AFRICA JOURNAL OF INTERDISCIPLINARY RESEARCH

1(1)

Assessing the Diffusion of Renewable Energy Technologies and its Impact on Socio-economic development of Rural Livelihoods in Uganda

Evelyne C. Kabasingwa [a] evelynkabtina@gmail.com

Mbabazi Mbabazize [a] mmbabazize@gmail.com

[a] Pan African University (PAUWES)

Corresponding author e-mail: evelynkabtina@gmail.com

Citation: Kabasingwa, E.C. & Mbabazize, M. (2023). Assessing the Diffusion of Renewable Energy Technologies and its Impact on Socio-economic development of Rural Livelihoods in Uganda. *Africa Journal of Interdisciplinary Research (AJIR),* 1(1), 22-57

Abstract

This study assessed the diffusion of renewable energy technologies and its impact on socio- economic development of rural livelihoods, focusing on the ripple effect analysis of two policy choices: disseminating clean-burning, fuel-efficient cook-stoves and photo-voltaic systems in HoimaDistrict, Uganda. The specific objectives were: to assess the level of investment and themarket for clean burning, fuel efficient cook-stoves, and to determine the socio-economic benefits ofphoto-voltaic systems for street lighting, home and institutional use in the development of rural livelihoods of the study area. The multistage sampling technique was employed, beginning with the purposive selection of Hoima District as the major study area. Secondly, respondents were purposively selected for a desired sample size, where by a sample size of 146 respondents and 8 focus group discussions was taken. The data collected were analysed using SPSS version 20 and STATA version 13.0 software. The results from the regression model indicated that education level, household income, household head occupation, access to information, training service and technical support have facilitated accessibility and adoption of clean burning, fuel-efficient cook-stoves and are statistically significant at 1% level. However, all these variables are attributed to the availability of artisanal fabricators that produce different sizes and designs of stoves at segmented prices from various materials, satisfying the customers‟ choices and preferences. Age, distance from fuel sources and from the market negatively affect the adoption at 10% level. Investment in fabrication on the other hand, is still low, but highly influenced by cheap raw materials that are easily available, high ready market, access to credit, expenditure levels and low levels of education leading to unemployment because most of the fabricators are the youth, implying an unemployed age bracket in the African trend. The study also established that photo-voltaic systems significantly transform rural

livelihoods through energy services, money savings, business activities, environmental sustainability, employment, improved study conditions, increased business opportunities all of them at 1% level; PVs increase fish harvests and lead to emergence of new businesses like casinos, salons, and football/cinema show centres (ebibanda), thus significantly transforming rural communities. Therefore, the government should prioritise the investment and promotion of the diffusion of renewable energy technologies to eradicate all forms of poverty sustainably.

Keywords: Renewable energy, renewable energy technologies, energy in Africa, Hoima District Uganda

==========

1.0 Introduction

Energy is the life-breath and blood of every modern society. Without energy, there is no life in anation as it is an indispensable element in all aspects of life, especially economic and human development. The universal access to modern energy is directly linked to the rest of the Sustainable Development Goals (SDGs) and Agenda 2063; it is a weapon for combating poverty, fostering economic growth and improving health and gender equality (OECD/IEA, 2017). However, most people in Sub-Sahara Africa face severe energy poverty; it is the part of the world with the largest number of people lacking access to modern energy. More than two thirds of the region‟s population, almost a half of the world‟s total, has no access to modern energy, yet 80% of these reside in rural areas. The region is also dominated by traditional forms of energy that are a threat to health albeit the abundant endowment of energy resources. Moreover, those with electricity access depend on the under-developed system which is very expensive and unreliable for their needs (OECD/IEA, 2014). See Figure 1.1 below of how Africa appears at night compared to other continents due to severe lack of electricity access.

