List of some of the financial institutions that participated in this study include: GCB Bank, National Investment Bank (NIB), Zenith Bank, Fidelity Bank, ADB Bank, Prudential Bank, etc.

2.4. Institutional Involvement and Collaboration. Extensive research conducted over the years highlights the value of institutional involvement and collaboration [14, 23]. This study defines institutional involvement as the participation and contribution by both government and private organizations in terms of ideas and expertise to facilitate the diffusion or dissemination of BT in Ghana, while collaboration is the process by which government and private organizations work together to ensure the dissemination and uptake of BT in Ghana.

Benefits of institutional involvement and collaboration are numerous, including subsidies and credit arrangements, manuals and guidelines, training, and supply of spare parts [19]. Other benefits involve maintenance services, monitoring and evaluation services [23], supervision services, and research and development [19].

Strategies to foster significant institutional involvement and collaboration include establishing a biogas programme with full government support, ensuring a financial flow mechanism, encouraging and facilitating private sector coordination [25], and establishing a regulatory body for biogas service providers [23].

Nonetheless, institutional involvement and collaboration is almost nonfunctional despite the mandate or task assigned to relevant government institutions by the [20], especially for biogas technology development. Additionally, due to the size and quality of human resources, an institutional structure on renewable energy seems to be established mainly at the national level [19], making the activities at the regional and district level more challenging. Furthermore, one other barrier to institutional involvement and collaboration is dissemination of tools [6, 13]. Thus, little or no resources are available for undertaking their activities.

2.5. Feasibility of Biogas Technology. Globally, about 50 million biogas plants have been installed, with the majority of these plants located in Asia, with concentrations in China, Nepal, India, Bangladesh, Vietnam, and Cambodia [26]. In sub-Saharan Africa, the dissemination to date has been more limited, even though East Africa has made good progress (Ethiopia and Kenya have almost 21,000 units each), and in West Africa, Burkina Faso has over 12,000 units installed (Hivos-ABPP 2018 production data). Yet, according to Heegde and Sonder [27], a study conducted by Netherlands Development Organization (SNV) and International Institute for Agriculture revealed that cooking with biogas is technically feasible for 18.5 million households and consequently, benefiting about 150 million people in Sub-Saharan Africa. Nonetheless, various barriers hinder the dissemination and scale-up of biogas technology across the African continent [25]. In Ghana, at least 400 known biogas plants have been installed [8], with the predominant design being fixed-dome, floating drum, and the Puxin type. Improvement of sanitation challenges and the search for alternative energy sources have been the main motivation for building biogas plants [23]. Studies have shown that a majority of the existing biogas plants, especially those meant for an energy source did not meet the expectations of its users [14, 23, 28]. On the other hand, biogas plants built for sanitation improvement are functioning well [8, 23]. Both Hanekamp & Ahiekpor [8] and Osei-Marfo et al. [23] have indicated that biogas technology is technically feasible in Ghana, citing unstandardized digester design and quality control of digester design, lack of monitoring during construction, lack of maintenance, and lack of follow-up by relevant institutions as key setbacks to the technology. It is imperative to note that the key to ensuring the sustainability of a biogas plant largely depends on the financial commitment on the part of users towards undertaking periodic maintenance of the system throughout the plant's lifetime. Osei-Marfo et al. [23] found that most plants are left to the

mercy of the weather once constructed, yet users expect optimum yield.

