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EDITED BY
Sheng Yang,
Central South University, China

REVIEWED BY
SHI Tao,
Hong Kong Polytechnic University,
Hong Kong SAR, China
Fiseha Mekonnen Guangul,
Middle East College, Oman

*CORRESPONDENCE
James Njuguna
✉ j.njuguna@rgu.ac.uk

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A PESTEL and SWOT impact analysis on renewable energy development in Togo

Nanimpo Kansongue[1], James Njuguna[1,2]* and Stephen Vertigans[3]

[1]School of Engineering, Robert Gordon University, Aberdeen, United Kingdom, [2]National Subsea Centre, Dyce, United Kingdom, [3]School of Applied Social Studies, Robert Gordon University, Aberdeen, United Kingdom

Similar to most developing countries, Togo continues to rely on the use of traditional forms of biomass energy which causes tremendous socio-economic, environmental, and health hazards. In addition, the imbalanced distribution and use of electricity, petroleum, and liquid gas reflect the disproportion in income and quality of life. This paper plans to highlight the development that renewable energy had in the past decade and the challenges facing the Togolese government, using a framework approach that will best address them. Framework approaches such as PESTEL and SWOT analyses are utilized to access both the internal and external factors in relation to renewable energy development and its impact on Togo. This will provide a better understanding of the sustainability issues facing Togo and provide solutions on the best methods that will lead to greater impact and development. The result shows that renewable energy development in Togo has improved in the past decade and had some impact on socio-economic development. However, better development will be achieved if approaches are introduced to provide a long-term solution to the high capital costs of the technologies, institutional sustainability is incorporated, the number of trained personnel/technical expertise is increased and the Government engagement with funding bodies to secure funds that will favor off-grid and poorest communities is increased. There is also a need to include local participation in the design and operation of projects and introduce a cross-subsidization tariff scheme that covers the operation and maintenance costs of off-grid solar PV users that will favor poor households. Finally, liberalization of the energy sector is needed as well as the government's support to help private investment in rural electrification *via* Build-Own-Operate arrangements.

KEYWORDS

sustainable development, renewable energy, impact, solar power, hydropower, PESTEL analysis, SWOT analysis, Togo

1. Introduction

Several frameworks in the literature such as the Environmental Impact Assessment (EIA), the International Organization for Standardization (ISO) regulations, the political, economic, social, technological, legal and environmental (PESTEL) analysis, and the SWOT analysis have been considered to analyze the current impact that renewable energy has had in Togo and to illustrate the issues facing the country as well as provide recommendations on the best way to move forward. To develop this further, our research is focused on better understanding renewable energy development in Togo to analyze the impact and find new opportunities and identify potential threats regarding its development (Kansongue et al., 2018, 2022). Looking at the different frameworks listed, the EIA would have been the best suit if the focus of their research was based on environmental impact assessment which is not the case as there are many of other factors that need to be considered. ISO regulations (ISO, 2018) are more of quality management standards that help work to be more efficient and reduce product failures. This is a good framework that is used in energy management practices, energy efficiency analysis, and reduction in green gas emission analysis among others. This research does not only look at quality management standards that could improve the efficiency of renewable energy products but have more broad areas to be considered in discussing the impact of renewable energy development in Togo. This includes economic, social, environmental, political, and technology among others which ISO framework if chosen will not allow an in-depth look into these various factors thereby will not be the best framework to use in such research. Looking further, PESTEL stands for Political, Economic, Social, Technological, Legal, and Environmental (Achinas et al., 2019). It is a framework used to analyze the key factors influencing an organization from the outside and was at first designed as an assessment tool of the external macro environment in which an industry or business operates (Iacovidou et al., 2017). It is useful in identifying and understanding the key political parameters that are likely to affect the industry; the key environmental and economic considerations and associated societal aspects; the technological innovations that are likely to occur; as well as the current and impending legislation that may affect the industry (Kralj, 2009). PESTEL offers people professionals insight into the external factors impacting their organization. Its analysis has been used in many studies to identify and overcome a variety of obstacles to development. For example, to identify and overcome obstacles relating to the development of the waste-to-energy incineration industry in China, Song et al. (2017) used the PESTEL framework to analyze the macro-environment of the waste-to-energy (WTE) incineration industry in China. They concluded that MSW management in China is controlled by many administrative departments that lack coordination. They also found that by including comprehensive references and suggestions, such as policy changes, application of the Public Private Partnerships (PPP) mode, and guidance on encouraging efficient project operations, the study is also expected to facilitate investment, operation, and management in WTE incineration projects and pave the way for potential private investors who intend to enter the Chinese market. This has also been used in Zalengera et al.'s (2014) study for outlining a novel thinking for addressing the political (P), economic (E), social (S), technological (T), legal (L), and environmental (E) challenges that constrain the development of renewable energy technologies in Malawi. They observed that although the Malawi National Energy Policy clearly lays out the steps toward improving the country's energy situation; unreliable financing mechanisms for large scale energy projects, shortage of trained human resources, lack of coordination among local institutions; unclear regulation framework and sometimes political governance impede the sustainable execution of energy projects and concluded that it is evident from that holistic approaches are crucial for strengthening Malawi's energy sector, and it requires radical political and governance decisions. PESTEL can provide more detailed guidance to decision-makers on issues that are likely to impact the success of their initiatives (Bell and Rochford, 2016). Despite its relative strength in describing multi-dimensional aspects, the use of PESTEL analysis is necessarily narrative; restricted to the identification and conceptual evaluation of the relative importance of contextual issues to determine those that should be subject to a more detailed analysis. Such issues include, for example, political drivers of change, social values that must be protected, environmental systems sensitive to adverse impacts, and legal or regulatory requirements (Iacovidou et al., 2017).

Furthermore, the SWOT analysis is also used to identify the strength, weaknesses opportunities, and threats. However, while PESTEL analysis only concentrates on the external factors, SWOT analysis looks at the internal and external strengths and weaknesses factors that are affecting the development of renewable energy in Togo as well as broader opportunities and threats. It can be used to explore possibilities for new efforts or solutions to problems, make decisions about the best path for your initiative, determine where change is possible, and help to adjust and refine plans mid-course (The University of Kansas, 2022). SWOT and PESTEL analysis are used to make a systematic and thorough evaluation of a new business or project. They are decision-making tools where PESTLE analysis helps the investors to take the decision about the investment and SWOT analysis supports the policymaker for further development. Using both frameworks approach gives decision-makers a better awareness and understanding of the changes that may occur and the impact that these changes may have on their business (Woodruff, 2019). While PESTEL analysis gives a thorough concept of the external environment where an organization operates; SWOT analysis identifies the internal environment of

the organization. The combination of both in this study which has not been done in previous research within the context of renewable energy development in Togo will help to understand what is being done well and derive a better strategy for better development as well as provide a better impact on socio economic development. This is because there is a strong belief that the current issues facing the energy sector can be improved and the introduction of the use of renewable energy with a focus on rural areas can make a significant impact in solving Togo's energy issue and provide sustainable development of the country.

2. Methodology

The data collection method is based on a mixed methodology method that includes three groups of data namely primary, secondary, and tertiary data collection. The primary source of data includes interview notes, field notes, and illustrations which were collected through face-to-face interviews, questionnaires, field notes, and observations. Secondary data collection is based on the use of journal publications, conference proceedings, national, international, governmental, and non-governmental reports. These are collected through a combination of desktop studies, literature reviews, workshops, and conferences. Tertiary data made use of database resources from archival review. A three-round method was used to evaluate the potential of renewable energy technologies and the impact of their development on the energy mix of Togo. Workshops were conducted with five rural communities namely Mansouri and Mango located in the north, Kamboli in the central region, Notse and Agome Glozou in the south. The participants were composed of farmers, fishermans, and artisans. In total, 80 participants took part. In addition, interviews were done with stakeholders from RE Private organizations, NGOs, Financial organizations, Policy makers, international organizations, and Academic institutions to get their viewpoint in relation to the current energy situation in Togo while accounting for the planned development actions to increase energy access using renewable energy. These stakeholders had more knowledge of renewable energy, and contribute to decision-making whether financially, with their expertise, or politically. The reason for this engagement was to incorporate the bottom-up approach in this research that considers the integration of the community with policy makers to capture all views to include in the analysis as well as encourage cross-sector cooperation. The discussion with the rural community helped better identify available resources, the type of activities or businesses, and existing energy needs that will help in finding possible solutions and recommendations that will best suit the need of the people. However, without talking to the policy makers to find out what their stake is, what could be done, what is available and what is needed, and ways to achieve required results will be useless. Overall, 31 stakeholders took part in the first data collection, 17 in the second data collection, and 16 in the third data collection. The first process of data collection confirmed that most people do not have access to energy for their daily lives and the majority rely on the use of biomass such as firewood, charcoal, and vegetable waste most of which is unclean and highly polluted when burned. The most affected people live in rural areas. Results also showed that there is little production while population growth is on the ascendency. It also revealed people's interest in developing other forms of energy such as Solar PV, biogas, hydropower, and wind energy to increase energy autonomy and provide socio-economic benefits. Achieving this will require an increase in political will, housing capability by training personnel, raising awareness, and more studies being done to determine suitability for best results. Finally, actors within the energy sector were identified as CEB, CEET, Ministry of Mines and Energy, DGE, Contour Global, Privates RE Companies, Government, NIOTO, ARSE, and ABREC.

