Evaluating Sustainable Energy Potentials through Carbon Emission Assessment of Small and Medium-sized Enterprises in the Global South: a case in Wula, CRS Nigeria

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Abstract

There is increasing focus on sustainable energy in developing countries as part of their transition to low carbon economy. Approximately, 40% of the world's population, mostly in low- and middle-income countries, do not have access to modern energy. Developing countries including Nigeria are facing energy poverty. Small and medium-sized enterprises (SMEs) have a role in achieving the United Nations' (UN) Sustainable Development Goals (SDGs). Absence of sustainable energy is hindering the growth of SMEs in the Global South with impacts on society. In Nigeria, inaccessibility and regular outages of power from the national grid compels SMEs to rely on fossil-fuel based energy which exacerbate pollution and carbon footprint having environmental, social and economic consequences. This project evaluates the potential of sustainable energy in SMEs for minimizing carbon footprint and accelerating the energy transition in a local community of Wula, Nigeria. This exploratory investigation conducted semi-structured interviews with 16 SMEs to obtain data on energy consumption including energy type, quantity consumed and annual cost to estimate carbon footprint and identify sustainable energy needs.

The study found that there is significant potential for sustainable energy in the local community and joined-up approach in interventions cannot only address environmental issues but social issues in the local community. The analysis indicates that SMEs spend $13,563.4 annually on fossil fuel-based energy and consume 33,215 litres of petrol/annum; and an estimated carbon footprint of 76,891.0642 $KgCO_2e$ (equivalent of 76.89106 tCO_2e) per annum. The project helps to understand state of the problem and plans to reduce CO2 emissions and sustain SMEs by installing sustainable energy systems based on the community needs and contribute towards the SDGs. This could open new markets and business opportunities for the poor in the rural area, hence lift families out of poverty and transform lives as a contribution towards SDGs.

Keywords: Sustainable energy, Carbon footprint, Small and Medium-sized Enterprises, Global South

1. Introduction

Recently, the public policies promoting the transition to sustainable energy have given its attention to the promotion of energy efficiency and the adoption of new sources of energy such as renewable or sustainable energy (green energy) in order to minimise increasing carbon emissions (Segarra-Blasco and Jove-Llopis, 2019a). The implementation of sustainable energy technologies has faced a range of barriers that have affected their rate of adoption globally (Luthra *et al.,* 2015). One key strategy for transitioning to a low-carbon and sustainable energy model is to enhance the share of renewable energy, mainly for electricity generation (Pfeiffer and Mulder, 2013). Energy poverty and absence of sustainable energy is hindering the growth of small and medium-sized enterprises (SMEs) in the Global South with severe impacts on the society. In the Nigerian context, inaccessibility and regular outages of power from the national grid compels SMEs to rely on fossil-fuel based energy systems which exacerbate pollution and carbon footprint with severe environmental, social and economic consequences. Nigeria is also facing electricity crisis resulting the threatening of most business sectors. It is estimated that around 40% of people in Nigeria are connected to the national grid but the connected population/communities are exposed to frequent power outages causing disruption (Aliyu and Adam, 2015). Furthermore, electricity is conventionally generated by employing the natural resources such as oil, coal and gas and the fossil-based electricity contributes to increase in carbon footprints (Balsalobre-Lorente *et al.,* 2018).

Growing energy demand and increasing concerns about environmental and economic costs call for sustainable energy interventions in Nigeria. Therefore, this project aims to evaluate the potential of sustainable energy in SMEs for minimizing the carbon footprint and accelerating the energy transition in a local community of Wula in Nigeria. The project has adopted a novel approach of co-creating sustainable energy solutions and bottom up approach to capture the perspective of the local community. It is argued that energy availability is crucial for the economic growth of the local community in Wula. Also, access to clean, affordable and reliable sustainable energy is key in achieving sustainable development (namely SDG 7: Affordable and Clean Energy) (Emodi and Boo, 2015). The paper first presents the literature review to develop theoretical background around the topic area. Research Methodology is presented followed by the analysis of data and findings. Then, key findings are discussed, and conclusions are drawn with direction for future project work.

