Small-scale biogas technology and Sustainable Development Goals in today´s Ethiopia

Authors:

Digging into the background of the research of Tewodros Tarekegn Lapiso, PhD student at the Biogas Research Team under the guidance of Assoc. Prof. Dr. Hynek Roubík.

The young researchers of the Biogas Research Team (BRT) are diligently working to increase the visibility of the success and potential of bioenergy sources. From Indonesia to Vietnam to Ethiopia and beyond, their efforts to highlight the impact and importance of incorporating renewable energy technologies are creating change worldwide.

With this popularization series, we aim to showcase the impact of our research on renewable energy in strategic countries around the globe.

Ethiopia is the second most populous country in Africa after Nigeria. As indicated in Figure 1, the population is estimated to be around 120 million. Most of this number is the share of young people that creates the title of 'younger nation' for the country (Jian X. & Mtoshikazu M. 2021). As this number indicates, the country needs enormous sustainable development inputs, including natural resources, energy, finance, and a skilled workforce. Although the country is blessed with many of these inputs, including fertile agricultural land, water, decent climatic conditions, livestock, and many more. However, most of its resources are not well uncovered, studied, and accounted for (Wassie, 2020).

As one of the global South nations, around 80% of the population resides in a rural part of the country engaging in agricultural activities, which makes it disadvantageous to access modern technologies (Grossi & Dinku, 2022; Jian X. & Mtoshikazu M. 2021). However, the agroecological regions of the country cover various types that create a conducive environment for different agricultural practices (farming and animal husbandry) (Dejenie & Kakiso, 2023). Despite this fact and the current effort to modernise the agricultural sector, it is still heavily dependent on natural phenomena (climatic variability and weather conditions, including the amount of rainfall) that frequently affect its productivity (Grossi & Dinku, 2022). In addition, the country's natural resources are under colossal pressure resulting from climate change, environmental pollution, increased population, urban sprawl, and, most importantly, the existing trend of energy consumption (Wassie, 2020).