The second process of data collection revealed that there has been the installation of solar mini plants in four villages across the country which serve as lighting and water pumps. It also revealed that previous solar installations in 22 villages resulting from the West African Economic and Monetary Union project are being used for lighting, charging of electrical equipment such as laptops, radio, TV, refrigeration system, and fans for cooling. In addition, the results showed that mainly policy makers are engaged in decision-making with contributions from top professors in academia. Private Renewable Energy companies and NGOs contributions are seen as proposals and not necessary considered in the final decision. Furthermore, the data revealed that Law No. 2018-010 relating to the promotion of the production of electricity based on renewable energy sources has been introduced and favors organizations with the public interest. Data also showed that few regulations exist that need to be improved and put into application plus public interest in prioritizing RE, diversification of RE as well as promoting it and raising awareness.

The third data collection was organized in 2020 for the purpose of validating information from previous data collection. This was necessary due to a time interval between the interviews considering development that could have occurred. It revealed an increase in the rate of access to electricity which went from 80% of the population not having access to electricity at the start of the research in 2014 to 50% during data validation and currently 47%. However, significant discrepancies exist between urban and rural access. This also revealed plans for several projects in line with reducing the share of biomass energy and increasing the share of alternative RE amongst others.

The Figure 1 gives an overview of the research approach conducted, the process and included participant.

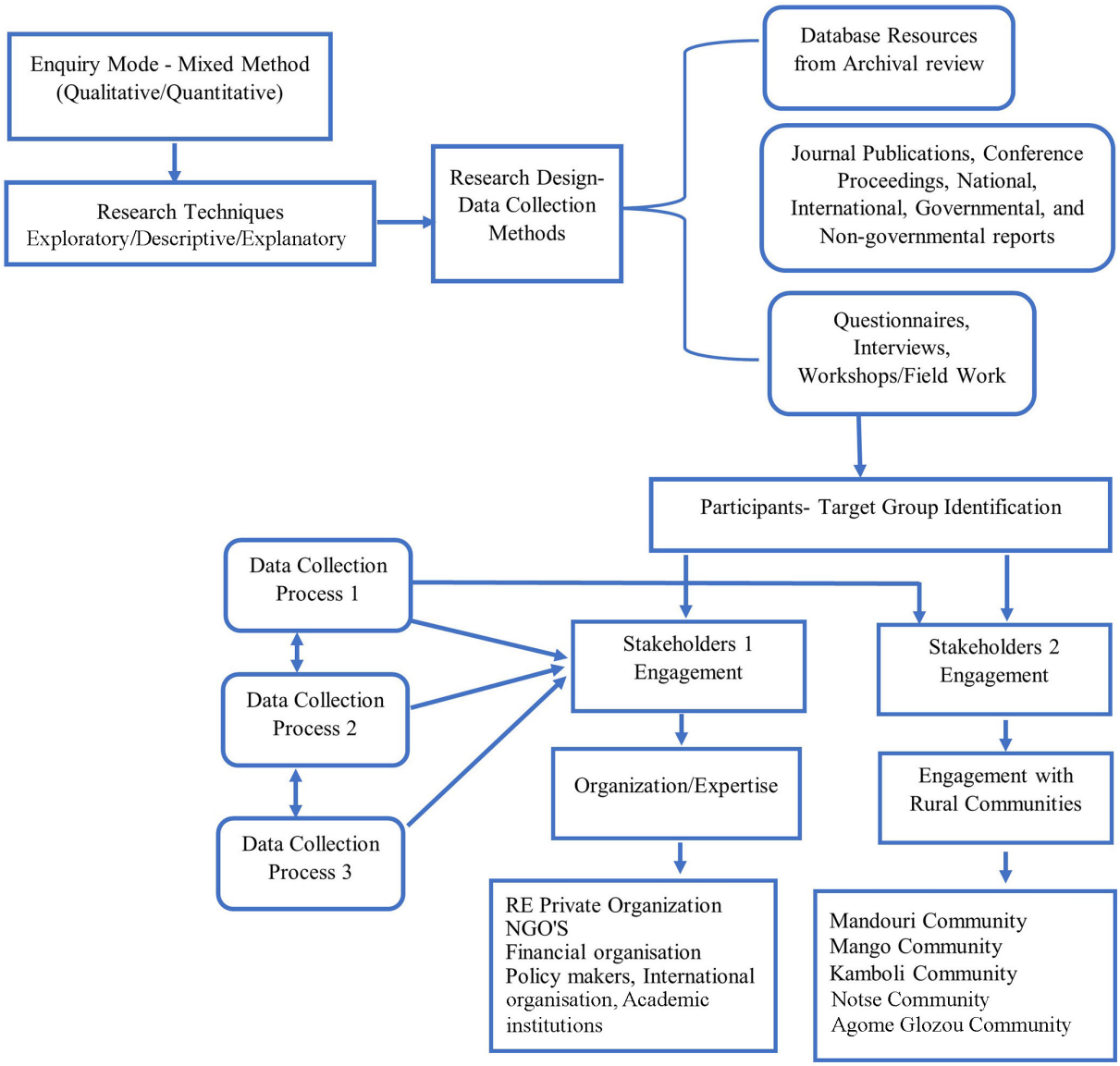

FIGURE 1
Overview of the research approach conducted, the process, and included participants.

The validation of the questionnaire was done in three steps to identify if the questionnaire were the right questions, clear enough, understandable, consistent, and minimal ambiguousness. Comparing the research topic to the literature served as a first reference step to designing the research questions and validating them. A thorough search of numerous databases for journal papers in the same field of renewable energy development was carried out to identify similarities and guidance on how best to frame these research questions. A systematic review investigated how other researchers tackled their studies and what could be the key component of discussions in this study as suggested in previous studies (Oppenheim, 1992; Bell, 1999). This included looking at some feasibility studies done and using credible published studies, looking at various case studies and their results. Various reports were reviewed, key points noted, and recommendations investigated to ensure transparency and replicability of the use method. The following questions were used to derive the impact of renewable energy development in Togo:

1) Would you advise the use of renewable energy in Togo?
2) Can the use of renewable energy contribute to your daily life and activities?

3) How can the use of renewable energy improve any health issues?
4) What impact can the use of renewable energy have on the:

   - Community level.
   - Regional level.
   - National level.

5) Do you think the use of renewable energy can reduce energy costs in the future?
6) What other impacts can the use of renewable energy produce on sustainable development (environment, socio-economic development)?
7) Solar energy was installed in 22 villages from 2013 to 2016 with the aid of the West African Economic and Monetary Union (WAEMU) project named "PRODERE" ("Programme regional de Developpement des Energies Renouvellables et d'Efficacite Energetique"). Do you know how those villages use the installed solar energy?

The questions above were addressed to different groups of stakeholders from rural communities, Renewable energy private organizations, NGOs, Financial organizations, Policy makers, international organizations, and Academic institutions. This was *via* organizing interviews with respondents from each group of stakeholders during the first and third rounds of the data collection and getting participants to complete the questionnaire that was sent to them during the second round of the data collection. In addition, findings from observation, field work, workshops with rural communities, and documents from field work also served as input in finding the impact. Table 1 below gives a detailed breakdown of the aim, methods used, and the task at hand and provides framework approaches for better development.