Figure 1.1: Map of Africa as seen from space at night

Source: *NASA Earth Observatory, 2016*

This energy poverty is escalated by the fast-growing population in the region leading to high energy demand. This critical challenge implies huge amount of funds for investment to meet the target of universal electricity access by 2025. It is estimated that $60 billion is needed per year to achieve the target (Heffron et al, 2017). Thus, energy deficit is an impediment to economic development, especially in the rural communities of Africa. This challenge must be addressed in a more sustainable way, considering

system thinking, to avoid repeating the past mistakes made in the name of economic development that are empirically evident globally as climate change effects and other anthropogenic effects. A steady yet accelerated transition in energy systems is inevitable if we intend to make the world a better place for all the generations. Climate change is global issue as reflected by the "*seven climate records in 2016: melting of Arctic ice; consecutive hottest months; hottest day in India ever; highest temperature in Alaska; consecutive and biggest annual increase in CO2; hottest Autumn in Australia ever; and highest amount of destruction in Australia's Great Barrier Reef*" (McCaauley & Heffron 2018). Some of the climate change effects arise from energy emissions that occur during various economic activities. Therefore, a meticulous and holistic energy system development of Africa"s abundant energy resources would transform the continent to leapfrog from a subsistence economy to a modern and desirable economy.

Uganda, in particular, is one of the countries with very low modern energy access. Electricity access at national level stands at 26.70% from 15% by 2013 (10%:2010; 9%: 2006; 5.6%:1991) (World Bank, 2018). However, the question is, are these figures enough to reflect the number of people utilising the electricity in reality?

1.1 What does electricity access mean in reality?

Electricity access does not necessarily mean being connected to electricity. The World Bank Group developed a Multi-Tier Framework to define and measure energy access since binary indicators are insufficient in fostering and tracking the SDG7. Consequently, affordable, reliable and modern energy should entail households, productive engagements and community facilities with seven attributes: capacity, duration, reliability, quality, affordability, legality as well as health and safety (SE4ALL, 2016).

1.2 Statement of the problem

Uganda is one of the countries with the lowest energy access yet already experiencing climate change effects. Therefore, the Ugandan government aims to achieve universal modern energy access by 2040 and 100% Renewable Energy by 2050. In spite of the significant investment required and the high number of different development programs related to electricity access and renewable energy deployment, analytical work and empirical evidence on the socio-economic impacts of such efforts remains relatively limited. Only a few studies have evaluated the relationship between inclusive solar power technologies access: photovoltaic systems for street lighting, institutional and home applications and human development indicators, and the vast majority of these have focused on Asian and Latin American countries (Lenz et al., 2015). With this study, the intention is to shed light on both the developmental effect of obtaining access to modern energy and the local value creation generated through renewable energy deployment. Uganda is arguably the

country facing the most pressing energy needs yet the region with little evidence on the topic. By focusing on Uganda, this study hopes to bring a more comprehensive and empirical-based evidence and identify factors influencing accessibility and adoption of clean burning, fuel-efficient cook-stoves among rural communities, understand the socio-economic impacts of inclusive solar power technologies as street lights and institutional as well as solar home systems in Hoima District, Uganda.

1.3 General objective

The global objective of the study was to assess the diffusion of renewable energy technologies and its impact on socio-economic development of rural livelihoods in Hoima District-Uganda.

1.3.1 Specific Objectives

1. To determine the socio-economic benefits of solar power technologies as PV systems for street lighting, institutions and home applications in the development of rural livelihoods in the study area.
2. To develop a policy brief and framework for accelerating the diffusion of Renewable EnergyTechnologies in the study area.

1.3.2 Research Questions

1.What are the socio-economic benefits of solar power technologies as PV systems for street lighting, institutions and home applications as fully-fledged policy programs for sustainable development in Hoima District, Uganda?

2.What should be done to accelerate the diffusion of Renewable Energy Technologies in Uganda?

2.0 Literature Review

This literature will support our analysis of the ripple effects generated by Scatec Solar‟s investment in Uganda. The second part of the chapter reflects on the opportunities for value creation in the renewable energy (RE) sector. This will build on a comprehensive review on the topic conducted by the International Renewable Energy Agency and the Clean Energy Ministerial (IRENA & CEM, 2014). The third part of the chapter focuses on the significance of improved cook-stoves as well as the socio-economic impacts of improved electricity access in developing countries and will support and supplement our analysis of the ripple effects that stems from electrification. Finally, the last section highlights the description of the case study, Uganda overview.

