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Strategies for Enhancing the Adoption of Biogas Technology in Malawi: A Pathway to Achieving Clean Energy Access

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Abstract

Biogas has been identified as one of the viable options which can be used to reduce energy poverty, deforestation and overreliance on the use of biomass and fossil fuels. Despite being introduced in the country decades ago, its uptake has remained limited. To address this challenge, this research was conducted to identify ways to increase its adoption in Malawi and to reduce its dis-adoption. The study employed qualitative methods to gather experience from biogas adopters, disadopters, potential adopters, and energy experts across four districts. The research study was carried out in four districts namely Mchinji, Mzimba, Ntcheu, and Chikwawa. The data collected was analyzed through thematic analysis. Results of the study indicated that there are several obstacles that are hindering adoption of biogas technology in the country and these include high investment costs, a lack of post-installation services, socio-cultural barriers, lack of technical support, and a lack of clear policy frameworks. To address these challenges, respondents proposed several holistic strategies which can be used to improve biogas adoption. These involve increasing public awareness, provision of subsidies and soft loans, creating strong technical support systems, setting biogas standards, decentralizing demonstration sites, and encouraging cross-sector collaboration. The research observed that a combined approach, supported by policy and driven by community engagement, is essential for increasing biogas technology and guiding Malawi towards clean, affordable, and sustainable energy solutions.

Keywords: biogas; strategies; adoption; technology adoption; renewable energy; Malawi

1. Introduction

Malawi relies heavily on traditional biomass fuels, such as charcoal and firewood, for cooking. It is estimated that 77.4 percent of the population depend on charcoal, followed by charcoal at 18 percent, while 2 percent use electricity [1]. The country needs to move from the use of traditional energy sources to clean energy sources This aligns with Sustainable Development Goal (SDG) number 7, which aims to ensure that everyone has access to affordable, reliable, sustainable, and modern energy [2]. However, the transition from traditional biomass cooking methods to clean alternatives remains a major hurdle for developing countries [3]. The latest data and selected energy

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scenarios indicate that, given the current rate of progress, the most vulnerable developing nations are unlikely to meet any SDG 7 targets [4]. It is crucial for developing nations to create comprehensive plans aimed at achieving Sustainable Development Goal 7 (SDG 7). As outlined in Vision 2063, Malawi aspires to transition away from biomass cooking to cleaner and more sustainable techniques by promoting innovations and technologies in the sector [5]. Malawi has developed a National Energy Policy to establish a guiding framework for improving access to affordable, reliable, sustainable, efficient, and modern energy for all sectors and individuals in the nation [6]. The policy acknowledged that the use of biomass will be inevitable and recommended sustainable production and efficient use of biomass. Biogas was identified as one of the sustainable energy sources to replace the use of charcoal and fuelwood. Biogas is a gas that is produced from organic waste. Biogas technology was introduced in Malawi decades ago, however, its adoption is limited due to high initial costs, weak institutional frameworks, low public awareness, and inadequate technical capacity [7]. Without strategic intervention, this underutilization hinders national development and clean energy goals. The study was therefore undertaken to explore strategies to enhance biogas adoption. The findings of the study have provided recommendations that could inform government policies, design programs, and encourage private sector investment. The recommendations will help in creating a sustainable environment for the deployment of biogas technology.

2. Results

The results of the study have been presented in the Appendix 1 as Table 1A.

3. Discussion

Malawi has enormous potential for scaling out access to modern and affordable energy using biogas technology. However, several barriers exist for the adoption of this technology, including economic, technological, social, and cultural issues. "Importantly, these barriers are not too difficult to overcome and could be tackled using locally adapted interventions. Several recommendations by the study informants arise about how to improve biogas adoption: raising awareness, providing subsidies for investments in biogas, promoting cheap and easy-to-use digesters, developing adequate extension models, prioritizing Research and Development (R&D), conducting a comprehensive assessment of resources, creating demonstration centers and working more closely with both the energy and agricultural sectors were all seen as key strategies to promote adoption.

3.1. Increase Public Awareness and Community Engagement

The most common theme that was identified was the need for better promotion and marketing of biogas technology, such as through mass media (radio and TV) and through community-level demonstration activities. Expert 1 stated that "If this could be shown on TV or radio, how to cook nsima (a staple food in Malawi) with this, it would be easy [for the technology to be accepted". Site visits and live demonstrations were seen as effective strategies for encouraging adoption of technology (Adopter 1).