Below is a breakdown of how the different methods listed in Table 1 will be used to derive the impact of renewable energy development in Togo. A framework for addressing the sustainability challenges facing Togo is provided based on the analysis. The method here is based on:

- Interviews: The steps and process of the interview are explained in Section 2 above. Based on these interviews, key points resulted from the responses of the participants per questions 1–7 listed above. Some of these answers enlivened the impact renewable energy has had in Togo based on recent development while others indicated the potential impact renewable energy could have in Togo and provided recommendations on ways for better development.
- Observations, field work, and workshops with questions based around finding out available resources produce, the stages involved, the current needs, and the available skills with communities helped in understanding the needs, practices, and problems of each chosen community. In addition, the observations on the ground based on various sites visit during the first data collection showed proof of some of the highlighted resources and issues and examples of things to document while taking observations. The analysis of these served as informational facts in identifying potential issues and solutions.
- Literature review: Several pieces of literature are used to represent the existing facts and current state (Zovio, 2021; The Writing Centre and University of North Carolina, 2022) of renewable energy development in general and provide guidance on ways to change or adopt processes that open a flexible mind of thinking to comprehend other researcher's views and allowed us to apply a range of knowledge to the research matter. The literature used in this section served as guidance or learning lessons that are applicable to this research and allowed us to derive impact or best solutions and recommendations for better development. In addition, correspondence with participants yielded further literature information such as promotional materials, annual reports, company reports, and concept

TABLE 1 Summary of the process used for impact analysis.

Aim	Methods	Task	Framework
Outline the impact of RE on the environment and socio-economic development	- Interviews - observations, - field work, - documents from field work - Literature	- Examine social impact: by understanding of local and regional settings and how people live in their society, understanding of the community, identify and assess potential social impact - Economic impact: this looked more into analyzing the economic impact of RE development such as employment/jobs creation, increase in household revenue - Environmental impact of RE usage including impact on the climate, demographic impact (productivity growth, living standard)	Framework for addressing the sustainability challenges facing Togo through a PESTEL analysis approach that looks at Political, Economic, social, technological, environmental, and legal factors. A SWOT analysis is also used to identify internal/external strengths and weaknesses factors affecting the development of RE in Togo

notes. Some of the field note documents are qualitative notes recorded during the research which formed evidence that helped in understanding the research subject and derived answers. The other documentation explained various activities and plans that some of the companies have made or plan. The findings in this section are used to discuss renewable energy's impact and future potential.

2.1. PESTEL analysis

PESTEL analysis is used to identify the strength, weaknesses opportunities, and threats. It looks at external factors and is primary used for market research. This research focuses on the use of renewable energy development in Togo and its impact on socio economic development. Based on the findings of the interview, observations, field work, workshops, and various documents used, several impacts have been listed including economic, social, environmental, and technological among others. To better look at these in detail, a PESTEL approach is considered because it helps provide a better understanding of current external influences that affect the development of renewable energy basing on instead assumptions, helps identify factors that could change, mitigate the risks, and take advantage of opportunities that need to remain competitive and develop a better long-term strategy. Besides, the use of this framework allow to closely look at the impact of renewable energy development based on social, economic, factors, political, legal, technological, and political affecting and provides a comprehensive framework for addressing the sustainability challenges facing the Togolese energy sector. Based on the result of the data collection, there are important factors that affect the development of renewable energy such as economic factors, technology, social, and environmental among others.

2.2. SWOT analysis

Similar to PESTEL analysis, SWOT analysis is also used to identify the strength, weaknesses opportunities, and threats. However, while PESTEL analysis only concentrates on the external factors, SWOT analysis in this study look at the internal and external strengths and weaknesses factors that are affecting the development of renewable energy in Togo. This helps to understand what is being done well and derive a better strategy for better development of renewable energy thereby providing a better impact on socio economic development. The use of the SWOT analysis help in this research to answer the questions summarized in Table 2.

TABLE 2 SWOT analysis matrix.

Strengths	Weaknesses
• What is been done well in Togo in terms of Renewable energy development? • What unique resources does Togo have? • What others see as strength	• What are the issues and what can be improved? • What fewer resources exist compared to others? • What could be seen as weaknesses?
Opportunities	**Threats**
• What opportunities are opened to Togo? • What trends can the Togolese take advantage of? • How could the opportunities be turned into strength?	• What are the possible threats? • What are other countries doing that could be a threat if Togo copies blindly? • What type of threats are clearly shown?

2.3. Data analysis

To analyze the results, data triangulation was used to increase the credibility and validity of the research findings. This was to cross check the finding and results obtained from the research as well as capture different dimensions of the same fact. It involved interviewing different groups of people and the use of multiple data sources such as qualitative and quantitative data sources to develop a comprehensive understanding of the facts in relation to renewable energy development. In addition, questionnaires were used in different rounds to cross check the data collected and to capture any differences. Furthermore, the use of different data collection methods that includes primary, secondary, and tertiary data collection as discussed in Section 2 above serves to minimize the risk of errors and avoid uninformed decisions. The data sample involved using results from 31 respondents from the first data collection, 17 respondents from the second data collection, and 16 respondents from the third data collection. All the participants were from different groups of expertise as detailed in Section 2. In addition, the results from interactions with 80 participants from rural communities were also used to conduct the analysis.

3. Results

3.1. Impact analysis based on PESTEL factors and SWOT analysis

This section discusses the impact of renewable based on political, economic, social, technological, environmental, and legal factors. It also discusses the results based on the SWOT analysis highlighting factors (strengths, weaknesses, opportunities, and threats) that are affecting the development of renewable energy in Togo. Table 3 below provides details of key items discussed for each PESTEL factor and Table 4 provides details of key items discussed for the SWOT analysis. The sources for the information provided in both Tables 3, 4

TABLE 3 PESTEL analysis factors.

Factors		Details	Status of impact
Political	Governmental Policy	Policy to distribute RE at a subsided price households as part of the electrification program−2018	Positive
		National Program for Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation (REDD+) 2010–2050 passed in 2015	
	Tax policy	Finance laws 2020 and 2021—Tax exoneration on solar products to help Companies—This law notably provides for exemptions or relief from the tax burden (customs duties and VAT) on the import of new electric and hybrid vehicles. It applies for a duration of maximum five years	Positive
	Environmental policy	National Environmental policy passed in 1998—which aims at defining specific actions to protect the environment in Togo and ensure a sustainable growth to the country in the medium to long term	Positive
	Funding grant and initiative	Need for Government to help private investment and engage with different funding bodies that could help	Neutral
Economical	Economic growth	Additional income generation for small business/farmers	Positive
	Inflation	Financing capabilities are exceptionally low but progressive increase in prices of goods and services	Negative
	Disposable income of consumers and businesses	Disposable income of people is relatively low to afford expensive imported solar kits	Neutral
	Wage rates	Extremely low wage rate	Negative
	Financing capabilities	Need for innovative financing mechanisms to develop RE	Negative
	Economic Investment	Need to foster income generating activities	Negative
Social	Population Growth	High rate in population growth	Neutral
	Age distribution	Population is unevenly distributed and mobile	Negative
	Health	Improvement in health issues/ health centers	Neutral
	Career attitude	Better growth opportunity for students, public facilities, social benefits in increasing small business activities	Positive
	Customer buying trends	Improve in customer buying trend due to long sales	Positive
Technological	Producing goods and services	Increase in Technology could help produce more goods	Negative
	Increased training to use innovation.	Low level of skills staff needs to be improved	Neutral
	Potential returns/investment	Cost of investing in solar product and potential return	Neutral
	Cost and tax	Cost of equipment and reduction in taxation	Positive
Environmental	Pollution and green gas house emissions	Reduce pollution from thermal power stations, reducing pollution resulting from cooking with firewood	Negative
	Promoting positive business ethics and sustainability	Encourage the promotion of positive business ethics and sustainability	Negative
	Reduction of carbon footprint	Reduce amount of energy used, reduction in waste	Neutral
Legal	Renewable energy legislation	Law on the promotion of electricity generation from renewable source (2018)—this law aims at enabling the country to enjoy 50 % of renewable sources in its mix of electricity supply by 2030, in line with its electrification strategy spanning the period 2018 to 2030 (Horizon 2030)	Positive
	Health and safety	Improve health issues and safety of people—the 2018 Renewable energy law also applies to the safety, operation, storage, marketing, and security of renewable energy sources	Positive

(Continued)

TABLE 3 (Continued)

Factors		Details	Status of impact
	Equal opportunities	Need for transparency and equal opportunities for companies that starts	Negative
	Future legislation	Introduce policies and legislation for better development, Togo has established a regulatory body, passed a public private partnerships (PPP) law and a public procurement decree, and established an agency to promote rural electrification in 2018	Positive
	Competition law	Laws that protect the consumers—mechanism to support low volume consumers such as social and lifeline tariff	Positive
	Environmental legislation	Law 2008-005—framework law on the environment—this law sets the general legal framework for environmental management in Togo Togo is exploring a legal framework to promote renewable energy and a new off-grid rural electrification strategy. It is also currently in the planning stages of revising its national energy law to strengthen the role of the regulator	Positive

are from the data collection results which came from primary, secondary, and tertiary sources of data as well as the analysis and recommendations derived from it. The status is decided based on the outcome and how each factor of improvement or development in renewable energy affected the people and communities involved. Tables 3, 4 provided a summary of the key items described in the PESTEL and SWOT results. The sections below provide comprehensive details with regard to the impact of renewable energy per each factor.