2.1 The economic impact of FDI in developing countries

Many Sub-Saharan countries lack adequate financial and technological resources to foster a sustained socio-economic development. Although international aid constitutes the largest contribution to external financial inflows into the African continent, attracting alternative finance is believed to be increasingly important in order to close the resource gap (UNCTAD, 2005; Ayanwale, 2007). The World Bank defines FDI as: “a category of cross-border

investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy" (World Bank, 2016G).

Throughout the last three decades, the inflow of FDI into the African continent has grown dramatically in response to increasing economic globalization, higher capital mobility and integration of financial markets (UNCTAD, 2005). In recent years, slow global economic growth has also made the faster- growing African economies relatively more attractive.

In response to the rise in FDI and the expected benefits there has been an ongoing debate regarding the economic impact of FDI in developing countries. The effect is widely discussed in both the theoretical and empirical literature.

2.2 Opportunities for domestic value creation along the value chain

A central question to the assessment of value creation in a RE sector is to what extent the value creation is being generated locally where the RE project is located, and how much of the value is a result of imported inputs. This depends on the maturity of the RE sector in the country where the project is being realized. Domestic economies that cannot supply the needed inputs to the value chain, must import either the needed material or expertise. In the following we present the opportunities for value creation in the different segments of the RE value chain, with emphasis on the solar PV sector. We will be looking at opportunities within the planning stage, manufacturing, installation, grid connection, operation and maintenance.

For example, in planning phase, the project-planning phase includes activities within resource assessments, feasibility studies, and planning of infrastructure. Experienced and specialized personnel are required to conduct such activities. With many RE projects being developed in a country, the level of domestic know-how and expertise can be expected to be substantial, which places a large share of the value creation during the planning stage to the country. Where the RE sectors are less mature, it is more likely that foreign consultants are engaged in the planning.

Enhancing education and training is thus important to bridge the gap of skills that exists in some cases, in order to retain the value creation at the local level. In the solar PV industry, the planning phase mainly consists of the planning and projecting of modules, which can be undertaken by the installer or a project developer.

In manufacturing phase; a certain degree of industrial capability in the country is necessary to generate value creation locally. If so, manufacturing can generate value in all its processes and offer large job creation potential depending on how technically advanced the different production processes are. A

Japanese study on the employment potential related to manufacturing, construction, operation and maintenance of solar PV and wind power technologies shows that employment in manufacturing stands for approximately 70 percent of overall employment for both PV and wind (Matsumoto et al., 2011).

The manufacturing process in the solar PV sector includes the production of the PV modules, from silicon and components for the balance of system (inverters, mounting systems, combiner box and other electrical components) (IRENA, 2012). Manufacturing of PV cells and modules is mainly driven by technology innovation and economies of scale.

Energy costs are also an important aspect for the development of a PV manufacturing industry, while labor costs play a less significant role as production is highly automated. In the recent years, the manufacturing of PV systems has been concentrated to Asia due to large investments made in production capacity in order to exploit the scale potential in the production (IEA, 2014).

At installation phase, the installation process relates to the construction and assembling of the renewable power plant, and the coherent infrastructure works. This phase includes labor-intensive civil engineering, infrastructure work including groundwork, foundations, channeling, water supply, buildings and roads, which are typically delivered by local companies. Complete system installations are more complicated to conduct when it involves imported equipment, which is often the case when installing solar PV modules. The manufacturers of the modules are therefore often involved in the installation activities with their own equipment and personnel. This leaves less work for local companies. Still, local companies can participate in delivering required services especially if the expertise already exists in the local area.