2. Literature Review

The reality that the earth is heading for an unprecedented environmental crisis has never been more imminent than in the last decade (Burgess, Bowring and Shen, 2014; Redclift, 2010). With increasing production and consumption patterns among super-rich nations driven mostly by profits, coupled with the unwillingness to honour carbon emissions treaties, there is no doubt of the earths continued environmental crisis. Whereas increasing production activities in the global north has meant greater prosperity for the citizens and businesses, the situation in the south is not just gloomy, but near bleak (Werther Jr and Chandler, 2010; Lin, Omoju and Okonkwo, 2015; Xu and Lin, 2015).

Occasioned by weak economies, weak fiscal policies and near absent social safety nets, and public infrastructure, nations in the global south tend to thrive solely on micro-economies, mostly micro, small and medium-sized enterprises (MSMEs/SMEs), whose productive capacity is equally limited by these preceding factors (Yacob, Wong and Khor, 2019; Segarra-Blasco and Jove-Llopis, 2019b). Despite the obvious lack of critical public infrastructure, specifically power supply, MSMEs/SMEs have consistently contributed to the sustenance of African economies but from conventional fossil dependent energy systems; hence making them outstanding culprits for carbon emissions. In Nigeria for instance, MSMEs/SMEs has in addition to high emissions, continued to struggle with the cost of fossil, imported goods and services and production with an increasing attendant cost and damage to the environment (Akuru and Okoro, 2009; Amrinder, 2016; Oyedepo, 2012; Pursiainen, 2018).

Several experts commentaries and the UN sustainable development drive for responsible consumption and production are making it imperative for governments at all levels, the private sectors and responsible communities to explore and pursue alternative sources of energy with the view to decarbonise the atmosphere (Braun, 2020; A. K. Aliyu, Modu and Tan, 2018; Munro, van der Horst and Healy, 2017; Hodge, 2017; Bello, 2015). Braun further argued that if nations must contribute substantially to curbing carbon emissions, there must be a deliberate drive towards even "demonopolisation" of energy generation because monopoly plays a central role that shield small and medium-sized enterprise from making sustainable progress.

In the Nigerian context, it is intriguing to reveal that the regulatory framework for the production and transmission of energy on a large scale outlaws the participation of individuals, hence the resort to the use of fossil-based systems by small and medium-sized enterprises and households. The scale of the population adapting to lack of sustainable energy in Nigeria is huge yet, the carbon footprint from this sector has been ignored and given less attention globally. Hence, innovative approaches to analyse the carbon footprint of SMEs and proffer solutions for local communities could portray a ray of hope for the global climate system, responsible consumption and production, and chart the way for affordable and clean energy systems. (Oyedepo, 2012) further illuminate the benefits of sustainable energy to include reduced cost of production; leading to higher returns on investment, improved spending capacity, hence the possibility of improved access to quality health care, education and nutrition; reduced carbon footprints, among other things.

To achieve some of these UN SDG targets, suggested a “full exploration and promotion of renewable energy sources (including hydro, solar and wind), energy efficiency practices, as well as the application of energy conservation measures in various sectors” (Hampton and Fawcett, 2017; Kalantzis and Revoltella, 2019; Rahil *et al.,* 2019). This position is in line with some empirical studies conducted by the (Kumar, Fujii and Managi, 2015) on linking renewable energy to rural development. It reveals that renewable energy sector grew by 26% between 2005 and 2010 globally, and at the time provides about 20% of the world’s total power, with substantial supply in the rural areas. The reports overarching summary agrees with the argument of Oyedepo (2012) that the impact of this thrust brought about an improvement in local revenue, local jobs, innovations in products, processes and policies, capacity building and empowerment, affordable and reliable energy.