2.6. Policies and Institutional Framework on Renewable Energy. Renewable energy policies in Ghana were initially developed in response to energy crises in the early 1980s, when there was a major drought, resulting in reduced inflows to the Volta hydropower reservoir [5]. This crisis adversely affected the overall performance of the economy, hence, it became the government's priority to develop policy and to set up a working groups to address the energy issues. Apparently, there was the need to explore other renewable energy sources to augment the hydropower due to the crisis. Since the 1980s to the present, successive governments as well as development partners have supported to promote renewable energy technologies in Ghana through policies, plans, and strategy documents. A list of major policies, plans, and strategy documents that have been developed since 1986 include Issues and Options in the UNDP/World Bank [29]; National Electrification Scheme (1989); Ghana-Vision 2020 [30]; Ghana Poverty Reduction Strategy (GPRS) (2003); National Renewable Energy Strategy (NRES) (2003); Growth and Poverty Reduction Strategy (2006); ECOWAS White Paper on Access to Energy Services (2006); Strategic National Energy Plan (SNEP) (2006/2020); Ghana Shared Growth and Development Agenda (GSGDA) I & II (2009/2014); National Energy Policy (2010); Energy Sector Strategy and Development Plan (2010); [20] (Act 832); Sustainable Energy for All Action Plan/Agenda of Ghana (2012/2016); Mini-grid Electrification Policy (2016), Bioenergy Policy (Draft) (Government of Ghana, 2018); and Renewable Energy Master Plan (2019).

In spite of all these policies, the main goal of the renewable energy subsector, which is to increase the proportion of renewable energy supply mix by 10% by 2020 and to contribute to the mitigation of climate change, is yet to be achieved.

With regard to all policy documents, Ana-Vision 2020 [30] sets strategic targets to encourage pursuing a vigorous programme in BT by setting up models in rural areas to reduce the pressure on forests for wood fuel, and to expand electricity supply using natural gas, solar energy, biogas, and domestic and industrial waste; Energy Commission [5] sets a target of 2% biogas technology by 2020; while RE Act [20] makes provision for feed-in-tarrif for renewable energy sources.

3. Methodology

This study adopted a descriptive design [22] to analyze and assess the extent of institutional involvement and collaboration in BT dissemination in Ghana. The study was conducted from January to May 2019 in the Central and Greater Accra regions of Ghana. These regions do not have the same number of installed biogas plants. The Greater Accra has higher biogas installations than the Central region; Greater Accra is the capital city of Ghana, and it is believed that businesses thrive there compared to the other regions; hence, there is inattention to the other regions [23]. The respondents for this study are heads of relevant governmnent institutions, project managers of financial institution, biogas service providers, and biogas experts/consultants. These respondents were selected based on their involvement directly or indirectly in renewable energy (biogas, solar, and wind).

Sample size was determined using Godden [31] as seen in Equation (1). Nonprobabilistic sampling technique was used in this study. Respondents were approached by the researcher to request for their consent to participate in the study, after the aim of the study was explained to them. Six interviewers conducted the interview with two people (the interviewer and the interviewee) present during each interview session. The interview was structured into sections: background information (government, financial, biogas expert, and biogas service provider), institutional involvement, collaboration with relevant institutions, and barriers to BT dissemination. One-on-one face-to-face interviews were conducted with all government institutional heads, biogas experts, project managers of financial institutional, and 15 biogas service providers, while 26 of them granted telephone interviews due to their busy schedules and location. Interviews were recorded and transcribed into written form for descriptive analysis. The results presented are those reflecting the respondents perspective and are presented in frequencies, percentages, charts, and direct quotations.

$$n = \frac{Z^2 * P(1-P)}{C^2}, \tag{1}$$

where n is the sample size, Z is the confidence level (95%), P is the total number of respondents, and C is the confidence interval (5%).

By substitution, the sample size for respondents is 80, however, the total population of 101 was used, see Table 1.

4. Results and Discussion

4.1. Institutional Involvement. Respondents were inquired to indicate their level of institutional involvement in promoting BT by rating them as low, moderate, or high (see Figure 1). The levels of involvement are described as follows.

4.1.1. Government Institutions. The response from the respondents revealed that the involvement of mandated government institutions in BT dissemination could generally be described as low ($n = 11$, 69%), although few indicated moderate ($n = 4$, 25%), and high ($n = 1$, 6%), respectively. This according to the respondents could be attributed to differences in services, roles, and expectations. These differences may cause role overlap or confusion, especially during decision-making. Although the respective institutions have their respective services, respondents had an expectation that all relevant government institutions would come together to draw a program of activities to guide and facilitate their involvement in BT activities. They appear to be independent, hence carry out their independent activities. Nonetheless, the Energy Commission, EPA, and GNCPC do collaborate and work together mostly when there is a

Table 1: Respondent status and sample size distribution.