3.0 Methodology

3.1 Research Design

This study employed a mixed methods approach whereby both quantitative and qualitative were used. This approach enables a researcher to lessen weaknesses of one method, offering combined strengths of both methods, by engaging deductive and inductive analysis in the same research study, hence obtaining a comprehensive understanding of the phenomenon (Cresswell, 2015). Also, a social survey was conducted, whereby a cross-sectional research design was used in which data from respondents was collected at a single point at a time whereby both purposive and cross- sectional data collection approach were adopted. The population of interest constituted people accessing and adopting clean burning, fuel-efficient cook-stoves among rural communities, stove fabricators, and users of solar solar photovoltaic systems for street lighting, home

and institutional application in Uganda. The sampling units were households, local authorities and institutions. Then, a systematic random sampling procedure was used to select the sample size of 146 respondents and 8 focus group discussions from Hoima District in Uganda.

3.2 Sampling technique and sample size

The multistage sampling technique was employed in this study. The first stage was the purposive selection of Hoima District as the major study area. In the second stage, respondents were purposively selected to make a number of desired sample sizes. Then, sample sizes of 146 respondents and 8 focus group discussions were selected in 2019.

3.3 Research Site and Rationale

This study was conducted in the Mid-Western region in Hoima District of Uganda. The area was chosen because of the recent discovery of oil, of which exploitation is expected to commence by 2020. The area is now called the Oil City; therefore many economic developments are taking place thus leading to high population. Moreover, according to UBOS (2017), electricity access in this area is very low, estimated at 16.8% and 58.3 of the households were using wick canister candles (tadooba) by 2014. Also, the district performed best among the fourteen (14) municipalities selected for USMID projects which involved installing solar powered street lights. Lessons for project replication could be drawn from this area. According to the 2014 National Survey and Population Census, a total of 572,988 inhabited the district on a surface of 3612.17km^2 land area.

4.0 Results and Discussion

The socio-economic impact of solar photo-voltaic systems and their contribution to sustainable development on rural livelihoods

The diffusion of solar energy technologies has had remarkable positive impacts on the livelihoods of the people living in remote and isolated communities where the national grid seems to be an enduring myth. Moreover, some of the impacts are short term whereas most of them are long term, leading to sustainable development most especially in the area of study, and these have been found to be both economic and social benefits as presented below.

Economic Benefits

In this section, the benefits have been presented and discussed in form of quotations and boxes to highlight the original opinions of the respondents in the various focus group discussions held during the data collection. During field visits, the research assistants also took photographs/pictures besides translations, and some of the pictures have been attached at the end of this report in the appendix. The following are the economic benefits of solar photovoltaic systems usage in the rural areas.

Enhancement of Fishing Activity

Like any other resourceful lake around the world, the shores of Lake Albert are filled with various landing

sites. The major economic activity here is fishing. Today, everything requires creativity andinnovations. The artisanal fishermen around the lake have greatly increased their level of income through the utilization of the solar photovoltaic systems lights. They charge their batteries during the day, and at night, they board their boats to go fishing with the batteries and solar lanterns. From the focus group discussion with the respondents, one of the respondents supposed, *"the solar lanterns are a good deal to us as fishermen. They help us in finding the right direction, empty our boats, and perform other tasks pertaining to fishing at night."*

Another respondent also argued,
"The lanterns you see here are used to attract more fish. We used to go fishing with kerosene tin lamps which were not bright enough. Nowadays, we are on another level due to technology. These solar lanterns attract more fish and results into increased fish catches. Consequently, our food and income have also increased due to the availability of solar PVs."

The fishing activity is majorly conducted at night in Uganda. Previously, the fishermen would do their work at night using kerosene candles and/or inexpensive torches. However, these lights are not bright enough and kerosene lamps are „dirty" sources of light, apart from not being sustainable: the utilisation of kerosene lamps is hazardous because in involves health issues according to Mills, 2012. It is also inefficient and very expensive in the long run. According to research, for the case of kerosene, one boat is capable of using "between 1 and 2 liters of fuel" while emitting a "substantial amount of the greenhouse carbon dioxide (CO2) to the atmosphere" (Gengnagel et. al., 2013). A research carried out to assess the best substitutes for conventional energy used by Tanzanian fishermen revealed that the fishermen preferred paying six times for a solar LED light to paying for pressured kerosene lamps (ibid.).