Another respondent mentioned that when biogas technology is made more widely known in terms of its benefits, the elderly may also be willing to adopt it. This viewpoint aligns with Sangwa [8], who stated that awareness meetings should be done to educate communities about the benefits and applications of biogas technology in simple language, and that training should encompass every aspect of biogas technology with communities learning from an expert rather than from a group leader who relays information from a seminar. Additionally, it was recommended that manuals be developed containing information about biogas. These manuals should outline the construction procedures for biogas digesters in simple language that local craftsmen can easily understand [9]. Lastly, social and cultural issues should be addressed in awareness meetings to dispel myths surrounding the use of biogas and dung.

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There is need to address information and promote social norms by conducting national awareness campaigns as recommended by Duodu [10]. The campaigns should be conducted in collaboration with civil society organizations, Non-Governmental Organisations (NGOs) and local media. The campaigns should emphasize the benefits of biogas technology. User manuals should be developed and translated into local languages to reach more people. The recommendations made by Duodu are similar to strategies made by respondents.

Community sensitization was identified as one strategy to increase uptake of biogas technology. To convince communities to adopt biogas technology, there is a need to conduct public meetings, awareness campaigns and conduct demonstrations, and these should be led by village headmen and those who are already using biogas technology. Several respondents underscored the significance of linking biogas promotion to environmental awareness, especially regarding the depletion of firewood and deforestation. This was noted by one of the potential adopters who indicated that if nothing is done, in the next five years, children will not have a single tree to cut from. This indicates that biogas was viewed as a sustainable environmental/ alternative.

Additional promotion strategies highlighted by Expert 2 included leveraging word-of-mouth and ensuring customer satisfaction. The expert proposed transforming biogas users into brand ambassadors by providing exceptional service and ensuring that systems align with customer expectations. This approach will help in focusing on building loyalty by providing good user experience and clear communication, which in turn improves the organization's reputation and supports long-term growth. In rural areas, communication through word of mouth is often more accessible and effective for development programs, as noted by Tornel-Vázquez et al.[11]. This approach fosters trust and engagement, enhancing the success of such initiatives.

Furthermore, educational institutions and NGOs were recognized as key players in promoting biogas. Expert 3 proposed using schools and universities as platforms for awareness campaigns, alongside involving NGOs that share a commitment to clean energy.

3.2. Government Role and Support

Another theme that emerged from the experts' interviews was the role of government in promoting biogas technology. It was highlighted that the Government's involvement in the promotion of biogas technology is very minimal. The experts proposed the need for more coordinated initiatives by having decentralized promotions. Expert 3 highlighted that due to a lack of coordination, many research studies and interventions are focused in districts such as Mchinji and this results in unequal exposure and access to technology throughout the country. It was further proposed that the Government should create pilot plants in different districts to enable various regions to experience and learn from localized implementations. This will help boost adoption through demonstration and accessibility. Further, it was proposed that the Ministry responsible for energy issues should be more proactive in organizing stakeholder discussions and gatherings to create momentum and design targeted interventions.

One important issue was the insufficient collaboration with research institutions, as noted by Expert 4. One important issue was the insufficient collaboration with research institutions, as noted by Expert 4. Research organizations have essential technical knowledge and understanding; however, they are often ignored when promoting biogas technology. The Expert stressed the need for the Government to involve Universities and research centres to help in identifying problems, provide solutions and improve designs.

The lack of technical standards is a major challenge for biogas technology. Expert 2 explained that without clear quality rules, many systems can be unreliable or poorly made, which can make people lose trust and harm the long-term success of biogas projects. Bensah et al.[9] noted that poor-quality digesters often fail and create a bad image of biogas. Lwiza et al. [12] suggested that the government, together with NGOs and private companies, should create standards for biogas digesters, equipment, and pipelines [13]. These standards should be put in a manual that all companies promoting biogas must follow [9].