The implication of these arguments is that properly deployed sustainable energy in local communities targeted at MSMEs/SMEs sector benefits a wider population, the environment and stimulates a bottom-up economic growth which is central to this study. Though other theoretical assumptions tend to ignore the cost implications of energy transition for SMEs, they recommend that regional and local governments must adopt a pragmatic integrated rural sustainable energy development programme. This pilot study examines the cost and cost implications of fossil energy consumption to complement the gap in literature and suggest possible approaches of energy transition for Wula (I) of Boki LGA of CRS, Nigeria (Balsalobre-Lorente *et al.,* 2018; Bello, 2015; Chappells and Shove, 2005). An integration of policy formulation to guide investments in renewable energy in local communities has been advanced as peculiarity boosting economies while factoring in strategies for achieving the UN Sustainable Development Goals, (SDGs) and the aims of New Partnership for African Development (NEPAD) (Ahmed-Hameed and Wapmuk, 2017; Edkins, Marquard and Winkler, 2010).

In alignment with this objective, this study proposed a further modelling of an integrated modular hydro-electric power (MHEP) systems for Wula community with an attempt to suggest community collaboration n co-creating local energy management policies. This is because it has been contended that active engagement with relevant stakeholders at the community, local, state and national levels are essential for establishment of new systems in the global south (Ferdig, 2007; van der Jagt, Alexander PN *et al.*, 2019). This study adopts gatekeeper's engagement strategy and snowballed into a wider community engagement to ensure effective dialogue to scope the readiness of MSMEs/SMEs owners to transit from fossil to renewable energy, reduce their carbon footprints and impact of CO_2 on the environment.

3. Methodology

The study implemented exploratory investigation to scope sustainable energy potential and applied semi-structured interviews to obtained data on energy type, quantity consumed and annual cost through a pilot study. Standard emission factors were applied to estimate carbon footprints of the SMEs in Wula (I), Boki, Cross River State Nigeria. See figure 1 below