3.1.1. Political

To reduce the rural energy deficit, the Togolese government put in place a separate entity called AT2ER within the Ministry of Energy that will specifically take care of renewable energy projects and the rural electrification program; an electrification strategy with the goal to achieve 100% access to electricity by 2030. In addition, it launched a solar electrification project in 2017 supported by the African Development Bank (AfDB) in partnership with a private company called BBOXX. The aim of the project is to bring light to 2 million Togolese (∼300,000 households) by 2022. Based on this the government put a policy in place for tax exoneration on solar products to help companies like BBOXX distribute renewable energy technologies at a subsided price to households as part of the electrification program. These subsidies have been introduced as part of the political framework by the party in power to get more people on board to sign up. As part of this program, BBOXX installs individual household solar kits for rural households and each household in turn pays $8.23 per kit for Basic, $11.32 per kit for Basic plus, and $19.29 per kit for Premium depending on their needs, all three are of 50 W to facilitate the upgrade. The government since 2019 subsidizes the cost by 2,000 F CFA (∼$3.80) per month for each household holding a solar kit and plans to do that for a period of 36 months from the start date of household conditional on payment of the monthly household fee by the latter itself.

It is worth noting that while this practice can lead to improved adoption and diffusion of renewable energy technologies, it makes it extremely difficult for the registered individual to sustain it due to a lack of funds. Based on data collected, only 4% of rural off grid households subscribe of which 40% of them go for the Basic Plus. If the farmer cannot pay after registration, the kits are repossessed after 120 days of grace period in a year. It should be noted that these subsidies financing of renewable energy systems impairs sustainability challenges by creating beneficial dependence on subsidy when in a real sense they do not have the means to sustain it and keep on with their payment as it should be for a long time. This results in the repossession of the kits which makes development or changes temporarily and not sustainable. This approach fails to provide a long-term solution to the high capital costs of the technologies involved as an average farmer will not be able to sustain payment of even $5 per month and most beneficiaries would not be able to purchase the systems for a long period of time due to their economic situation. These could be remediated if the kits are not imported at high cost and made locally at cheap prices that can be afforded by the community. However, more research needs to be done to implement this.

Institutional sustainability is a key reason for the development of renewable energy. This has been shown in Chile where the rural electricity rate is nearly 100%. The key reason for this success owes to the Ministry of Energy recognizing that renewable energy is much cheaper compared to diesel generators for the life cycle of the project (Feron et al., 2016, 2017). This shows the importance of institutional sustainability when it comes to the sustainability of rural electrification programs (Feron et al., 2017). Besides, receiving support from their government helped private investment in rural electrification *via* Build-Own-Operate arrangements which is another key to their success. Furthermore, Chileans took into consideration local participation in the design and operation of projects. Looking at the current issues in Togo, there is a need for government intervention, engagement, and complete support toward renewable energy projects

TABLE 4 Summary of the SWOT results.

SWOT factors	Results	Results
Strengths	What is been done well in Togo in terms of Renewable energy development?	- Policy for tax exoneration has been put in place to help companies distribute renewable energy technologies at a subsided price - Some trained personnel: 50 engineers, 100 experts and 3,000 technicians - Institutionally, a separate entity called AT2ER was created within the Ministry of Energy that will specifically take care of renewable energy project and rural electrification program - On the organizational level, an electrification strategy has been put in place with the goal to achieve 100% access to electricity by 2030
	What unique resources does Togo have?	- Togo is endowed with lots of potentials for renewable energy amongst which solar and small-scale Hydropower are the most recommended - Government plan to increase hydropower capacity through the development of 3 project namely Sarakawa (24 MW hydroelectric dam on the Kara River), Tetetou (use of the Mono River to construct a hydroelectric dam of capacity 50 MW) and Titira (Plans to develop hydroelectric project with capacity 24 MW) - High percentage of Youth that could be used as a working force for development
	What others see as strength	- Renewable energy will bring about a cleaner environment and reduction in carbon emission - Renewable energy will create new jobs
Weaknesses	What are the issues and what can be improved?	- There is no approach to provide a long-term solution to the high capital costs of the technologies. Institutional sustainability is important when it comes to sustainability of rural electrification programs - Lack of funding. There is a need for the Government to engage with different funding bodies that could assist in putting up in place policies that favors off-grid and poorest communities
	What fewer resources exist compared to others?	- Most of the in-house technician have little knowledge and majority of experts come from the exterior such China, Germany, Italy, and France - Renewable energy resources such as solar thermal, onshore wind, offshore wind, geothermal
	What could be seen as weaknesses?	- Lack of capital and technical expertise to develop renewable energy in the current challenging Togo's economy
Opportunities	What opportunities are opened to Togo?	- Availability of lot of natural resource in renewable energy that could be utilized to achieve sustainable development - The capital city is on a coastal area which could be exploited to develop wave and Tidal energy
	What trends can the Togolese take advantage of?	- Building on local capabilities could enhance irrigation and aquaculture managements
	How could the opportunities be turned into strength?	- Eco Tourism could be created by constructing a traditionally built and locally resourced base structure (including use of renewable energy power) that will provide accommodation and leisure facilities for tourism which could increase local employment, establish stronger retail for hotel need supplies, and highlights Togo's importance in wildlife conservation - The design and construction of a multifunction dam for managing water supply and providing suitable facility for fish production could be helpful in developing asset of this city
Threats	What are the possible threats?	- Long dry season coupled with climate change issue. Recent shortage in rain could have big impact on hydropower plants operation and energy production - The season of Harmattan with strong wind could end up destroying hydropower plants infrastructure - Energy storage could be a challenge
	What are other countries doing that could be a threat if Togo copies blindly?	- Adoption of least-cost analysis in implementing a rural electrification planning framework that first evaluates and assesses the cost-effectiveness of undertaking an off-grid project, compared to grid extension for other countries without looking into what could be suitable in Togo - Introduce cross-subsidization tariff scheme that cover the operation and maintenance cost of off-grid solar PV users that will favor poor households basing on imported technologies without proper studies - Need for key policy makers to recognize that renewable energy is much cheaper compared to conventional types of energy for the life cycle of the project without proper research to find best adapted technologies that will be efficient for Togo - Support from the Government to help private investment in rural electrification through Build-Own-Operate arrangements basing on technologies that are more feasible in other countries
	What type of threats are clearly shown?	- The monopoly, non-liberalization of the energy sector within the country by the Electricity Company of Togo which does not help, and liberalization of the sector is needed for investors to invest - Renewable energy requires high starting cost but more beneficial in the long run.

and implementations. Furthermore, Togo could also learn from Kenya whose electricity increased from 23% in 2013 to about 50% in 2016 (Lee et al., 2016). This success owes to the formation of the Rural Electrification Authority (REA) in 2006 which played a key role in this development. There have been huge investments through subsidies and adequate planning. A GIS based special least-cost analysis (Lee et al., 2016) has been adopted in implementing a rural electrification planning framework that first evaluates and assesses the cost-effectiveness of undertaking an off-grid project, compared to grid extension (The World Bank, 2008). In addition, the government of Kenya engaged with the World Bank which influenced its recent policy that favors mini grids as the least-cost off-grid electricity. This was done with the support of the Energy Sector Management Assistance Program (ESMAP). They also assisted the government to initiate an electricity access plan focusing on the most marginalized and poorest counties (ESMAP, 2017). Just as Kenya's Government did, the Togolese Government needs to engage with different funding bodies that could assist in putting up in place policies that favor off-grid and poorest communities.