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Finally, the conversation showed how important it is for different institutions to work together. Expert 3 proposed that the Government should encourage collaboration among organizations that are involved in the promotion of renewable energy such as such as Community Energy Malawi and Malawi Environmental Endowment Trust (MEET), so that biogas should be promoted alongside other technologies like solar. This will allow resources to be used efficiently making the technology visible, attracting more support from donors and policy makers

3.3. Financial Support – Subsidies and Revolving Funds

A significant and recurring theme identified in both expert and user interviews is the substantial initial investment required for biogas technology, which poses a major obstacle to its adoption. Both specialists and community members firmly support the idea of government assistance through subsidies and the establishment of revolving funds to alleviate the financial strain.

Experts highlighted the importance of having organized financial systems that enable adaptable payment options, like loans that are paid back gradually with savings accrued from lower costs on cooking fuel and chemical fertilizers. As noted by Expert 2 and Expert 5, although the upfront investment is considerable, the long-term advantages—such as decreased household expenses and the availability of organic fertilizer—render biogas a feasible solution if the financial barriers to entry are diminished. The suggested model entails utilizing monthly savings (e.g., US$25 on cooking fuel and US$192 each year on fertilizer) to gradually repay loans, thus making the technology more attainable for a larger number of households. There is also a broader rationale for subsidies when viewed from a national standpoint. As Expert 2 highlights, fostering biogas production might lead to savings in foreign exchange by decreasing the need for imported chemical fertilizers and fossil fuels. This positions subsidies not just as a form of social assistance but also as a thoughtful economic investment.

Users' viewpoints further reinforce the necessity for subsidies, especially concerning construction materials and initial starter packs. Many individuals who have stopped participating and those considering adoption recommend cost-sharing strategies, in which NGOs or the government offer partial assistance (such as materials or livestock), while the users cover the remaining costs. This approach not only alleviates the financial burden but also promotes a sense of ownership and sustainability of the systems.

For instance, Potential Adopter 1 supports the implementation of starter packs and the strategic choice of first beneficiaries (such as educated or receptive individuals) to create momentum and impact on others. Dis-adopter 3 likewise suggests supplying cattle to families to fulfill feedstock needs, connecting the financial and technical aspects of adoption.

Additionally, certain recommendations tackle socio-cultural obstacles that are indirectly related to adoption. For example, the suggestion to supply gloves and soap to alleviate hesitation about handling dung (Dis-adopter 3) serves as an affordable incentive that might enhance users' readiness.

However, to foster a sense of ownership, it is vital that these financial aids are extended only to individuals who demonstrate knowledge of biogas technology, show genuine interest, but lack financial resources. This recommendation aligns with the views of Mwirigi et al. [13] and Kwamboka [14], who suggested that loans and subsidies would encourage the adoption of biogas technology by providing the financial means to install these systems. Additionally, the establishment of a revolving fund was proposed to allow individuals to pay for installation costs in instalments. Furthermore, providing incentives to the private sector for the local manufacturing of biogas components, which are currently imported, could help reduce the prices of biogas digesters, making them more affordable.

3.4. Sustainability and Capacity Building

Capacity building of the local artisans was recognized as another important factor for the sustainable implementation of biogas systems. Expert 1 emphasized that empowering artisans to construct and maintain these systems reduces reliance on external technicians and minimizes upfront

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costs for users. The suggestion is consistent with previous studies which stated a strong relationship between availability of skilled technicians and adoption of biogas technology [14]. Technical knowledge was identified as a critical factor in the uptake of biogas technology and where these skills were utilized, there was a high adoption rate [15,16]. Bensah et al. [9] suggested that the widespread dissemination of biogas systems require a pool of technical experts to provide quality installations and on-demand post-installation services. Introduction of specialized biogas technology courses in universities and technical colleges is one way of ensuring availability of experts in the field. Ali Siddiqui et al. [17] agreed that the availability of technicians demonstrates the uptake of biogas facilities and benefits farmers in some rural areas socially and economically. It was further proposed that local artisans should be made knowledgeable in area of biogas technology and competent enough to conduct maintenance of biogas systems once there is a problem and should be readily available at affordable prices[14]. In addition, biogas adopters should be furnished with basic training for them to be able to conduct minor repairs or maintenance. Another technical support respondent suggested was on after installation services or follow-ups. The respondents suggested that the installers should monitor them once the systems have been installed. Hence, the training should cater for all involved agencies ranging from adopters to experts.