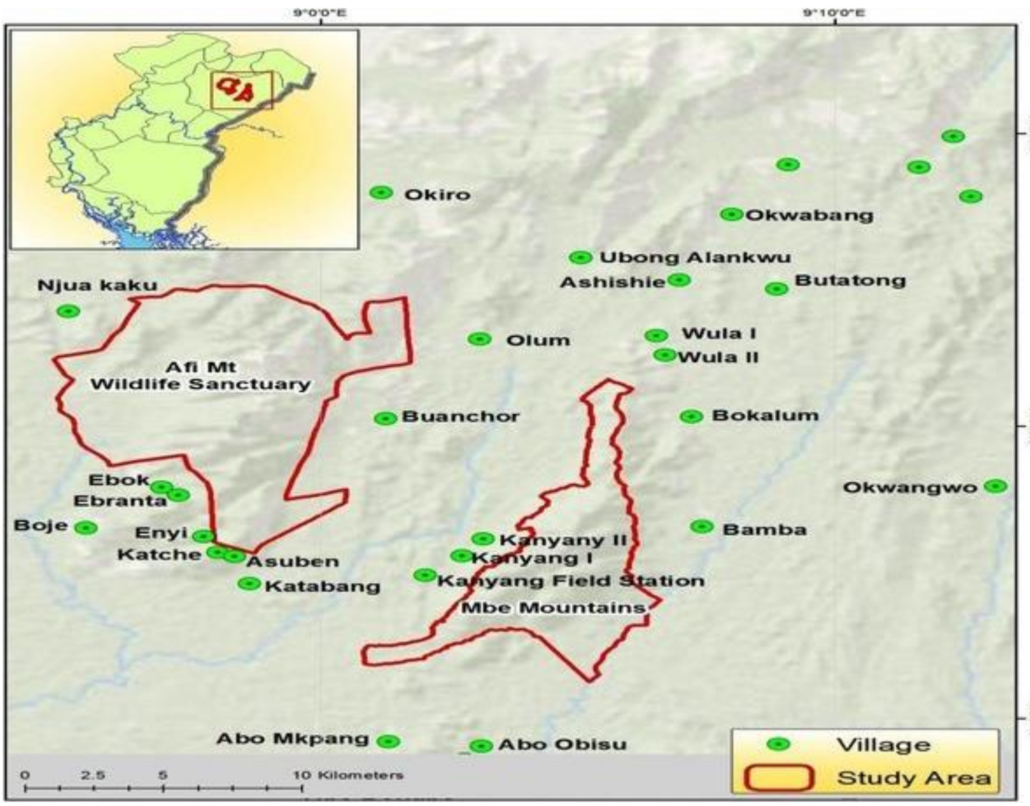

Figure 1; Topographycal Map of Wula I & II in Boki LGA of Cross River State, Nigeria. Source: (Shomkegh, Adaje and Verinumbe,)

Wula (I) is about 20 km from protected areas of Boki (Afi Wildlife Sanctuary and Kanyang forests) with endangered species of plants and animals of global importance. Predominant occupation is peasant farming and dependence on forest wealth. We delineated an area with a population of about 10,000 people stratified 16 SMEs for the study. SMEs are the ubiquitous businesses in the community which activities have direct impact on both the environment and socio-economic life of the people. As indicated on Kalantzis and Revoltella, (2019), examples of the businesses in the community includes services such as barbering shops, restaurants, and medicine stores.

As part of exploratory study, we invested 48 hours on a pilot survey in September 2019; conducted both one-to-one and focus group interviews with relevant stakeholders in the community to collect data and formed arguments on cocreating effective and sustainable energy solutions. SMEs owners were engaged in a one-to-one interview while youth and elderly community leaders were involved in focus group interviews to ensure that sustainable energy decisions were unanimous and acceptable to all stakeholders. Participants were interviewed to assess energy demand and supply, estimate quantity consumed and acceptance threshold of alternative energy (Devine-Wright and Wiersma, 2020; Bartolini *et al.,* 2020; Zhang *et al.,* 2020). We interviewed (in total) 46 households to evaluate community acceptance of alternative renewable energy plan and 16 active SMEs (25 minutes each) to understand prevailing energy realities - which data formed the bases of this paper (see (Yacob *et al.,* 2019; Ugwu and Haupt, 2007).

Consistent with the objective of the study, we collected energy data according to sources, rate of consumption, and cost implications, for each SME per day and estimated annual consumption from extrapolatory calculations (Bolton, 2017; Cheung and Wang, 2018; Faghani, Ashrafi and Sedaghat, 2018). Photographic evidence of petrol generating sets and corresponding daily consumption was collected to corroborate evidence. However, the study excludes cost analysis of engine maintenance and servicing which could be considered in subsequent outputs.

Nonetheless, the direct cost of fuel was calculated using the local retail price of N150.00/litre and N300.00/litre for petrol and diesel respectively. SMEs carbon footprint was estimated using standard emission factor (section 4) (Lingl and Carlson, 2010).

4. Results and Analysis

Detail analysis of energy (fuel) type, daily and annual consumption by SMEs in Wula, Boki area of Cross River State Nigeria, is presented. Further estimate of financial cost and carbon footprints resulting from fuel consumption is calculated and analyse in this section. We implemented *Petrol (100% mineral petrol) gross calorific value (CV – 0.24099)* and *diesel (100% mineral diesel) gross calorific value (CV – 0.25267)* emission factors to determine kilowatt (kWh) of petrol and diesel fuel consumed per kilogram of carbon equivalent (Liu *et al.*, 2015; Lingl and Carlson, 2010). See formula below:

$$\textit{Carbon footprint } (KgCO_2e) = \textit{emission factor } (CV\ (kWh))\ X \textit{ quantity of fuel consumed}$$

$$\textit{Tons of } CO_2 \textit{ equivalent } (tCO_2e) = KgCO_2e/1000$$

We used the prevailing retail cost of diesel and petrol (N150 and N300 NGN/litre) respectively in estimating the energy cost while oanda exchange rate was implemented to determine USD equivalent. Accordingly, fuels *100% minerals* factors were adopted because both fuel sources were unblended with biofuels sources.