3.1.2. Economics

There have been few benefits with the installation of solar kits based on the Rural Electrification Programme called CIZO. A total of 40,199 solar kits have been installed by BBOXX within the country. The ARSE (2019) shows that 24 601 customers installed solar kits since 2017. It also showed that 20 shops were opened, and 10,225 customers had the Basic solar Kits installed (comprising of solar panels, batteries, and three bulbs) in 2019. In addition, ∼6,511 customers had installed the Basic Plus Kit (comprising of solar panels, batteries, 4 bulbs, one loadable torch, and a radio). There was no Premium solar Kit installed (comprising of solar panel, batteries, 1 television of 24″, 4 bulbs, 1 loadable torch, and a radio). A total of 1,158 solar kits were withdrawn for a default payment. Findings from the data collection showed that these installations have mostly been used for electrification and some basic needs. The same goes for the SOLEVA solar kits which had a total of 1,003 customers installation by December 2019 and 1,385 by April 2020. According to the interview results, beneficiaries mentioned these coupled with the installed CEET streetlights and the solar photovoltaic mini grids have helped children study reducing the amount of money spent on buying kerosene for the lamps. In some cases, public lighting has helped women have a prolonged sale for their products instead of having to stop selling once it becomes dark. This helped provide additional income to the users thus improving the economic situation of the households. Furthermore, from the data collection result, participants mentioned that some of the installed solar kits have encouraged professional activities, and helped the small business increase their income in rural areas as more time is spent to continue their activities and improve productivity. Another tangible example of renewable energy development's impact highlighted by one of the private's sector participants during the interview was to do with bill reduction. Discussions with an owner of a clinic with 30–40 rooms that used to pay 1.2 million F CFA to CEET every year for bills showed that he was able to lower his expenses to 800,000 F CFA per year in <3 years once he got solar installed. Besides these, based on responses received from participants during the interview, the majority believe the use of renewable energy will add value to produce where farmers can take the opportunity to grow their products even in dry seasons thereby generating more revenue.

Besides these few benefits resulting from the recent installation of solar kits in Togo, it is worth noting that the estimated population according to United Nations WFP (2021) is 8,478,250 and Togo has a per capita gross domestic product (GPD) of 672.50 US dollars according to 2019 Trading Economics. In addition, Togo is classified as a Least Developed Country (LCD) and Low-Income Food Deficit Country (LIFDC) (United Nations WFP, 2021) and remains among the poorest countries in sub-Saharan Africa. Over 50% of the population lives below the poverty line (under USD 1, 25 per day). Findings from the interviews with various stakeholders, workshops conducted in rural areas, and observations during the field visit showed that the most affected by the lack of energy in Togo are those living in rural areas of Togo and are the least developed. The poverty level is twice as high in rural areas (68.9%) than in urban areas (37.9%) and 34.8% in Lome in 2015 (PND, 2018). In 2021, the poverty level is estimated to be 58.8% in rural areas and 26.5% in urban areas according to the The World Bank (2021). This is due in large measure to an annual population growth rate of 2.5% that is outpacing development progress, concentrated economic growth in the modern sectors, and limited access to quality services.

Based on gender, the poverty level is higher in households headed by women than in men-headed households. This figure was estimated to be 57.5% for women and 54.6% for men in 2015 (PND, 2018). The Poverty level has since decreased and is now estimated at (45.7%) in women-headed households and (45.2%) in men-headed households (The World Bank, 2021). Women remain more vulnerable, as they have less access to economic opportunities, education, health, and other basic socioeconomic facilities (The World Bank, 2021). Social records indicate that self-employed farmers have the highest poverty rate despite the decrease in the level of poverty. The decline is mainly due to the significant investments made in the agriculture sector by the Government. Employees in the public sector recorded the lowest poverty rate in 2015 (28.1%) according to PND (2018). Employees in the private sector and other self-employed are the socio-economic groups within which poverty rates have increased between 2011 and 2015 (44.1–49% and from 39.7–46.2% respectively) (PND, 2018). Besides the

TABLE 5 Inflation rate between 2009 and 2020.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Inflation rate (%)	3.71	1.45	3.56	2.58	1.83	0.19	2.58	1.29	−0.98	0.93	0.69	1.83

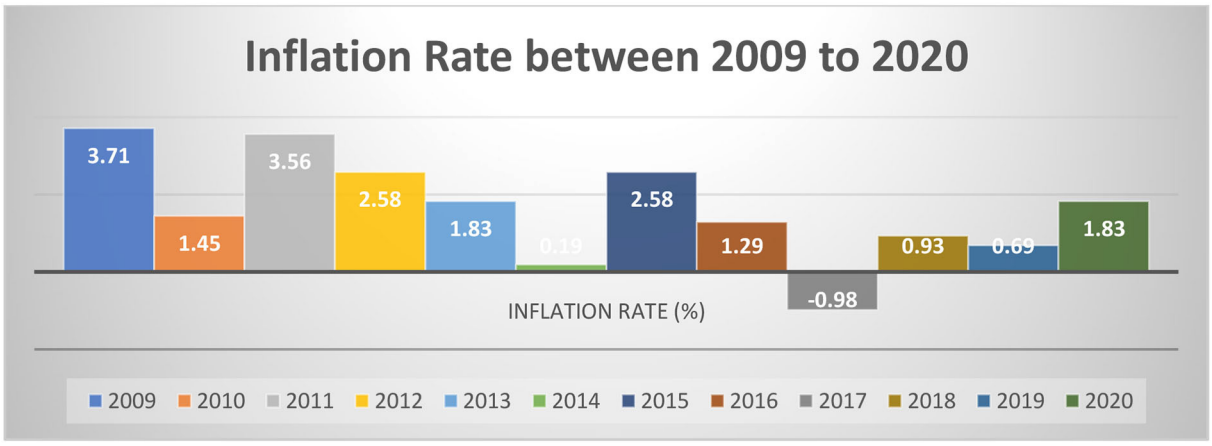

FIGURE 2
Togo inflation rate between 2009 and 2020 (World Data, 2021).

poverty level being high in rural areas, the lack of access to the electricity grid is another issue. To improve the electrification rate, the government's policy put in place subsidized solar products to help companies like BBOXX distribute renewable energy technologies at a subsided price which presents a significant barrier to sustainability. This is because, looking at the financing capability of people, subsidizing the price is a plus, however, it is worth noting that majority of the population could not afford to pay over $5/month. Furthermore, renewable energy technologies kits in Togo are imported and are mostly expensive. Based on findings from the interview, the disposable income of people is relatively low to afford goods due to inflation issues within the country due to expensive imported solar kits (CEET, 2018, CEET, 2019). Table 5 shows the inflation evolution between 2009 and 2020 as also shown in Figure 2.

The inflation rate according to World Data (2021) was ∼4.3% per year between 1979 and 2020. An item that cost 100 Francs in 1979 is now charged 510.91 Francs at the beginning of 2021, an increase of 410.91. Between 2013 and 2016 Inflation was brought under control by 1.4% on average due to the decline in food prices, which generally benefited from good weather conditions over the period and a decrease in petroleum products (PND, 2018). Since 2019, inflation began rising again from 0.69% in 2019 to 1.83% in 2020, due to higher food and oil prices (The World Bank, 2021; World Data, 2021). Besides all these, the COVID-19 pandemic has halted growth that fell to 1.8% in 2020 compared to 5.5% in 2019, following a decline in investments and consumption. Travel restrictions have adversely affected the tourism and services sector, while the agriculture sector has remained resilient. A rebound in capital goods imports to combat COVID-19 and a reduction in exports widened the current account deficit from 0.8% of GDP in 2019 to 1.5% in 2019. Grants and concessional loans helped finance the current account deficit. Debt rose from 52.4% in 2019 to 60.3% in 2020, owing to the significant increase in the fiscal deficit from 0.9% in 2019 to 6.9% in 2020 and a slowdown in economic activity.

Thus, without innovative financing mechanisms, the adoption of renewable energy technologies will remain low. This is because there is a need to come out with ideas that will foster income generating activities that will facilitate paying for good quality systems capable to meet people's energy needs. For example, Eco Tourism could be created by constructing a traditionally built and locally resourced base structure (including the use of renewable energy power) that will provide accommodation and leisure facilities for tourism which could increase local employment, establish stronger retail for hotel need supplies, and highlights Togo's importance in wildlife conservation. In addition, the design and construction of a multifunction dam for managing water supply and providing a suitable facility for fish production could be helpful in developing assets of this city.

3.1.3. Social

Renewable Energy development has had a few advantages on the society in Togo so far. Based on findings from the interview questionnaires 3.1–3.6 of the first data collection and

research question i.e., 'What impact can the use of renewable energy have on the: Community level, Regional level, National level.' of the second and third data collection questionnaires, the installed solar panel at some locations provide lighting for health centers which assist in products storage such as vaccines and medications for the best functionality of the hospitals. In addition, some of the respondents mentioned that solar installation has helped with food storage in some houses and the progress of work at offices during a power outage.