Interview participants indicated that essential parts like tubes and regulators are often hard to find in local hardware stores, making it difficult to grow biogas systems. This showed the need for a reliable supply chain and better technical support, in which case NGOs and private companies could help provide technological support. It was proposed that there is need for involvement of NGOs and the private sector.

3.5. Centralized Biogas Production

The expert proposed setting up a central facility to produce biogas and compress it for cooking just like Liquefied Petroleum Gas (LPG) and Liquefied Natural Gas (LNG). This approach will make the gas more affordable and locally available than importing LPG. Furthermore, if biogas is compressed, it becomes portable and households could use the same stoves used for LPG. This will make biogas simpler and more attractive for ordinary families.

Additionally, the expert noted that centralized production could lead to the growth of a biogas industry, creating local job opportunities and minimizing foreign currency requirements, while also providing environmental benefits. The expert argued that centralized systems are generally more beneficial than decentralized ones. Densely populated areas, like central Malawi, could be effectively served by a single facility. The establishment of a piping distribution network would allow households to avoid significant initial costs, with payment only required for connections, illustrating a model that has proven successful in other nations.

3.6. Diversification of biogas feedstock

Most respondents who had stopped using biogas technology stated a lack of enough animal dung. Some respondents said that over-reliance on cow dung limited the adoption of biogas adoption especially for families that do not have cattle or have problems accessing sufficient dung. It was therefore proposed that other feedstock alternatives, such as kitchen waste and agricultural waste, be promoted, as this would help households have more flexible options.

Using a variety of feedstocks not only makes biogas systems accessible to more households but can also improve gas production and support the long-term functioning of the systems. This has been noted from other regions that using mixed feedstock rather than single feedstock has led to high efficiency and has helped to increase system performance. Therefore, to increase the adoption of biogas technology in Malawi, one strategy is to encourage households to diversify their feedstock sources.

3.7. Decentralized Demonstration Sites

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The respondents suggested that the Government or NGOs should establish demonstration sites where people can see how biogas system operates. Setting up demonstration centers where people can see in practice how the biogas plant works can enhance their understanding and help them decide [14]. The demonstration effect is a powerful driver of biogas uptake [18]. This can be achieved by deploying digesters in public institutions (e.g., schools, hospitals), using community learning centers and collecting performance data and generating success stories.

3.8. Research and Development

Some respondents, especially those who were using fixed dome digesters, suggested the introduction of simple and affordable biogas digesters which can be easily adopted by rural people. The respondents explained that many people visit to appreciate the use of technology but are always put off when they are told about the price of the systems, hence the recommendation. Some people mentioned to have heard about plastic biogas digesters and proposed the possibility of promoting that type. Tumutegyereize et al.[19]suggested that there is need to move away from the use of fixed dome to small and compact types which does not require more space for installation.

3.9. Collaboration Institutions for Biogas Dissemination

Biogas technology is often promoted in various sectors without sufficient collaboration among them. An integrated approach involving multiple stakeholders is essential for effective promotion. In Malawi, the livestock sector accounts for about 8% of GDP and 30% of agricultural product value [20]. Many biogas adopters reported a shortage of animal dung for biogas due to insufficient livestock numbers [7]. Dis-adopter 3 suggested that the government should supply livestock along with biogas promotion. However, there are already initiatives that have been put in place by the Government through the Department of Animal Health and Livestock (DAHLD) and NGOs such as Land O'Lakes, to assist small-scale farmers by providing resources. The support includes access to initial stock and improved dairy technologies. Over 8,000 smallholder dairy farmers are caring for around 40,494 cattle, mostly using zero grazing methods (DAHLD, 2010, cited by [20]. Effective collaboration between the Ministry of Energy and the Department of Animal Health and Livestock is crucial for engaging dairy farmers. The dairy industry in Malawi is well-regulated, promoting collective selling among organized farmer groups [20,21]. In this context, the existence of daily farmers working in groups might serve as an initial foundation for promoting biogas usage in the nation, which could eventually be expanded to encompass other farmers. One of the significant challenges dairy farmers currently face is the need to maintain high-quality milk due to problems with breakdown of generators and also electricity blackouts, leading to spoilt milk [22]. In some cases, farmers do not have access to electricity which hinders storage of milk. Implementing biogas digesters could provide a viable solution to this issue, as the technology would enable farmers to store their milk in refrigeration units more effectively. Currently, there appears to be a lack of collaboration between the Ministry responsible for Energy and the Livestock Department. The Ministry of Energy can also collaborate with various sectors, including the Ministry of Agriculture, Ministry of Fisheries, local government, Land Resource Department, Forestry Department, Environmental Affairs Department, Ministry of Livestock, academia, and NGOs. All these stakeholders are already engaged in different projects aimed at supporting the same farmers.