Respondent category	Population size	Percentage of total	Sample size
Government institutions	16	16	13
Biogas service providers	41	41	33
Financial institutions	37	36	29
Biogas experts/ consultants	7	7	5
Total	101	100	80

major activity to be undertaken (workshops/seminars with biogas service providers) or when experts' contributions are needed on a major project. The majority acknowledged that their involvement with biogas service providers and financial institutions in undertaking activities is relatively low, even though these institutions are relevant stakeholders and are key in BT dissemination.

4.1.2. Biogas Service Providers. biogas service providers indicated that there exists moderate ($n = 31$, 76%), low ($n = 8$, 19%), and high ($n = 2$, 5%) involvement among them, as an association with government institutions with a majority of the involvement being moderate. Thus, they participate in activities that are organized by government institutions, especially the Energy Commission, EPA, GNCPC, and the MMDAs. Although their activities are mostly undertaken in the MMDA BT adoption and is used by many communities and households in Ghana can be described as low, this could be attributed to the low commitment by the MMDAs towards the dissemination of BT. Additionally, it was discovered that very low or no collaboration exists between service providers and financial institutions. Thus, biogas service providers do not receive any financial support from financial institutions. Their projects are funded by themselves or donor agencies. The executives of biogas service providers also revealed that they were in consultation with the Energy Commission in securing a license for BAG members to enable proper monitoring of their activities by the association. That became necessary due to the frustration members go through in obtaining a license for operations and the need to keep records of biogas installations.

4.1.3. Financial Institutions. it was revealed that low ($n = 35$, 95%) institutional involvements exists between financial institutions, biogas service providers, and government institutions. Although these financial institutions indicated that they have at once supported RE projects (solar and hydropower), BT does not appear to be promising and that the risk of failure is quite high. These factors might have contributed to their low involvement in supporting the dissemination of BT in Ghana. They, however, indicated that they were prepared to support relevant stakeholders in which ever capacity they could.

4.2. Collaboration with Relevant Institutions. Respondents, composed of biogas service providers, government, and financial institutions, were asked to indicate the level of collaboration between their institutions and other relevant institutions as low, moderate, or high, in terms of awareness creation, promotion, monitoring, and evaluation (see Figure 2). The answers or responses of the assessment are:

4.2.1. Awareness Creation. It is meant to let people know that BT exists and that it can contribute to improve community livelihood, environment, and economy, thereby alleviating poverty. A majority of the respondents indicated that collaboration in terms of awareness creation was moderate ($n = 48$, 51%) with the others indicating high ($n = 4$, 4%), and low ($n = 42$, 45%) collaborations, respectively. BAG on behalf of biogas service providers has been up to the task of creating awareness occasionally. They engage the media houses (television and radio) to discuss BT and its associated benefits whenever they receive funding from donor agencies. The government institutions, also through sanitation challenge workshops create awareness. BT is usually presented as a sustainable alternative for solving sanitation challenges. Outcomes of such workshops are mostly aired on radio or television as a news items to the Ghanaian populace, hence, creating awareness.

4.2.2. Promotion. it is about publicizing BT and its benefits, to increase the adoption and uptake rate. This could be achieved through media advertisements, signpost, and hand flyers [23] as well as word of mouth by users. The majority of the respondents who indicated low collaboration ($n = 76$, 81%) for BT promotion were of the view that BT was not a priority project, hence, the government's commitment towards its promotion is low. Furthermore, 15% ($n = 14$) and 4% ($n = 4$) of the respondents indicated moderate and high collaborations, respectively. This is reflected in the low resource availability (finance and other logistics) for BT promotion activities. Resources that would facilitate the work of mandated government institutions are readily not available, making promotion activities and programs challenging. Few BAG members who can afford the cost of advertising their services do so to expand their business [23], and by that BT receives some level of promotion.