Another benefit includes the reduction of the use of firewood for lighting and cooking which lowers the number of people affected by respiratory diseases due to inhaling smoke produced using burning wood for cooking. There has also been an improvement in water availability and access to potable water due to solar pumping for the communities. Besides, the data collection findings showed that the use of renewable energy is helping students in their studies have a better opportunity to study. Furthermore, the results showed that a few socializing events such as TV projection shows, and dance events have been organized allowing people to socialize due to the electrification access. Overall, the use of renewable energy has helped several public facilities that have light and has added substantial social benefits in increasing small business activities thereby reducing the level of unemployment and contributing to better overall health.

Despite the benefits offered by the installation of renewable energy, the population growth rate in Togo is on the ascendency with an average of 2.84% annually which increases the demand for energy needs as well. For example, between 1981 and 2010 the total population rose from 2,719,567 to 6,191,155 (International Monetary Fund, 2014) and it is currently estimated at 8,478,250 (United Nations WFP, 2021). The population is unevenly distributed: 42% live in the Maritime region, which covers only 23.2% of Togo's total area. The disparity in population distribution and growth complicates development plans according to the International Monetary Fund (2014). Togo's population is also highly mobile; a lot of people migrate in search of economic opportunities with some moving from rural to urban areas and others leaving the country. Most urbanization has occurred in the Greater Lomé Metropolitan Area, where 23.9% of the population resides. However, urbanization is poorly regulated, with no urban planning or environmental policies. Rapid and uncontrolled urbanization causes housing and infrastructure problems. According to the latest census data on the age and sex of the population, the proportion of young people remains high (International Monetary Fund, 2014). This proves that fertility and mortality are still high, and 42% of the population is under age 15, and 60% is under age 25. The youth based on the lack of decent jobs are exposed to social scourges such as banditry, prostitution, delinquency, and alcoholism among others. Togo experiences migratory movements which are reflected by a rural exodus (especially to the capital Lome) and long-standing and significant international migration (PND, 2018).

According to the interview results respondent believe that if there were better living standards in rural areas, less migration will be registered. Based on the literature (Ayenagbo et al., 2011), field visit, workshops, and interview questionnaires, Togo is endowed with lots of potential for renewable energy among which solar and hydropower have been recommended based on the results of the data collection. Respondents believed that developing solar and hydropower in rural communities will help solve energy issues and socio-economic issues forcing the youth to migrate to urban cities.

Currently, several developmental projects are taking place in the country such as the installation of solar kits to provide lighting and water pumps to help the communities. Results from the non-governmental participants suggested that some of the issues associated with these installations are the lack of inclusion of local communities in developing their future energy needs. They recommended that proper planning for sustainability before implementation of each project and adequate monitoring after implementation are carried out to ensure the good functionality of projects for success. The inclusion of local communities in developing their future energy needs has been emphasized by Feron et al. (2016). Their research findings prove that for a project to be accurate, it must meet the specific local needs and consider the socio-cultural reality of each community. Moreover, major progress on cultural justice, equity, and environmental awareness is needed for ensuring the sustainability of rural electrification efforts in Chile. In addition, Zalengera et al. (2014) in their research also stated technologies and their development methodologies including financing mechanisms should be adapted to contexts in which they would operate. They added this requires in-depth knowledge of several aspects such as energy needs and requirements; prioritization of energy services; purchasing power; satisfaction of energy services and experiences with prevailing energy technologies; social practices and social set-up of communities; and available technical skills. Furthermore, Kolios and Read (2013) in their approach to Risk Identification of the Tidal Industry in the United Kingdom emphasized the communication issues within the industry and its external stakeholders. They found local fishing communities must be considered at an early stage in marine energy development as well as the general public and local communities to better plan for the future.

It is worth noting that the lack of energy in Togo especially in rural areas remains a big issue impacting the lives of people. Most of these areas are endowed with resources such as solar potentials, presence of a lot of rivers, that could be developed, thus, permitting the installation of solar power technologies and small-scale hydro power that could bring a lot of benefits. For example, based on the response from data collection, participants in rural areas illustrated that the installation of solar in some hospitals has helped with the storage of vaccines, drugs,

accessing vaccines, and anti-venom, thus, helping availability in these localities and saving many lives. Recommendations from the respondent suggested that the use of renewable energy could improve health issues because this will help reduce the use of a fire hood thereby a decrease in the amount of smoke which could lead to a reduction in respiratory diseases. For these, aside from the government subsidizing prices for a household with per solar kit per month, financing is needed to develop community installed solar plants for hospitals, schools, and solar water pumping for example to provide clean water to the communities amongst others.

Another key aspect of society is the need for education. This could be a powerful force for advancing opportunity, prosperity, and growth. There have been few trained personnel: 50 engineers, 100 experts, and 3,000 technicians that could help with a future project plan in the development of renewable energy. However, in general, the domestic financing of education in Togo has steadily increased, in nominal terms, while the share of education spending has, for its part, fluctuated, representing on average 17.3% of Total public expenditure. The total operating expenses absorb the largest part of the public education budget, this limits the government's ability to invest in education sector reform. Indeed, from 2014–2017, on average 98.4% of expenditure on education were devoted to the spending of operation, i.e., essentially the wages.

International funding has increased slightly between 2009 and 2017. The share of the funding sector of development partners by the ratio of total sector investments increased from 71% between 2009 and 2011 to 89% between 2014 and 2017. The proportion of bilateral aid was on average at 92% and that of multilateral aid at 8%. France and Germany are by far the two main funders of education in Togo. The volume predictability and quality of aid to the education sector have not changed much over the period examined. Partners' investment only materializes in the form of projects, which limits the predictability of aid and has probably contributed, at least in part, to restrict the capacity of the government of Togo to plan, properly implement and monitor and consistent with the Education Sector plan (PSE) 2014–2025 (Universalia, 2019). Should the level of education improve this could impact people positively in a way that will help renewable energy development.

3.1.4. Technological

From Research question on 'Solar energy was installed in 22 villages from 2013 to 2016 with the aid of the West African Economic and Monetary Union (WAEMU) project named "PRODERE" ("Programme regional de Developpement des Energies Renouvellables et d'Efficacite Energetique"). Do you know how those villages use the installed solar energy?' findings show that Law no. 2018-010 of 8 August 2018 relating to the promotion of the production of electricity based on renewable energy sources was introduced and based on participants from the Ministry of energy stated this law regulates the renewable energy sector and exempt taxes and customs duties on renewable energy equipment. Based on conversations with participants from a private organization, this law gives priority to renewable energy development and allows an increase in the national electrification rate by opening to the private's sector under state supervision while guaranteeing the quality of the installations. This is an advantage that encourages organizations to purchase equipment. However, findings from the interview showed some restrictions depending on the number of kWh consumed. Participants mentioned that tax exoneration benefits more companies with public interest that have some project and there is no benefit for individual or private companies that want to do business. Responses from participants showed that for consumption above 100 kWh, authorization and a license are needed by each actor in the private sector from the Ministerial decree which discourages SMIs and SMEs that are starting up.

With the constant growing of the population and increase in energy needs, efforts must be made to increase energy production to solve basic energy needs like cooking and heating. As Kolios and Read (2013) stated, firewood is becoming scarcer, and renewable energy technologies for cooking and heating such as solar cookers, solar water heaters, biomass briquettes, and biogas could be more important than small scale solar PV and/or wind energy technologies designed only for lighting, particularly for households. Policy makers must bear in mind sustainable development when deciding on priorities in terms of development. For now, the Togolese government is focused on increasing energy access to most Togolese and making plans to build a mini solar grid and increase hydropower capacity through the development of three projects namely Sarakawa (24 MW hydroelectric dam on the Kara River), Tetetou (use of the Mono River to construct a hydroelectric dam of capacity 50 MW), and Titira (plans to develop the hydroelectric project with capacity 24 MW) amongst others to achieve their set target of 100% electricity for all in 2030. To date, the most common technologies put in place are solar Panels for streetlights. This is a step forward which, however, will not resolve the energy issues facing the communities with regards to having energy for their basics needs for cooking, business, etc. For instance, making sure water pumping is installed in rural areas would be suitable for community water supply. Based on findings from the interview and field visit observations, the North of Togo has rivers that could potentially be used with solar powered plants to develop irrigation. This could be of big help to the farmers to continue their farming activities even in dry seasons and not only have to wait for raining seasons to grow their produce thereby producing goods and services in all seasons. In the same way, a solar powered value-added crop processing unit could also be put in place to help farmers grow, process, and store more agricultural products during all seasons of the year, thus, reducing poverty. These could be based on an example such as the one shown in Reza and Sarkar (2015) where

the idea of solar irrigation in real practice was implemented and showed the economic and technical viability of a directly coupled solar photovoltaic irrigation pump system operating at Gaibandha, Bangladesh. Singh et al. (2012) also developed a solar powered pump controller, using a fuzzy logic control strategy to feed water for cultivation. This was tested with the growth of vegetables like a tomato plant that resulted in saving 50–60% in water consumption and the cost of energy generation.

