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COMMENT

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From potential to practice: rethinking Africa's biogas revolution

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The purpose of this comment is to call for more critical engagement with the potential and practice for biogas investment on the African continent. Over the past two decades, immense amounts of money have been spent by African governments, private individuals, and most conspicuously, international aid agencies and donors, on countless biogas projects in every country on the continent. Yet, despite the investments, biogas in African countries has not taken off, and the continent is strewn with the ruins of hundreds of failed and abandoned biogas projects. Moreover, scholarly literature contains little feedback about what actually happens on the ground. Drawing on this critical reading of the literature, including its blindspots on project outcomes and failures, and drawing on the authors' own extensive experience with small-scale biogas projects in Malawi and South Africa, this comment article calls for more scholarly critical reflection on why a biogas revolution, that has been perennially over the horizon, has yet to arrive while centring the role of social scientists to engage with biogas owners and operators to bridge the socio-technical divide from potential to practice.

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Introduction

In May 2021, a newspaper article from Kampala, Uganda made the rounds on Twitter for the wrong reasons. The story reported that a new biodigester project, located at a wastewater treatment works in the city, and funded by the state, the African Development Bank (AfDB), and the European Union (EU), would not be able to produce methane because the faecal matter generated from Kampala residents, and used by the biodigester as feedstock, did not contain the 'necessary ingredients' to produce gas (Odyek, 2021). The article quoted Dr Florence Grace Adongo, the director of water resources management in the Ministry of Water and Environment as saying "It seems that what we are eating is lacking something, the diet of the people is not producing methane…. it is not viable" (Odyek, 2021, p. 1). Although the National Water and Sewerage Corporation (NWSC), which owns the digesters, quickly disavowed the story, claiming the plants had not yet been commissioned (NWSC, 2021), Twitter users enjoyed poking fun at the story. Commentators seesawed between questioning the veracity of Dr. Adongo's claim, and positing other, underlying causes that may be responsible for the plant's failure to produce methane, such as poor construction or siting, and jokingly offering emergency supplies of high-methane producing foods as supplementary rations to Kampala residents. For many of us who have worked with, or written about biogas on the continent, who have dealt with quotidian mishaps and structural barriers or follies which often lure projects towards their inevitable, ignominious ends, the story evoked a sense of déjà vu: a missed opportunity to engage with the root causes of project failure.

Irrespective of if the Kampala report was correct or not, the tenor of the story rang true for many who have followed the history of biogas development in sub-Saharan Africa. Through a process of anaerobic digestion, biogas digesters facilitate the conversion of organic waste materials such as faecal matter, food waste, or animal dung into biogas, which is primarily composed of energy-rich methane gas (CH_4). With little to no processing, biogas can be used for cooking, lighting, or electricity generation, and has therefore been touted on the African continent for decades as a golden pathway to sustainable energy production (Ali et al., 2020; Funmi et al., 2021; Msibi and Kornelius, 2017; Surroop et al., 2019), local economic development (Lietaer et al., 2019; Mengistu et al., 2015), increased agricultural production and soil remediation (Ngumah et al., 2013; Smith et al., 2014), climate change mitigation (Bruun et al., 2014; Funmi et al., 2021; Hoch et al., 2018), decreased deforestation (Bär et al., 2021; Lietaer et al., 2019; Twinomunuji et al., 2020), reduced household and ambient air pollution (Lietaer et al., 2019; Twinomunuji et al., 2020), and as a waste management solution (Ali et al., 2020; Funmi et al., 2021; Ngumah et al., 2013; Owang et al., 2020a; Surroop et al., 2019). In chasing this dream, immense amounts of money have been spent by African governments, private individuals, and most conspicuously, international aid agencies and donors, on countless biogas projects in every country on the continent, trying to mimic the success that biogas has had in other contexts, such as China, where massive state investment has seen widespread biogas acceptance and adoption, especially in rural areas (Aamodt and Wenqin, 2013; Rupf et al., 2015). Yet, despite the investments, biogas technology has not only not spread but seems to be moving backward. Indeed, the continent is strewn with the ruins of hundreds[1] of failed, ruined, abandoned biogas projects, primarily small-scale or household size, but also on the macro-scale, serving as permanent reminders of poorly conceptualized projects and an unwillingness to critically engage with some difficult questions. (Haider, 2021). Most obviously: Why has biogas in Africa not taken off? Like in Kampala, it cannot just be the feedstock that is wrong; rather, there must be underlying causes for failure going unaddressed.