4.1. Energy Source, Consumption and Impact

Results of SMEs activity, fuel type, daily and annual fuel consumption (in litres) is shown in Table 1. The result shows that 100% of energy used by SMEs in the local community is from fossil sources (mostly petrol and diesel). Each SME consumes an average of 4.44 litres and 5 hrs/day between 6 pm and 11 pm, a combined daily total of 71 litres from 16 SMEs. This implies that electric energy dependent commerce is closed after 11 pm with the entire SMEs and households' resorting to alternatives mostly firewood and kerosene lantern which has exponential negative health implications. Kerosene fuel could trigger degradation of air quality while producing toxic and carcinogenic gases. The direct exposure to kerosene have various consequences such as unintentional poisoning, dermatitis, chemical depression and headaches, loss of memory and affects respiratory, kidney and blood functions (Epstein *et al.*, 2013). The combine impact of inaccessible sustainable energy and community adaptation strategies is subjecting both businesses and communities to several health dangers and avoidable environmental impact. From the data, it is found that a total of 25,950 litres of fossil petrol/diesel is consumed annually and the health implications in the community remained under reported and ignored by concerned authorities. This is in contradiction to the UN SDG 3 (Good Health and Well-being) which aims to ensure healthy lives and promote well-being for all at all ages in communities across the world. It is believed that investment in alternative sustainable energy solutions could help reduce these health and environmental impacts and vulnerability and enshrine new livelihoods and save the climate in line with the UN SDGs.

Table 1; Estimated SMEs annual fuel usage and carbon footprints

SME TYPE	FUEL TYPE	DAILY USAGE (LITRES)	ANNUAL USAGE (LITRES)	ANNUAL EMISSION ($KgCO_2e$)
Provision store for one-stop shopping	Petrol	4	1460	351.8454
Commercial Foodstuffs vendor	Petrol	6	2190	527.7681
Hair Dressing Shop	Petrol	5	1825	439.80675
Tailoring Shop (Making and mending cloths)	Petrol	5	1825	439.80675
Provision Store and Onestop shopping	Petrol	4	1460	351.8454
Commercial Mobile Phones Charging Shop	Petrol	8	2920	703.6908
Sports viewing Centre and Sale of cool drinks	Petrol	3	1095	263.88405
Sale drinks, Provisional items and Fast Food	Petrol	5	1825	439.80675
Provision Store for Onestop shopping	Petrol	10	3650	879.6135
Commercial Food vendor	Petrol	2	730	175.9227
Medicine Store (Chemist)	Petrol	3	1095	263.88405
Provision Store one-stop shopping	Petrol	6	2190	527.7681
Fast food and Food items	Petrol	3	1095	263.88405
Patent Medicine Store	Petrol	3	1095	263.88405
Medical Diagnostic Laboratory	Petrol	4	1460	351.8454
Iron fabrication and Welding	Diesel	20	7300	1844.491
TOTAL Consumptions and Footprints		71	25,950	8089.74685

4.2. Estimating Carbon footprint of SMEs

The combine carbon footprint of selected SMEs stands at 8,089.747 $kgCO_2e$ (equivalent of 8.089 tCO_2e) per annum; implying an emission of 505.609 $KgCO_2e$/SME/annum. With each SME emitting at least half a ton of carbon dioxide, the implications for global warming and widespread severity of climate change is on the society and could exacerbate physical and socioeconomic consequences (Yao, Huang and Song, 2019). If sustainable energy measures are continuously ignored, there is a high tendency of aggravated impact on SMEs, preserved forest, biodiversity and ecological systems (Amrinder, 2016; Midgley and Bond, 2015). The carbon footprint of local business community in Wula requires attention and sustainable energy interventions could minimise emissions whilst ensuing the economic and human health & well-being. Therefore, the local interventions can help align with the SDGs such as SDG 7 (Affordable and Clear Energy), SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities & Communities) and SDG 13 (Climate Action).