Orskov et al. [23]recommended integrating biogas technology as a key component of a comprehensive farming system. Such a holistic agricultural approach provides farm designs that support the sustainable use of nutrients, water, labor, finance, and energy over the long term. The proposed approach allows efficient utilisation of the available resources at the farm. According to Regina et al., one reason for the non-adoption of biogas technology in Malawi is the lack of sufficient water and the considerable distances to water sources. These findings align with previous studies that have identified shortages of water, lengthy distances to water sources, and significant labor demands as key barriers to the adoption of biogas [7,24]. Embracing a comprehensive agricultural approach is one method to address obstacles.

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Orskov et al [23] further stated that feeding of biogas should be done with household wastewater. Recycling household water offers significant advantages, not only by conserving water but also by treating wastewater, making it suitable for irrigation. Utilizing wastewater directly for agriculture is generally not recommended, as it frequently contains harmful substances. (Arnold, 2009). The method will additionally minimize the time and effort required to gather water.

Orskov et al. [23] also suggested the implementation of water harvesting technologies at the agricultural site. Water harvesting involves gathering and storing rainwater for various purposes later on [25]. Water can be collected in a storage tank or a pond [23]. The ponds could be used for fish farming. The wastewater generated by biogas technology could be redirected to the fishpond to aid in the growth of plankton, which serves as food for the fish. As a result, water from the fishpond can subsequently be utilized for irrigation. The recycling of animal waste in fishponds has been successfully implemented in Vietnam [26]. Additionally, the nation is experiencing a significant increase in the cost of chemical fertilizers due to the conflict in Ukraine [27]. The slurry extracted from the biogas digester can be applied to fields to reduce the demand for chemical fertilizers, and any surplus slurry can be sold to other farmers. The suggested holistic farming method will be advantageous as it will address issues related to water scarcity, energy shortages, labor difficulties, and soil fertility, while also creating income opportunities through fish farming. This approach will necessitate cooperation among various stakeholders.

Adopting a holistic farming approach requires targeting farmers with an interest in biogas technology and having the capacity to operate the systems. At the same time, biogas technology should not be given for free as it has been observed that people tend to disown the technology as a result leading to total failure.

4. Materials and Methods

This study employed a qualitative research design to explore the barriers and strategies for enhancing biogas technology adoption in Malawi. The approach aimed to capture the lived experiences and perspectives of diverse stakeholders including adopters, dis-adopters, potential adopters, and energy experts.

Data was collected from four districts—Mchinji, Mzimba, Ntcheu, and Chikwawa—selected for their varying levels of biogas technology implementation. A total of 22 participants were purposively sampled, including households with different adoption statuses, along with six experts involved in biogas system installation. This sampling method aligns with [28] recommendation for the purposeful selection of samples in qualitative research, ensuring the gathering of rich information. Semi-structured interviews were conducted to allow flexibility and depth in responses. This approach has been widely used in energy transition studies due to its effectiveness in collecting detailed information in energy transition studies [29]. Transcribing of the collected data was verbatim and anonymized to confidentiality and to maintain ethical integrity. The study was approved by National Commission of Science and Technology (NCST), and consent was collected before interviewing participants.

Data was analysed using thematic analysis based on the framework proposed by Braun and Clarke [30]. The thematic approach was chosen for its flexibility in identifying patterns within qualitative data. Themes were developed inductively from participants' narratives rather than being based on pre-existing theoretical frameworks. Credibility and trustworthiness were obtained by employing triangulation from government reports, literature and case studies from countries which have advanced biogas programs. This type of validation method made use of best practices in a qualitative study [31].