The purpose of this comment is to shine a light on how biogas interventions have been written about and discussed, specifically within an African context. Briefly surveying contemporary biogas literature, and drawing on the authors' own extensive experience with biogas project development in Southern Africa, both as scholars critically mapping outcomes in Malawi and as biogas implementors in South Africa, we argue that the way we, as biogas practitioners talk about and internalise failure must be critically discussed, if we are to learn from the process, rather than to continue to repeat the same mistakes, if biogas in Africa is ever going to approach the potential it is continually posited to have.

Evaluating biogas: writing about failure

Although biogas has generated a tremendous amount of scholarly output, the bulk of the work that has been produced, especially on small-scale decentralised digesters, demonstrates an overwhelming tendency to focus on positives: on biogas's unlimited potential to solve several pressing global issues, while generally ignoring why this has not yet happened. Moreover, the bulk of biogas literature tends to take a high-level approach, often through reviews rather than with new empirical data, with very few case studies on specific interventions, and a tendency to focus on the limited success that has occurred with small-scale digesters, in specific contexts, with only brief speculation on why these limited successes remain so.

Although failure remains largely a taboo topic for a field that seems determined to continue to look forward, challenges *are* often discussed. Yet the discussion is usually systemic; the narrative moves through a discussion of 'barriers', from a global, regional, or national perspective, which may help to illustrate trends at a macro-level but does little to help us understand why so many projects often fail. As such, within this vast body of work, the *promise* of small-scale biogas remains, there are just several barriers preventing its actualisation: barriers that are continually discussed but rarely seem to get addressed. Specific barriers that have received significant attention include: the high initial cost of technologies, as well as the constant cost of maintenance, especially for the poor (Bekchanov et al., 2019; Chen et al., 2017; Dyah, 2019; E. U. Khan and Martin, 2016; Landi et al., 2013; Mittal et al., 2018; Puzzolo et al., 2016; Rupf et al., 2015; Taylor et al., 2019), a lack of state or donor investment in biogas, for both research and to assist with funding (Bößner et al., 2019; Boyd, 2012; Ho et al., 2015; Mukeshimana et al., 2021; Nevzorova and Kutcherov, 2019; Patinvoh and Taherzadeh, 2019; Silaen et al., 2020), as well as the inability for small plant owners to take advantage of international carbon credit schemes (Shane et al., 2015); the difficulty of accessing biogas technology within some national contexts (Hamid and Blanchard, 2018; Parawira, 2009), a lack of supportive public policy framework in certain nations (Bekchanov et al., 2019; Bößner et al., 2019; Boyd, 2012; Gao et al., 2019; Hasan et al., 2020; Ho et al., 2015; Patinvoh and Taherzadeh, 2019; Roopnarain et al., 2020; Yousuf et al., 2016), or low state or institutional capacity to implement a national biogas programme (e.g. Budiman, 2021; Landi et al., 2013; Nevzorova and Kutcherov, 2019; Rupf et al., 2015), as well as onerous regulatory barriers (Mittal et al., 2018; Taylor et al., 2019;), including potential political instability in some contexts (Kamp and Bermúdez Forn, 2016), a lack of sufficient or consistently available feedstocks (Chen et al., 2017; Glivin and Sekhar, 2020; Iqbal et al., 2014; K. Khan et al., 2018; Mittal et al., 2018; Nevzorova and Kutcherov, 2019; Roopnarain et al., 2020), poor climactic conditions, including variable temperatures or water scarcity (Kamp and Bermúdez Forn, 2016; Mittal et al., 2018; Rupf et al., 2015), space for digester installations, especially in dense village or urban contexts (Akinbami et al., 2001), labour intensity of daily operation for owners (Roopnarain et al., 2020; Silaen et al., 2020; Taylor et al., 2019), the unpredictability of biogas production and yields, which may render small-scale commercial utilisation unfeasible (Bensah et al., 2011; Owang et al., 2020b), potential cultural stigma or taboos associated with handling faecal matter or animal waste (Budiman, 2021; Dyah, 2019 Mittal et al., 2018; Rupf et al., 2015; Shane et al., 2015), market barriers which influence demand for the gas, such as competition with other available, potentially cheaper, fuel sources (Bensah et al., 2011; Mittal et al., 2018; Nevzorova and Kutcherov, 2019; Taylor et al., 2019; Zuzhang, 2013), the poor monitoring and maintenance of existing digesters (Iqbal et al., 2014; Shane et al., 2015; Taylor et al., 2019), and finally, a lack of knowledge, information, and training for potential biogas owners or installers (Bößner et al., 2019; Dyah, 2019; Hasan et al., 2020; Landi et al., 2013; Mittal et al., 2018; Patinvoh and Taherzadeh, 2019; Rupf et al., 2015; Taylor et al., 2019). Again, this body of scholarship may help form a picture as to why small-scale biogas, as an idea or larger international or national project, may have 'failed' to take off, but the insight they provide into why individual projects 'fail' is fragmentary.