The financial institutions indicated that they have no memorandum of understanding with the relevant institutions (both government and private) to support BT promotion activities; therefore, their annual budget does not make provision for that in a situation they are called upon for support. Furthermore, BAG revealed that there is no national biogas policy to aid BT promotion, which would consequently increase its uptake. These setbacks, coupled with others do not ensure the success and effectiveness of BT promotion in Ghana and this is supported by a similar study [32]. As such, BT dissemination has been very low in Ghana even though the technology was introduced over three decades ago [14].

4.2.3. Monitoring. it is meant to be a regular gathering of information on the activities of BT to track the progress or

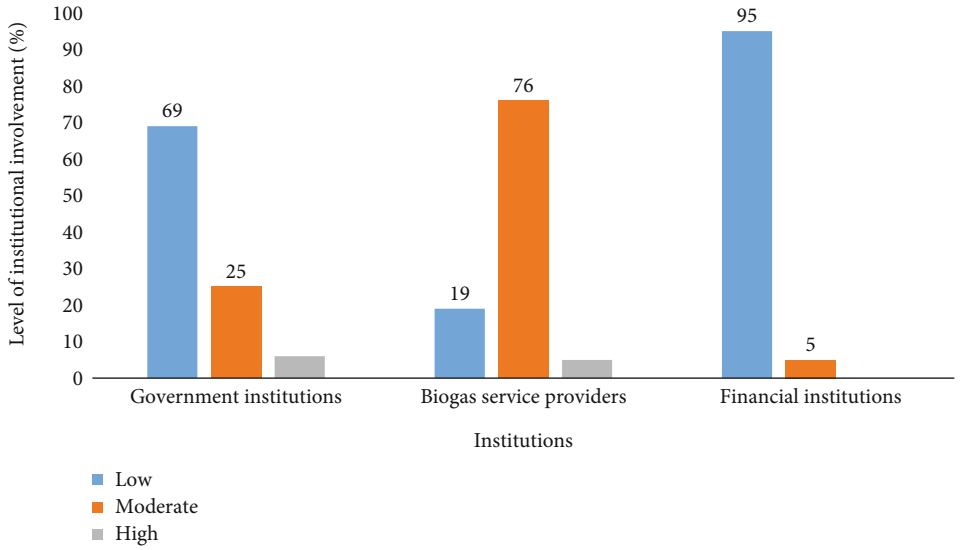

Figure 1: Institutional involvement in biogas promotion.

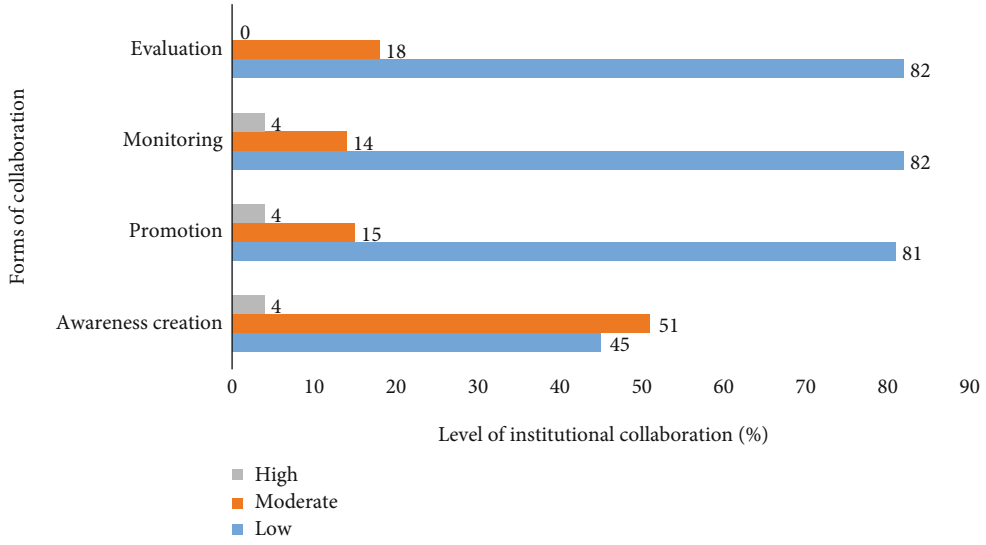

Figure 2: Level of collaboration.