5. Conclusions

Biogas technology provides an opportunity for clean and reliable energy access in Malawi. However, its adoption has faced several challenges, including high costs, limited services and

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cultural barriers. The study has established the need for coordinated support, providing practical solutions and community engagement. Further, it has proposed the establishment of centralized production facilities and the involvement of universities, research centers and the private sector. These approaches will make bio-gas efficient, affordable and easier to use.

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Abbreviations

The following abbreviations are used in this manuscript:

SDG	Sustainable Development Goal
R&D	Research and Development
NGO	Non-Governmental Organisations
MEET	Malawi Environmental Endowment Trust
LPG	Liquefied Petroleum Gas
LNG	Liquefied Natural Gas
DAHLD	Department of Animal Health and Livestock
NCST	National Commission of Science and Technology

Appendix A

Appendix A.1

Table A1. Thematic results.

THEMES	SUB-THEME	DIRECT QUOTE	SOURCE
Promotion and Marketing	Awareness raising	*"The key thing is about the marketing, raising awareness, if you this could be done on TV over the radio and that there is this type of technology that exists and people demonstrating that they are able to cook nsima (Malawi staple food) with this technology then it's very easy for it to gain acceptance."*	Expert 1
	Awareness	*"If you see us on social media platforms, that is mostly just to create awareness."*	Expert 2
	Benefit Awareness	*"Yes, the people should understand the benefits because if an elderly person were to understand the benefit of just putting animal dung, mixing it for 15 minutes and off you go after washing your hands, he would not hesitate."*	Adopter 1
	Environmental Awareness	*"There's a need to come up with saying that "we've seen how the environment has*	Potential adopter 1

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		changed, we can see that in the next five years, our children will not even have a single tree to cut from. So, maybe if we find a way like this one, which seems easier since all you need to know is about the animal dung and waste, the mixture, and then producing gas for cooking instead of just relying on firewood." Anyone with a human consciousness cannot refuse to be part of this technology."	
	Community sensitization	*"Periodic gathering public meetings where people get sensitized on this technology."*	Expert 3
	Community sensitization	*"The government should be engaged in community sensitization to make sure that biogas is well known to people."*	Potential adopter 2
	Community sensitization	*"Community sensitisation."*	Potential adopter 4
	Community sensitization	*"Community awareness."*	Potential adopter 3
	Community sensitization/demonstration	*"What can help is by calling for a meeting with village headmen. You can also invite people to see it when it has been installed at someone's house. Because trees are becoming scarce and if you ask anyone about the scarcity of firewood, everyone will say yes firewood is scarce. No one goes to the forest to look for trees the only way is that of cutting a tree at his house."*	Potential adopter 1
	Education Institutions & NGO Engagement	*"Sensitizing students in various schools, colleges including universities like Mzuni faculty of environmental affairs, chancellor college and mobilizing as well as sensitizing other NGOs who have interest for biogas technology and need to promote it in their areas."*	Expert 3
	Site Visits/demonstration	*"I believe that understanding the application of this practice in cooking may influence individuals to reconsider their current approach and motivate them to adopt more diligent behaviours. It is essential to recognize that cooking is a daily necessity in our lives."*	Adopter 1
Promotion strategies	Word-of-Mouth Referrals	*"Right now, our customers, we get them through referrals... if you hear of us on the radio or TV stations, we want people who will just promote it."*	Expert 2
	Customer Satisfaction as Strategy	*"Our first philosophy, our first strategy is to make customers our ambassadors... We make sure that when we are installing a customer's biogas system, we should give him the right size... we should meet his expectations."*	Expert 2
Government Role and Support	Decentralized Promotion & Coordination	*"If all districts could have a few plants in sampled locations, not just Mchinji where many people are conducting their research, it would be beneficial. Additionally, if the responsible ministry could convene*	Expert 3