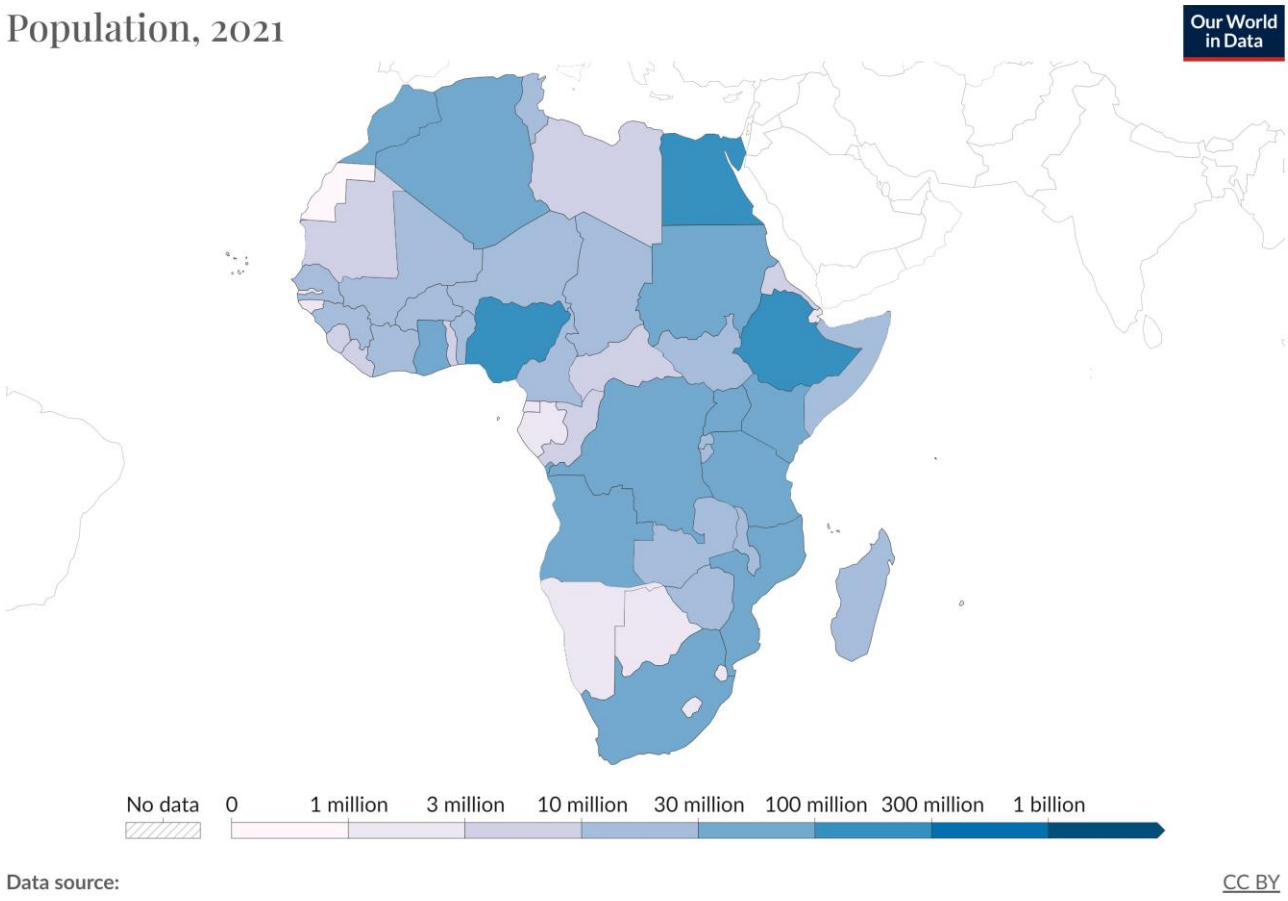

Figure 1: *Map of population growth (Ritchie et al., 2023).*

The massive energy need in the country is met by approximately 88 % from biomass and the rest from fossil fuels and other sources (The & Bank, 2019). This makes Ethiopia one of the five main emitters of non-CO2 greenhouse gases (methane (CH4) and nitrous oxide (N2O)) from fossil fuel and biomass combustion in 2030. It is projected that Afghanistan (89 MtCO2e), China (88 MtCO2e), India (62 MtCO2e), the United States of America (46 MtCO2e), and Ethiopia (41 MtCO2e) will produce (United States Environmental Protection Agency 2019). The country's electricity coverage was 44 %, according to a survey conducted in 2018 (Ministry of Water, Irrigation and Electricity, 2019).

In changing this scenario, the nation started to act in 1997 by developing the Conservation Strategy of Ethiopia (CSE) and the Environmental Policy of Ethiopia (EPE). Afterwards, many regulations and guidelines were developed while improvements in developmental policies and programmes were made side by side. Nevertheless, they did not integrate the economic aspect with the environment and tended to favor the economic aspect. The absence of coordination also plays its role (Jian X. & Mtoshikazu M., 2021; Dejenie & Kakiso, 2023). In recent years, despite all these unprecedented challenges, the country has started progressive practical initiatives to achieve sustainable green development by harmonising policies, strategies, and projects that exist in different sectors. The development and intensification of renewable, green, affordable, and modern energy are at the forefront of these initiatives. This includes the development of energy from biomass, solar, wind, geothermal and hydropower (United Nations Environment Programme, 2019).

The process of developing green, affordable and modern energy from renewable natural resources and organic waste can create a market, employment, goods, and services. The framework in Figure 2 illustrates that this will lead to environmentally friendly and socially inclusive sustainable development, which stands on a circular economy (Subbarao et al., 2023). Biogas technology is a prime example of this. The technology is built upon a natural phenomenon to be carried out by microscopic bacteria without oxygen (anaerobic digestion (AD)). The process produces biogas, mainly containing 50-70% methane and 25-50% carbon dioxide. Other gases, nitrogen, hydrogen, oxygen, and traces of hydrogen sulfide, water vapor, and ammonia, are present in smaller amounts (Hashemi et al., 2021; Mutegoa & Sahini, 2023). It is renewable energy. The process byproduct digestate, on the other hand, is used as a soil amendment and organic fertiliser that increases agricultural productivity and improves food security (IFAD, n.d.).

Figure 2: *Interactional Framework of biogas with SDGs and circular economy.*

In Ethiopia, the technology was introduced to the country around 1957 at Ambo Agricultural College (Kamp & Bermúdez Forn, 2016). Then, with many ups and downs through times and governmental approaches, it is still in its infancy. The most implemented biogas plant in the country is a small-scale digester with a size of 6 m^3. In this category, as shown in Figure 3, a fixed dome digester is dominant, followed by a floating drum digester. The country implemented the national biogas programme in 2009 with the support of SNV. Through the implementation of this program, the number of small-scale biodigesters reached 22,166 in 2018 (United Nations Environment Programme, 2019). When this number is compared to the size of the country, population growth, the gap between available energy and existing needs, and the potential of the nation to produce biogas, it is insignificant. In addressing this limitation, different studies were conducted to answer country-specific questions and further accelerate the dissemination and expansion of technology.

Figure 3: *Fixed-dome small-scale biogas plant (© SuSanA Secretariat (2009), used under Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Generic).* ***A)*** *Construction of fixed-dome biogas plant near Hanoi © SuSanA Secretariat (2009), used under Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Generic.* ***B)*** *Top manhole of biogas digester © SuSanA Secretariat (2011), used under Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Generic.*

To support Ethiopia's current efforts and fill the existing research gaps in examining small-scale biogas plants according to the Sustainable Development Goals (SDGs), a finely tuned, detailed new study is proposed as a Ph.D. dissertation and implementation is in progress. The study aims to identify and review the constraints and challenges that hinder the dissemination of small-scale biogas plants in Ethiopia to recommend a solution in the context of the SDGs and the circular economy. Furthermore, it will investigate the contribution of small-scale biogas plants to individual sustainable development goals and will assess the productivity of existing small-scale biogas plants in comparison to regulatory requirements, safety regulations, and standard production averages in line with the SDGs. It is expected to be completed by June 2026.

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