dissemination [12]. Respondents revealed that there is low collaboration in terms of monitoring ($n = 77$, 82%) and that there is no monitoring team to even check the quality standards of biogas installations. Additionally, the respondents showed moderate ($n = 13$, 14%) and high ($n = 4$, 4%) monitoring collaborations, respectively. The institutions mandated by law to collaborate and ensure the development of BT, which includes monitoring both government and private organizations are handicapped. Respondents, especially those in the government institutions, indicated that this could be attributed to inadequate resources and lack of political will. Due to lack of monitoring, there is no record of total installed biogas digesters/plants in Ghana and this is supported by previous research [14, 23]. Thus, institutions and especially the biogas service providers are carrying out their activities without any form of monitoring to ensure that the right things are being done. Research has shown that proper monitoring can yield positive results such as identifying gaps and challenges in activities, and revising how activities are conducted due to the information gathered [12]. Effective monitoring will therefore go a long way to improve the dissemination of BT and consequently, increase its uptake.

4.2.4. Evaluation. this involves gathering and analyzing information about BT activities to improve its effectiveness [33]. Respondents indicated that collaboration regarding the evaluation of BT activities (e.g., awareness creation and

promotion) is generally low ($n = 77$, 82%) with the rest showing moderate collaboration ($n = 18$, 18%). There is no existing committee which evaluates BT activities to suggest measures to be taken to improve BT activities. As a result of low collaboration in terms of evaluation, there has not been much improvement in BT dissemination and adoption in Ghana. Additionally, the impact of BT and its numerous benefits are not experienced by the Ghanaian populace. Research has shown that evaluation brings about improvements in program design and implementation as well as demonstrates program impact on society. Lack of evaluation could lead to spending a significant amount of money and time pursuing strategies that may cause no change to the issue being addressed [34]. Furthermore, without evaluation, the society may not know about the great work that relevant institutions and stakeholders might be doing to solve existing sanitation challenges, which includes the adoption of BT.

4.3. Biogas Experts'/Consultants' Opinion. The opinions of biogas experts were sought as a way of assessing the level of institutional involvement and collaboration in dissemination BT. These biogas experts have about 10 years' experience in BT. They were of the view that institutional involvement is either low or almost nonexistent, stating that laws and regulations have inadequate implementation strategies; hence, there is no clear direction to be followed. With regard to collaboration, they indicated that it is relatively low, except on occasions where donor agencies sign a memorandum of understanding to collaborate with government institutions that may also require the involvement of private institutions. In such situations, both government and private institutions (biogas service providers) collaborate for joint programs.

One expert remarked: "we have very good institutions but they do not see the urgency in collaborating to make BT attractive to people. BT has many benefits, but how will people get to know if there is no intentional awareness creation or promotion? Government institutions should seriously collaborate with BAG to carry out this important task" This is an indication that collaboration has not been the best among relevant institutions.

Another expert expressed: "the [20] and other regulations and policies are not explicit on BT promotion strategies. Very little information has been given to BT, however, much is said about other renewable technologies. There should be a national biogas policy to guide BT dissemination and strategies for implementation". Thus, existing policies/regulations do not emphasize or are somehow silent on BT compared to other renewable resources.