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	Engagement with Research Bodies	*meetings to discuss this technology and develop various interventions, it would help advance our efforts."*	Expert 4
		Yeah, it's a matter of the government doing a bit more, especially in engaging research institutions about the process of promoting technology. They need to be approached and allowed to help solve the problems.	
	Biogas Standards	*"We don't have standards of biogas in Malawi. If the government sets standards, the technology that will be available will be of good quality."*	Expert 2
	Multi-institutional Collaboration	*"If the government can lobby all major institutions involved in different renewable energy sectors, including solar, such as Community Energy Malawi, MEET, and others, to also integrate biogas into their project programs.*	Expert 3
Financial Support	Subsidies and Revolving Funds	*"The government should help by providing subsidies or even introducing what we call revolving funds, which involve flexible payments. This way, customers can acquire these technologies on a loan.*	Expert 2
		Honestly, the initial cost of biogas technology is quite high, but the long-term benefits are substantial. Yes, we can get support from the government to ensure that there are subsidies or flexible payment options for our customers. As I mentioned, if a customer spends, for example, MK20,000 each month on cooking and about MK150,000 annually on fertilizer, they can pay that amount gradually until they have paid off the loan."	
		"Government support is crucial for developing frameworks that provide customers with flexible payment options and subsidies. For example, currently, customers can pay US$25 for a bottle of cooking oil, and some even pay US$192 for a bag of fertiliser; people can use savings to repay the loans over time. These are types of initiatives that the Government and NGOs can implement to increase the adoption of biogas technology."	Expert 5
		"The government needs to find a mechanism for providing a subsidy."	Expert 2
		Government can also do the same on biogas technology... biogas also provides fertilisers... we are saving forex.	Expert 2
		"Subsidize construction materials because people were admiring them."	Dis-adopter 2
		"Subsidy/incentives, provision of cattle as one way of promoting biogas. For 3 cubic meter digester we recommend for three cows which can produce 20 litres of dung per day."	Dis-adopter 3

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		"It might be a belief but some people are not willing to touch dung as it is considered as dirty thing. This can be dealt by providing groves and soap."	Dis-adopter 3
		"So, I think the first thing that organisations can do when they come is to give them a starter pack. You can tell them that we will give you this and the rest you will do it yourselves. I think a lot of people maybe 10 can receive it. The thing is people did a bit of school are a bit open minded and can comprehend on how the world is progressing. But if it happens that you never got any education then you just assume that you cannot do it whilst you are suffering. On the other hand, some of us know that as long as one hands, you can doit. So, the organisations can advise farmers to contribute a certain part and that they will also contribute a certain part. I think through this way, they can receive it."	Potential adopter 1
		"Subsidising of the materials for plant installation"	Potential adopter 2
		"Subsidising construction materials"	Potential adopter 3
Sustainability and Capacity Building	Durable Technology & Training	*"To my fellow entrepreneurs, we must look beyond the allure of profit. Our goal should be to develop sustainable biogas solutions by offering durable technology and comprehensive capacity-building initiatives. When we install these systems for communities, we want to ensure their satisfaction. Happy users will naturally draw interest from others, leading to an increased demand for this technology. This approach will ultimately facilitate broader adoption and implementation of biogas solutions."*	Expert 2
	Local artisan capacity building	*"The other aspect will be not only like marketing or raising awareness on how to use it but also how to make them for our local artisans to be able to make this technologies even on their own then they don't have to like spend all the money at once they can be doing construction or the brick lining little by little until it is done just like the way we build our houses if that knowledge could be on passed and the fact that you people can be assured to say well the tube the parts are readily available, regulators you can get at such shops and hardware then it should be easy for the technology to spread, so that will need the help of NGOs and private sector."*	Expert 1
Biogas Technology Innovation	Centralized Biogas Production	*I believe it could begin as a concept or a supposition rather than something that has been thoroughly tested. I remain convinced that if we could establish a centralized*	Expert 1

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		plant capable of producing biogas from waste, we could compress that biogas to make it portable and comparable to the LPG and LNG currently available in similar cylinders. This approach could enhance its competitiveness in terms of pricing, especially since I anticipate that local production would give it a cost advantage over imported LPG. Additionally, making biogas portable will still use the same appliances used for LPG, such as cookstoves. I believe this approach will increase the adoption of biogas technology and hence creating opportunities for our local population.. Additionally, it would reduce foreign exchange demands and provide numerous environmental benefits associated with biogas. I suggest that centralized systems would be more advantageous than decentralized ones. Even without converting biogas into gas cylinders, there are densely clustered villages in the central region where a single plant could suffice. By implementing a piping system for distribution, we could emulate the methods used in other countries, allowing households to avoid significant initial capital expenses and instead incur only connection costs.	
Diversification of Feedstocks	Diversification of Feedstocks	*Encourage the use of other dung apart from using dung from cows.*	Dis-adopter 2

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