Another important factor to consider is the production of technologies that are suitable for the environment in which they are being used for good functionality and reliability. It is, therefore, essential to increase training to use available equipment and develop expertise that will help have people capable of producing components and systems in house that are techno-economically viable. Doing this will reduce the risk of getting inappropriate technologies like that of the broken-down water pumps supplied by a previous project in Southern Togo. It is worth noting that this technological analysis mainly focused on solar energy application and development because other sources of renewable energy such as wind and biogas are not really in use thereby the lack of in country data to access the impact these have had. Biomass such as firewood, charcoal, and vegetable waste is mostly unclean and highly pollutant when burnt as discussed above which can create health problems (Awopeju, 2020; Kyayesimira and Muheirwe, 2021).

3.1.5. Legal

Most renewable energy technologies used in Togo are imported. In 2018, Togo approved another IPP for a 65 MW Thermal power generation plant and has taken significant strides to reform its legal framework to attract private-sector investment (USAID, 2021). The government put in place the following laws (LSE, 2022):

- Finance laws 2020 and 2021: This law notably provides for exemptions or relief from the tax burden (customs duties and VAT) on the import of new electric and hybrid vehicles. It applies for a duration of a maximum of 5 years.
- Law on the promotion of electricity generation from a renewable source (2018): This law aims at enabling the country to enjoy 50% of renewable sources in its mix of electricity supply by 2030, in line with its electrification strategy spanning the period 2018–2030 (Horizon 2030).
- Law 2008-005—Framework law on the environment: This law sets the general legal framework for environmental management in Togo. It aims to:
  - Preserve and sustainably manage the environment.
  - Guarantee to all citizens an ecologically sound living environment and balanced.
  - Create conditions for rational and sustainable management of resources natural for present and future generations.
  - Establish the basic principles for managing, preserving the environment against all forms of degradation in order to develop natural resources, and fight against all kinds of pollution and nuisances, and
  - Sustainably improve the living conditions of the population while respecting the balance with the surrounding environment.

The 2018 renewable energy law also applies to the safety, operation, storage, marketing, and security of renewable energy sources. Based on interviews with stakeholders, taxation is still expensive on imported solar kits as well as batteries causing high cost of energy. In addition, based on discussions, tax exemption is considered in some cases such as in the case of companies with the public interest and does not benefit private's organizations. This is because the government wants to be selective about the type of companies that starts. It was also revealed from data collected, that heavy consumers are charged 18% for tax. Lowering taxes on renewable energy technologies equipment without being too selective on a certain category of companies or consumers will enhance the affordability of renewable energy systems and lead to better adoption and diffusion. It is therefore, necessary for a more transparent and equality legal framework to be put in place to regulate and offer clear coordination among the Togolese tax service staff that oversee importation activities.

Another issue affecting most of the Togolese communities is health issues resulting from the lack of clean water and the use of firewood. Wood for instance is used for cooking exposing villagers to smoke pollution (causing respiratory disease), cold, and wind during Harmattan (because of the excess in cutting trees that are being used for firewood). If favorable policies are put in place to encourage communities to obtain part of their energy for cooking and water heating from renewable energy sources, this could reduce the use of firewood, thus, reducing health issues and saving lives. Similar policies have been key drivers of renewable energy technologies in Western countries whereby energy suppliers are obliged to source part of their energy from renewables (Zalengera et al., 2014).

3.1.6. Environmental

Most of the renewable energy development outlined above is being used for electrification, water pumping, and basic needs based on the findings from the data collection. The majority of households in rural areas continue to rely on the use of firewood for cooking causing women to inhale a lot of smoke while taking home cores. This continues to cause respiratory issues amongst other health issues. There is a need for Governments

to identify energy technologies that will be appropriate based on the local concept and communities, and affordable. Currently, an important barrier is the high cost of solar equipment which discourage its wide adoption. It is essential that instead of importing renewable energy technologies, a critical evaluation and research is done in house to identify the best technology that will be most appropriate to Togo and build appropriate knowledge to help manufacture these technologies in house at reduced prices. Besides, if strong policy regulations are put in places such as the introduction of laws that protect air quality, water, and the environment this will encourage people to switch to best practices for better results.

Togo is aware of the major environmental risks it faces especially issues with coastal erosion, deforestation, desertification, and climate change (PND, 2018). Currently, the energy sector set a high potential to reduce greenhouse gas emissions by 2030. On the national level, for instance, Togo is committed to reducing its emissions by 11.14% by 2030 and 20% afterward (PND, 2018). From the discussion with some participants from the electricity company, there is major pollution from the thermal power stations coupled with damage to the soils. All these issues could be solved by increasing the share of renewable energy and reducing the amount of pollution from thermal power stations, reducing pollution resulting from cooking with firewood, deforestation, desertification, and climate change by switching to the use of solar cookers and water heaters. If all these are investigated carefully and environmental and legislation policies are put in place, a better impact could be achieved. This is supported by Kolios and Read (2013) who stated that developers must consider the bigger picture and how their actions may have detrimental effects on the environment at any stage of the project.

4. Discussion

The energy sector does not contribute effectively to economic development, in particular to the improvement of agriculture, industrial, and mining productivity. Togo is weakly endowed with modern energy resources and still depends largely on traditional energies mainly wood energy which constraint population growth and climate change. In addition, the monopoly of the electricity sub-sector hinders the development of mini grids in rural areas (PND, 2018).

To date, petroleum products are still the main modern energy accessible to rural areas. Togo's dependence on these energies is more worrying as domestic and industrial demand is growing steadily. The following are noted (PND, 2018):

- Instability of the prices of petroleum products due to insufficient security stock of petroleum products.
- The weak national capacity to cover national gas needs.
- The country's 100% dependence on oil-producing countries particularly on fluctuations in the price of a barrel of oil.
- Low capacity and dilapidated hydrocarbon storage infrastructure.

The PESTEL and SWOT analysis above provided detail with regard to the benefits, motivation, barriers, and possible solutions for each factor. To summarize, in the past decade, the following development keys point could be noted:

4.1. Increase in energy production and a decrease in the importation

The total energy production purchased in 2009 was estimated at 713.01 GWh according to the electricity company of Togo report (CEET, 2010) with a percentage of only 3.2% production. This amount increased to a total of 1,094.0 GWh in 2015 (ARSE, 2015); 1,258.25 GWh in 2018 (Energy purchased was 872.63 GWh, and energy produced by CEET was estimated at 12.23 GWh and that of Contour Global 373.39 GWh, therefore, a total of 385.62 GWh (CEET, 2018). Energy purchase plus production further increased to a total of 1,350.35 GWh in 2019 with 64.52 and 35.48% of energy purchased and energy produced in the country, respectively. This breakdown is shown in Table 6. This variation shows some positive development as mentioned by the PESTEL and SWOT factors.

4.2. Increase in total customers or number of subscribers and an increase in energy access rate

In 2009, the total number of customers was 1,61,654 (CEET, 2010), and the access rate in 2010 was estimated at 25% according to Sustainable Energy for All (2012). This increased to 27.62% in 2013 with an estimate of 2,33,036 electricity subscribers which further increased to 4,38,911 clients in 2018 (CEET, 2018). The national electrification rate increased to 45.09% in 2018 and 50.3% at the end of 2019. This increase is due to the continued investment in the extension of the distribution network, which favored more access of the population to connect to electricity (ARSE, 2019). Table 7 shows the access rate per region in the years 2010, 2011, 2018 and 2019.

4.3. Increase in the share of renewable energy

Renewable energy development in Togo has increased in the past decade. Details of the recent development of Renewable

TABLE 6 Estimation of energy purchased and production for the years 2009, 2018, and 2019.