Finally, another expert stated that: "it appears the government has no interest in BT promotion, which consequently has led to the low dissemination by relevant institutions. If the government should show interest and commitment, the end result will be increased BT adoption and uptake in Ghana". Thus, it is clear that experts consider the commitment of the government in BT dissemination as low and that it has in turn affected relevant government institutions, in particular, in promoting BT.

The above comments imply that these biogas experts are not satisfied with the level of institutional involvement and collaboration in dissemination BT in Ghana.

4.4. Challenges/Barriers to BT Dissemination. During the study, some barriers were identified as hindering the effective dissemination of BT. Key among them include the following.

4.4.1. Lack of a National Biogas Policy. BT faces an intense challenges as far as dissemination and uptake is concerned. It is in competition with other cheaper alternatives like wood fuel and sawmill residue, which are available locally for cooking applications [9, 10, 13] as well as other sanitation systems like septic tank, ventilated improved pit, pour flash, and biofilm, for excreta management. These alternatives, however, have negative health and environmental impacts associated with their use, i.e., indoor air pollution causing respiratory diseases, loss of forest resources, emission of greenhouse gases, and air pollution [9, 10, 13].

These negative impacts do not only affect health and the environment, but the economy as a whole. This therefore calls for a national BT policy to be formulated, which will be a stand-alone document to support its dissemination. The policy, when formulated could detail the strategies to be employed to create awareness and promotion, thereby increasing BT uptake. Additionally, the policy may highlight the long-term benefits associated with BT, i.e., improvement in community livelihood and health, sanitation, sustainable energy, and reduced emissions [35] during the promotion exercise. These could whip the interest of potential users to forego other energy and sanitation alternatives, however cheap they may be due to their associated negative impacts. Furthermore, when a national BT is formulated and enforced, all new building projects would be obliged to install biogas systems while old buildings replace other sanitation technologies with biogas technology. This will consequently improve health, environment, and the economy.

4.4.2. Low Government Commitment. one main barrier to effective BT dissemination is low government commitment. The commitment of government in the dissemination of BT is key to its success. Government's commitments may be in the form of financial resources for BT development, allocation of air time for awareness creation on national television and radio, provision of vehicles for BT promotion activities, human resource capacity development, developing a public-private partnership BT business model, and instituting a national biogas program. It is worth noting that many BT projects have failed or faced challenges shortly after diffusion in Ghana due to low government commitment and this is supported by [14]. However, BT diffusion has been successful in other countries due to high government commitment as well as the government recognizing BT as a tool for reducing greenhouse gas emissions and a means of using less fossil fuel ([11], as cited in Ministerie van LNV et al., [36]).

Thus, high government commitment could motivate mandated institutions and other stakeholders to advance BT dissemination with much efficiency. There is no doubt

that the government's commitment towards BT dissemination plays a significant role in achieving success or failure.

4.4.3. Low Financial Support/Financial Challenges. one of the important barriers to BT dissemination in Ghana is low financial support. It is known that the success or failure of a relatively new technology depends mostly on financing [19]. It was revealed that many BT activities have been ineffective and or halted due to very low financial support. It is usually incumbent on the government to make financial resources available for the dissemination of technology (BT) which will have a positive impact on peoples' health, sanitation, and the whole economy, however, due to financial constraints, other financial institutions are expected to assist to ensure its success. Conversely, these financial institutions are not readily motivated to support BT promotion activities because of the risk of failure and/or no trust in the success of the technology [23]. This was confirmed during interviewing with project managers of financial institutions: it came to light that the collaboration was almost nonexistent and there is no memorandum of understanding between them (financial institutions) and relevant BT stakeholders (government institutions and biogas service providers).

5. Conclusions and Recommendations

This study concludes that institutional involvement and collaboration in disseminating BT is generally low, although the technology was introduced about three decades ago. Thus, institutional involvement is low for both government and financial institutions, whereas, biogas service providers show moderate involvement in disseminating BT in Ghana. Additionally, institutional collaboration in terms of awareness creation is moderate, while collaborations regarding promotion, monitoring, and evaluation are all low. The barriers relating to effective institutional involvement and collaboration in dissemination BT are associated to lack of a national biogas policy which makes the technology loose its importance, low government commitment, and low financial support. However, the financial institutions indicated their interest and willingness to support the dissemination of BT in the near future.