Some scholars have been blunter in their handling of failure, yet, remarkably, while writing within broader national contexts, have been able to maintain their optimism about biogas, even when confronted with objective failure. For instance, Diouf and Miezan (2019), writing about Senegal, discuss the state's biogas rollout, which promised 8000 household digesters, yet only delivered 600. Yet, even in this instance, the authors are not critical of the basic premise of the project, and, despite the failure, continue to propose alternative pathways through which the original target may be achieved. In Nepal, Lohani et al. (2021) note that although the country has built more than 430,000 small-scale digesters over the past 60 years, there has been little domestic technological development, and less than one percent of the total biogas potential has been realised, despite decades of government support and financing. Yet, like Diouf and Miezan (2019), they remain optimistic, not questioning the wisdom of further investment, but rather espousing the need for further technological development to help digesters adapt better to local conditions. However, Bruun et al. (2014) warn of the risks of failure, describing abandoned digesters as potential climate change bombs due to possible methane leaks. As such, they warn that the further proliferation of small-scale digesters may contribute significantly to global emissions of methane.

Embedded, qualitative research or individual case studies on specific biogas projects are limited, especially in comparison to the ocean of macro-level research on the topic. Yet the few studies that do exist have shed some light on why projects may experience poor outcomes after commissioning, with the technical challenges of maintaining plants in rural areas figuring prominently. For instance, Mahdi et al. (2012) used a mixed methodological approach to examine 85 digesters in Bangladesh's Pabna District, finding that 65% were not operating or operating poorly, with most failure owing to technical complications linked to the digester or the associated appliances. Likewise, in a survey of 141 digester owners in central Vietnam, Roubík et al. (2016) found that one-third of owners had experienced serious problems, with technical challenges, such as leaks in the reactor or piping, malfunctioning of the stove, or breakdowns in anaerobic digestion featuring prominently. Furthermore, although Wamwea (2017), writing about Kenya, generally observed better outcomes, they also found that the leading cause of failure amongst sampled owners was technical issues. In all three instances, technical challenges were compounded by the plant's owner's inability to deal with them, which when left unresolved, often led to plant abandonment. Finally, even in China, which is widely considered a biogas success story, Huanyun et al. (2013) point to low biogas use rates as well as underutilization of digestate as key contributors to plant abandonment by owners, while Jian (2009) describes mounting challenges associated with securing sufficient feedstock in depopulated and declining rural communities as another major, and growing, factor for plant failure. Lastly, in South Africa, Dumont et al. (2021) discuss the 'yuck factor' within biogas, a strong negative emotion that may lead people to withdraw from participation, which is a useful concept for examining user-faced 'quit' moments in biogas interventions.