	2009		2015		2018		2019	
	Energy (GWh)	Percentage (%)	Energy (GWh)	Percentage (%)	Energy (GWh)	Percentage (%)	Energy (GWh)	Percentage (%)
Energy purchased	690.21	96.8	1,073.09	98.09	872.63	69.35	871.25	64.52
Energy produced	22.81	3.2	20.91	1.91	385.62	30.65	479.1	35.48
Total	713.02	100	1,094.0	100	1,258.25	100	1,350.35	100

Source: CEET (2010, 2018), ARSE (2015), and ARSE (2019).

TABLE 7 Breakdown by region of the electrification rate.

Region	Year 2010 Access rate	Year 2011 Access rate	Year 2018 Access rate	Year 2019 Access rate %
Lome	86	63.99	93.37	94.77
Reste of maritime		10	44.86	64.0
Plateaux region	5	9.06	19.10	22.30
Centrale region	2	17.67	24.69	28.51
Kara region	5	12.58	27.49	31.33
Savanes region	2	8.89	16.08	18.11

Source: SOFRECO (2010), Réalisation de l'étude d'un plan stratégique du sous-secteur de l'énergie électrique au Togo, p 54–56 and ARSE (2011, 2019).

Energy in Togo are presented in section 4. As discussed in section 5.3.1.2, based on the CIZO project discussed in section 4, the total number of recorded customers that have active solar kits installed by December 2019 were 40,199 and 1,003 for BBOXX and SOLEVA respectfully. These installations were done between 2017 to 2019. It is worth noting that the national capacity supply for the various energy needs in 2019 increased by 317.59–339.56 MW, an increase of 6.92%. The share of renewable energy in 2019 was 11.65% against 11.83% in 2018 (ARSE, 2019).

In 2008–2010, the share of renewable energies (excluding biomass) was essentially made up of hydroelectricity of national origin which represents 0.3% of the total supply or 1.57% of conventional energy supplies (electricity and petroleum products) (Sustainable Energy for All, 2012; World Bank, 2013). The share of renewable energy in the mix increased to 7.27% in 2019 (ARSE, 2019). This shows progress in the development of renewable energy within the country. A summary of the estimation of the electric power generation based on renewable energy sources in 2019 is shown in Table 8.

4.4. Introduction of renewable energy law

With regards to Law No. 2018-010 of 8 August 2018 relating to the promotion of the production of electricity based on renewable energy sources, the legal arsenal in Togo was strengthened in December 2019. As shown in the PESTEL discussion, this is an advantage and a good starting point for development. This law establishes the general legal framework for the implementation of electricity generation projects based on renewable energy sources, either for own consumption or commercialization. It defines the legal regulation of the installations, equipment, materials, and movable and immovable goods necessary for the production, storage, transport, distribution, marketing, and consumption of electricity from renewable energy sources (Energypedia, 2020). This law also applies to the safety, operation, storage, marketing, and security of renewable energy sources (Loi Energie Republique Togolaise, 2018). There are various decrees that specify the Renewable Energy Sources Act for individual measures. The decrees serve:

- To determine the performance thresholds of the various legal regulations for electricity generation projects based on renewable energy sources (Decret No. 2019-019, 2019).
- To determine the conditions for concluding and terminating concession agreements for the generation and marketing of electricity from renewable energy sources (Decret No. 2019-018, 2019).
- To determine the conditions for granting and withdrawing the license for the generation, distribution, and marketing of electricity from renewable energy sources (Decret No. 2019-021, 2019) or
- For the creation, allocation, organization and functioning of the Togolese "ageance d'électriffication rurale

TABLE 8 National estimation of renewable energy in 2019.

Operators	Type of renewable energy sources	Site	Installed capacity
CEB	Hydroelectricity	Nangbeto (Plateaux region)	65 MW
CEET	Hydroelectricity	Kpime (Plateaux region)	1.6 MW
	Mini grids based on solar photovoltaic	- Bavou (160 kWc) - Assoukoko (250 kWc) - Takpapiéni (100 kWc) - Koutoum (100 kWc)	610 kWc
	Public lighting based on solar photovoltaic	Throughout the entire national territory	2.79 MW
BBOXX-EDF	Solar kits photovoltaic	Throughout the entire national territory	2.01 MW
SOLEVA	Solar kits photovoltaic	Throughout the entire national territory	23.02 kWc

Source: CEET and AT2ER Statistics (2019).

et des énergies renouvelables" (AT2ER) (Decret No. 2016-064, 2016).

5. Conclusion

From the PESTEL analysis the following key results were noted:

Subsidizing the price of equipment acquired by each individual or household for couple of years does not guarantee long term affordability and use but a long-term solution to the high capital costs of the technologies is to be investigated for better adoption. Thus, institutional sustainability is a key reason for the development of renewable energy.

The few installed solar kits and power plants have contributed to helping children study and lowering the cost spent in buying kerosene for the lamps. It also helped women/small business owners have extended time to continue their activities and improve productivity, encouraged professional activities thereby providing additional income to the users, thus, improving the economic situation of the households. In addition, social records indicated that self-employed farmers were found to have the highest poverty rate with higher poverty rates found in rural areas. Besides most of these areas are not connected to the electricity grid.

Other benefits of the installed solar included providing lighting for health centers that helped store vaccines and medications, food storage, provided improvement in water availability, and access to potable water due to installed solar water pumping for the communities. Besides, these provided light to a few facilities and added substantial social benefits in increasing small business activities thereby reducing the level of unemployment and contributing to better overall health. This is an advantage that will go a long way in allowing youth to concentrate on small businesses instead of devoting their time to social scourges such as banditry, prostitution, delinquency, and alcoholism among others as well as cut down the rural exodus to the capital town for example.

The results also showed issues associated with installations in previous projects which is due to the lack of inclusion of local communities in developing their future energy needs. It was found out that there is a need for proper planning for sustainability before the implementation of each project and adequate monitoring after implementation is carried out to ensure the good functionality of projects for success. The study also showed that there is a need for education/trained personnel which could be a powerful force for advancing opportunity, prosperity, and growth.

The results also showed that there could be an improvement in terms of tax exoneration so individual or private companies that want to do business can also benefit from it. Besides, the results showed that the North of Togo has rivers that could potentially be used with solar powered plants to develop irrigation that could be of big help to the farmers to continue their farming activities even in dry seasons thus producing goods and services at all seasons.

From the result, most households in rural areas particularly continue to rely on the use of firewood for cooking causing women especially to inhale a lot of smoke which continues to cause respiratory issues amongst other health issues. It also showed that policy regulations are needed such as laws that protect air quality, water, and the environment to encourage people to switch to best practices. Finally, taxation is still very high on imported solar kits and batteries causing the rise in cost of energy.

Altogether, there are many advantages associated with the use of renewable energy technologies that should be critically considered in decision-making toward a pathway to achieve the development of renewable energy technologies. Investors may want a quick return on their investment and if regulations and laws do not help them to invest due to the high cost of equipment and taxes and consumers' interest, it will be difficult for them to invest. In house capacity building to help with the design and manufacture of equipment that are affordable and efficient within Togo could remediate these issues. In addition, it could help reduce the importation of kits at high cost as well

as the risk of acquiring technologies that are not appropriate for Togo.

In addition, the Togolese Government needs to engage with different funding bodies that could assist in putting up in place policies that favor off-grid and poorest communities. This is because, without Innovative financing mechanisms, the adoption of renewable energy technologies will remain low.

The community interest for instance will be a focus on achieving socio-economic and environmental impacts to better their living conditions. It is, therefore, important to include the local communities in developing their future energy needs. Furthermore, if proper planning before the implementation of each project is done, the right equipment will be put in place for the benefit of the communities.

Finally, aside from introducing subsidies in prices for households, financing is needed to develop communities installed power plants in a way that will be sustainable for the communities in meeting their own needs without having to always seek the help of experts from outside of their communities. This could be achieved by raising awareness and developing training programs for skills needed by personnel within each community. It is worth mentioning that Togo took steps in providing a 2-week training in collaboration with Kya Energy Group and the University of Lome for 3,000 technicians in 2019 (600 technicians per region in all five regions of Togo) for the CIZO project. The hope is to be able to employ all those trained technicians in the future once the upcoming project is executed. However, the training provided was based on imported equipment and to date, none of the trained staff is employed.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: none. Requests to access these datasets should be directed to JN, j.njuguna@rgu.ac.uk.

Author contributions

Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, validation, visualization, and writing—review and editing: NK, JN, and SV. Supervision: JN and SV. Writing—original draft: NK. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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