4.3 Estimating Financial Cost of Energy (COE) on SMEs

SMEs in the Wula community struggle with significant financial Cost of Energy (COE) as a result of high demand and lack of access to the national grid. The data indicates that SMEs spent an equivalent of $15,432.81 USD annually by consuming 25, 950 litres of fossil energy (petrol and diesel); an equivalent of 0.6 cents/litre (see Table 2). This excludes the cost of generator's monthly maintenance and parts replacement which according to an SMEs operator, *"has high impacts on her business turnover"* and on rural livelihoods. On the contrary, a $15, 400 USD investment on renewable alternatives such as solar PVs and mini-wind systems could serve the energy need of SMEs, reduce reliance on fossil environmental impacts and provide higher return on investment. Renewable investment could save SMEs energy cost, reduce carbon footprint and improve quality of life in the community.

Table 2; Estimated annual fuel usage and financial cost

SME TYPE	**FUEL TYPE**	**ANNUAL USAGE (LTRS)**	**FUEL COST/ANNUM (=N=)**
Provision store for one-stop shopping	Petrol	1460	219,000
Commercial Foodstuffs vendor	Petrol	2190	328,500
Hair Dressing Shop	Petrol	1825	273,750
Tailoring Shop (Making and mending cloths)	Petrol	1825	273,750
Provision Store and One-stop shopping	Petrol	1460	219,000
Commercial Mobile Phones Charging Shop	Petrol	2920	438,000
Sports viewing Centre and Sale of cool drinks	Petrol	1095	164,250
Sale drinks, Provisional items and Fast Food	Petrol	1825	273,750
Provision Store for One-stop shopping	Petrol	3650	547,500
Commercial Food vendor	Petrol	730	109,500
Medicine Store (Chemist)	Petrol	1095	164,250
Provision Store one-stop shopping	Petrol	2190	273,750
Fast food and Food items	Petrol	1095	164,250
Patent Medicine Store	Petrol	1095	164,250
Medical Diagnostic Laboratory	Petrol	1460	219,000
Iron fabrication and Welding	Diesel	7300	2,190,000
Totals		25,950	6,022,500

The financial and amount of emission by SMEs in Wula indicate the scale of the problem suggesting urgent sustainable solutions feasible to the community. However, the next phase of this study will explore sustainable interventions to reduce estimated CO_2 emissions and further explore sustainable strategies for improving return on investment for SMEs. This is with the view to contributing towards the achievements of relevant SDGs such as SDG 3: Good Health and Well-being, SDG 7: Affordable and Clean Energy, SDG 11: Sustainable Cities and Communities and SDG 13: Climate Action. Continual energy audit and investment decisions driven by the need to improve energy supply, expand business and economic well-being and protect the environment is critical in Wula. Some of the renewable energy potentials in the community include access to sunlight upon which solar energy could be harnessed; regular wind speed and access to rivers for mini hydro-electric system. With these potentials in place, opportunity to construct a Modular Hydro-Electric Power (MHEP) systems is presented and could be experimented further into this project. This is consistent with the opinion that understanding energy demand, interventions, cost and carbon emission scenarios is strategic to supporting and growing local investment for small and medium-sized enterprises (Özbuğday *et al.,* 2020; Wu *et al.,* 2019; Kalantzis and Revoltella, 2019). Potentially, this study could further open new markets and business opportunities for the rural poor, lift families out of poverty and transform lives as a contribution towards wider achievement of SDGs.