Although these sources hint that there may be more substantial challenges to rural, small-scale digester development than the macro-body of the literature suggest, there remains a significant gap for further embedded research on project success and failure. How can funding and funders be more critically examined as predicator for project success or failure? How much does context matter, and to what degree do owners matter? Are more investments in biogas *always* better? Or as Bruun et al. (2014) note, should we pause and reconsider the further proliferation of small-scale digesters in light of so many poor outcomes? Regardless of how the domestic biogas industry develops, it is essential to develop a more critical body of literature and to start learning from failure, rather than being doomed to repeat it.

Conclusion: moving forward

As the literature sketch above has suggested, we know quite a bit about what biogas can do *in theory* towards poverty reduction, waste management, energy provision, etc., but have had very little qualitative feedback about what is actually happening on the ground. The potential of biogas remains, but with very few case studies on specific interventions, and a tendency to focus on limited successes while ignoring failures, there remains a lack of critical reflection towards a technology that, on the African continent, has failed to live up to expectations.

Our own research on biogas, centred on Malawi and South Africa, and dedicated to gathering rich quantitative *and* qualitative data on biogas outcomes within African countries, has produced a number of early results that have been revealing, and signal a need for further, grounded investigation. For instance, in Malawi, which superficially possesses many of the aspects often cited as precursors to a biogas revolution[2], countless abandoned digesters can be found dotting the landscape, and any expected biogas revolution has yet to catch fire. The initial mapping of projects, and engagement with owners, funders, and providers have suggested that the interplay and relationship between these three stakeholders is a key determinant of a project's success or failure, with the owner being the most important factor, as their willingness and ability to engage with the systems seems directly correlated to outcomes. Our own, preliminary, on-the-ground, engagement with projects in both Malawi and South Africa suggests that owners who had better outcomes with biogas were the ones, who largely, sought it out for themselves, while owners who were more passive 'beneficiaries' within the intervention, generally experienced poor outcomes. Although the full extent to which donor involvement has boosted, or constrained, biogas adoption within Africa remains to be unpacked, these early findings may shine a critical light on the role of development aid in biogas provision within those contexts. However, what has become clear is a greater need for embedded, qualitative work, by critical social scientists within biogas research. Technical post-mortems of abandoned or failed systems, lead, in our experience, to a one-dimensional understanding of project success or failure. Rather, engaging with owners, through participatory, qualitative research, which centres and interprets owner's experiences, and can identify potential points of friction between systems and users, may reveal understudied or systemic challenges within current models of biogas provision. Moreover, critical social science research, that challenges existing praxes, and evokes the kind of critical reflection that may lead to a meaningful change in practice, is necessary if biogas in Africa is ever going to approach the potential it is continually posited to have.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Notes

1 Perhaps more, quantifying and mapping the scale of failure is one major research gap.
2 Abundant and diverse feedstock, relative water security in most parts of the country, persistent energy shortfalls and low electrification rates necessitating innovation, overreliance on firewood for domestic use which has led to severe deforestation, and finally, the attention of many international donor agencies willing to fund infrastructure projects, particularly ones with a veneer of sustainability which can serve to sop up some of the Global North's climate change guilt.

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Competing interests

The authors declare no competing interests.

Ethical approval

This research was approved by the National Committee On Research in The Social Sciences And Humanities (NCRSH) in Malawi, Protocol No. P.03/21/560. The study was performed in accordance with relevant guidelines/regulations applicable to research with human participants, per NCRSH standards and guidelines.

Informed consent

Written informed consent was obtained from all participants for participation in the study.

Additional information

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