Based on the study outcomes, the following recommendations are made:

(i) the government should task the Energy Commission to formulate a national biogas policy

(ii) that government shows high commitment by making the needed resources available for use to improve BT dissemination and uptake

(iii) a national BT steering committee, composed of experts including the finance minister should be constituted to champion the cause of BT

Data Availability

The raw data was processed to produce the results in this manuscript.

Disclosure

This manuscript has been submitted as part of a PhD thesis.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This work was supported by the Netherlands Government under the NUFFIC project NICHE 194-01 (grant number CF9419) and the University of Maastricht, Netherlands. The authors would like to thank all respondents for their support during the data collection.

References

[1] UN, *Transforming our world: the 2030 agenda for sustainable development*, New York, 2015.

[2] WHO, *WHO Publishes New Global Data on the Use of Clean and Polluting Fuels for Cooking by Fuel Type*, Geneva, Switzerland, 2022.

[3] A. Brew-Hammond, "Energy access in Africa: challenges ahead," *Energy Policy*, vol. 38, no. 5, pp. 2291–2301, 2010.

[4] C. S. Bhattacharya and P. Abdul Salam, "Low greenhouse gas biomass options for cooking in the developing countries," *Biomass and Bioenergy*, vol. 22, no. 4, pp. 305–317, 2002.

[5] Energy Commission, *Strategic National Energy Plan 2006 - 2020*, Energy Commission, Ghana, 2006.

[6] AGECC, *Energy for a sustainable future, The Secretary-General's Advisory Group On Energy And Climate Change. Summary Report And Recommendations*, New York, 2010.

[7] C. E. Bensah, M. Mensah, and E. Antwi, "Status and prospects for household biogas plants in Ghana – lessons, barriers, potential, and way forward," *International Journal of Energy and Environment*, vol. 2, no. 5, pp. 887–898, 2011.

[8] E. Hanekamp and J. C. Ahiekpor, *Technical assistance to the Ghana Energy Commission to develop a dedicated programme to establish institutional biogas systems in 200 boarding schools, hospitals and prisons, and to prepare for CDM application: feasibility study*, Ghana, 2015.

[9] R. Arthur, F. M. Baidoo, and E. Antwi, "Biogas as a potential renewable energy source: a Ghanaian case study," *Renewable Energy*, vol. 36, no. 5, pp. 1510–1516, 2011.

[10] R. Arthur, F. M. Baidoo, A. Brew-Hammond, and C. E. Bensah, "Biogas generation from sewage in four public universities in Ghana: a solution to potential health risk," *Biomass and Bioenergy*, vol. 35, pp. 3086–3093, 2011.

[11] J. Sok, *Economic and institutional aspects of biogas production, [M.S. thesis]*, Agricultural Economics and Rural Policy, 2012.

[12] P. Bartle, "The nature of monitoring and evaluation," 2007, http://cec.vcn.bc.ca/cmp/modules/mon-wht.htm. Accessed May 2020.

[13] S. Mittal, O. E. Ahlgren, and R. P. Shukla, "Barriers to biogas dissemination in India: a review," *Energy Policy*, vol. 112, pp. 361–370, 2018.

[14] C. E. Bensah and A. Brew-Hammond, "Biogas technology dissemination in Ghana: history, current status, future prospects,

and policy significance," *International Journal of Energy and Environment*, vol. 1, no. 2, pp. 277–294, 2010.

[15] J. Hollingsworth and R. Boyer, *Contemporary Capitalism: the Embeddedness of Institutions*, Cambridge University Press, 1997.

[16] D. Eaton, G. Meijerink, and J. Buman, *Understanding Institutional Arrangements: Fresh Fruits and Vegetable Value Chain in Eastern Africa. Markets, Chains and Sustainable Development Strategy & Policy Papers, no. XX*, Stichting DLO, Wageningen, Netherlands, 2008.