5. Discussion and Conclusion

The study has offered evaluation of the potential of sustainable and renewable energy in SMEs in the Wula community in Nigeria by measuring their carbon footprint and gaining empirical insights from SMEs owners/managers in the local area. This research is first of its kind in attempting to help SMEs in Wula to transition towards a model for low carbon sustainable energy and address social, economic and environmental challenges. The study has adopted co-creation and bottom-up approach to include SMEs owners and managers to understand the problems and have their perspective on the demand side of sustainable energy which has been underdeveloped in the context of SMEs energy strategy (Hampton and Fawcett, 2017). The study found that SMEs in the Global South have significant potential to accelerate towards energy transition in communities. By adopting sustainable energy technologies, SMEs cannot only minimise their carbon footprint (Segarra-Blasco and Jove-Llopis, 2019a), but also reduce cost of fossil fuel energy consumption. However, the main issue is the country's inability to make use of these sustainable resources (Emodi and Boo, 2015).

The study found that 100% of the energy consumption in SMEs in Wula is from fossil fuels which has severe environmental and social impacts. This may suggest that the energy supply in SMEs may not be able to meet the demand as there could be interruption due to lack of fuel supply and financial reasons, as stated by Aliyu et al. (2015). There appears to be demand for more sustainable or renewable energy and this comes against a backdrop of area being deprived and no grid availability by the national government (Aliyu et al., 2015). Large scale renewable energy is an option however, there has been no local or national policy mechanism to support the interventions. Therefore, the paper recommends for policymakers that Nigeria needs to design an energy policy for the SMEs that pursues both energy efficiency and renewable/sustainable energy. It needs to be noted that the country is blessed with abundant renewable energy resources that have not been fully exploited yet (Aliyu et al., 2015), offering an opportunity for environmental sustainability, carbon management and economic growth.

The project suggests that the potential of sustainable energy in SMEs can help accelerate the energy transition in communities in the Global South whilst meeting the SDGs. This evaluation can inform the development of national and local policies for energy transition to meet climate change mitigation targets and contribute towards the SDGs, mainly SDG 7: Affordable and Clear Energy, SDGs 11: Sustainable Cities and Communities and SDG 13: Climate Action. Sustainable energy interventions do not only help address environmental challenges such as carbon emissions and pollution but can help save financial cost for economic sustainability and social prosperity including health in developing countries (Ahuja and Tatsutani, 2009). This means that the SDGs are interconnected and intersect. In contrast, there might be some trade-offs which need to be made in decisions by practitioners and policymakers. It is recommended that responsible government agencies could tap into sustainable energy potentials to better support SMEs and community livelihoods by reducing their emissions and carbon footprint in alignment with the UN SDGs. This study is expected to help both policymakers and practitioners in terms of SMEs who are serious toward sustainable energy and carbon management implementation and are looking for appropriate insights into the state of the problem.

It is paramount to highlight limitations of the paper. The analysis allows to measure carbon footprint of SMEs and identify scale of the problem in the local area in Nigeria as well as direction for transitioning to sustainable energy adoption. However, it does not provide pathway of which renewable energy technologies would be feasible in this particular context and only the need/application of such actions is discussed. Future research can conduct feasibility study of a selection of sustainable energy technology options. In alignment with the strategic energy objective, this study proposes a further modelling of an integrated modular hydro-electric power (MHEP) systems for Wula community with an attempt to suggest community collaboration n co-creating local energy management policies. This is because it has been contended that active engagement with relevant stakeholders at the community, local, state and national levels are essential for establishment of new systems in the global south (Ferdig, 2007; van der Jagt, Alexander et al., 2019). It needs to be noted that this project is a work in progress and future work package also aims to carry out need assessment of SMEs and local communities based on Multi Criteria Decision-Making analysis. This will help understand how sustainable energy is prioritised which may inform some local and political action regionally and nationally. The project aims to co-create sustainable energy solutions with local SMEs and communities not only to minimise carbon footprint of SMEs (and reduce environmental impact of the community) but also help contribute to economic prosperity of local residence and transform their lives.

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