[17] UN-GGIM, *Trends in National Institutional Arrangements. 7th Session of the Committee of Experts*, United Nations, 2017.

[18] G. M. Hodgson, "What are institutions?," *Journal of Economic Issues*, vol. XL, no. 1, 2006.

[19] M. G. Mengistu, B. Simane, G. Eshete, and S. T. Workneh, "Institutional factors influencing the dissemination of biogas technology in Ethiopia," *Journal of Human Ecology*, vol. 55, no. 1-2, pp. 117–134, 2016.

[20] Parliament of the Republic of Ghana (PRGH), *Renewable Energy Act, 2011, Act 832*, 2011.

[21] Daily Graphic, "Biogas association formed to promote technology," 2016, https://www.graphic.com.gh/news/general-news/biogas-association-formed-to-promote-technology.html.

[22] G. T. Berhe, G. R. Tesfahuney, A. G. Desta, and S. L. Mekonnen, "Biogas plant distribution for rural household sustainable energy supply in Africa," *Energy and Policy Research*, vol. 4, no. 1, pp. 10–20, 2017.

[23] M. Osei-Marfo, E. Awuah, and N. K. de Vries, "Biogas technology diffusion and shortfalls in the central and Greater Accra Regions of Ghana," *Water Practice Technology*, vol. 13, no. 4, pp. 932–946, 2018.

[24] R. Singh and D. S. Setiawan, "Biomass energy policies and strategies: harvesting potential in India and Indonesia," *Renewable and Sustainable Energy Reviews*, vol. 22, pp. 332–345, 2013.

[25] Bank, W, "The power of dung: lessons learned from on-farm biodigester programs in Africa," 2019.

[26] H. Clemens, R. Baillis, A. Nyambane, and V. Ndungu, "Africa biogas partnership programm: a review of clean cooking implementation through market development in East Africa," *Energy for Sustainable Development*, vol. 46, pp. 23–31, 2018.

[27] F. Ter Heegde and K. Sonder, *Biogas for Better Life: An African Initiative: Domestic Biogas in Africa; a First Assessment of the Potential and Need: Discussion Paper*, SNV - Netherlands Development Organisation, 2007.

[28] W. Ahiataku-Togobo and Y. P. Owusu-Obeng, *Biogas technology- what works for Ghana?*, Ghana, 2016.

[29] UNDP/World Bank, *Ghana: Issues and Options in the Energy Sector*, UNDP, 1986.

[30] Ghana-Vision 2020, "The first step:1996-2020. Presidential report on co-ordinated programme of economic and social development policies," 1995.

[31] B. Godden, "Sample Size Formulas," *Journal of Statistics*, vol. 3, p. 66, 2004.

[32] D. K. Njoroge, "Evolution of biogas technology in South Sudan: current and future challenges," in *Proceedings of the Biodigester Workshop*, USA, 2002.

[33] M. Q. Patton, *Qualitative Research Evaluation Methods*, Sage Publishers, Thousand Oaks, CA, 1987.

[34] EMI (Ecosystem Management Initiative), *Measuring progress: an evaluation guide for ecosystem and community-based projects*, School of Natural Resources and Environment, University of Michigan, 2004.

[35] M. Osei-Marfo, N. . Vries, and E. Awuah, "Dynamics of household heads' intentions to adopt biogas technology in Ghana," *Journal of Energy Research and Reviews*, vol. 4, no. 2, pp. 44–56, 2020.

[36] Ministrie van Landbouw, Natuur en Voedselkw LITEIT, Volkshuisvesting, Ruimtelijke Ordeninge en Milieubeheer, Economische Zaken, and Ontwikkenlingssamenwerking en Verkeer en Waterstaat, *Overheidsvisie op de bio-based economy in de energietransitie*, De keten sluiten, Den Haag, 2007.