In our study, it was established that the solar lanterns have now significantly improved productivity by increasing fish harvests and enabling fishermen to perform the fishing activity smoothly at night. The increased productivity has added another value on the availability of nutritious food (fish) and increased income. However, this technology may lead to overfishing if no precautions are taken into consideration.

The fishing activity is also enriched due to the fact that some fishermen preserve their fish harvests in freezers using solar power so that they are sold at better prices without losing value. It should be noted that most of these areas around lake Albert are in escarpments, where the grid is not viable at all. The terrain makes it very difficult for the national grid to be feasible, and the transport network is not well developed. Thus, solar energy is the best alternative to add value to fishing and other economic activities in the area for improved income generation. This analysis is further evidenced by photo plate.1 as

attached in the appendix.

Casino Betting

Among emerging businesses that are booming due to the increased diffusion and adoption of Solar Photovoltaic is casino betting, where people insert some money (coins) in a machine and either get more money if they are lucky or lose it to the business owners. It is a way of earning money by both the customer and the owner through gambling. These machines cannot operate without electricity, therefore, without solar power, such games would not be available in remote and isolated communities where the central grid is not viable at all. The study revealed that casino betting is becoming a popular way of earning a living in an instant manner, and the machines are powered by solar energy as seen in Photo Plate 2 as attached in the appendix.

Charging Stations by Entrepreneurs

Entrepreneurs are benefitting by earning daily income from charging public mobile phones and radios. There are different established kiosks and centres where people without electricity bring their phones and radios to be charged. This is a very lucrative business because almost every adult in Uganda can now afford a mobile phone. With increased technology, many people either use rechargeable radios or phones to listen to the news or music. Therefore, the charging stations receive enough customers every day since the majority of the rural people cannot afford to have their own solar systems. In addition, the people in charge of running the charging businesses have diversified their services by introducing the sale of other goods and services such as cold drinks, bread, phone and radio accessories among others. Selling various goods at these centres have led to attraction of more customers and increased the owners‟ income, hence experiencing the ripple effect of installing PV systems. This is evidenced in photo plate 3 in the appendix.

Barbers' Shops and Salons

The study found out that, even people in rural communities are able to keep themselves kempt by not having to move to urban centres in search of barbers or hair dressers. There were a few establishments of barbers‟ shops and salons. Since there is no grid connected electricity, all these are powered by solar photovoltaic systems. The entrepreneurs in these businesses are earning good money while the clients are being well-groomed. Thus, both the clients and the salon owners are benefiting from diffusion of solar power technology.

We are privileged to have solar power in our village because it has improved the quality of lives. Before the coming of solar here, we would spend money on transport to urban centers to have our hair dressed, but now we do it from our own village due to the presence of solar electricity.no more spending extra money. It is really amazing!

one of the women in the focus group said.

Increased Business Hours

The study recorded that due to the diffusion of solar photovoltaic systems, there was an increase in working hours for micro business people in the area. Most of these were general merchandise shopkeepers, and restaurant attendants who stated that they would retire for the day as early as six in the evening (6:00 PM) before the installation of the panels. The extension in the number of working hours recorded ranged between 2 to 5 hours, which implies more income for them. In the study done by (Obeng and Evers, 2010), it was recognized that solar electricity made significant contribution towards the flourishing of rural micro businesses through extending working hours at night in Ghana. In addition, (Attigah and Mayer-Tasch, 2013) reported an increase in the income generated by attracting more customers in the evening. The surge in income was attributed to the extended hours of business operations after the installation of PVS in Uganda.

Emergence of New Business Activities

Some of the responses from the interviewees showed that after the installation of the solar panels, new business activities evolved. Examples of these activities included charging other people‟s phones and radios, football shows and sale of cold drinks among others. Of all, the sale of cold drinks due to refrigeration was the commonest, since the company (Solar Now) that sold the solar equipment to most of the respondents, also offered them a fridge as part of the package. This idea was a great one since the area has high temperatures, especially along the rift valley area, the reason why cold drinks have gained popularity, hence generating more income.

The findings show that some enterprises added value after the acquisition of solar power. For example, bars attracted more customers by playing music and selling cold beer. Moreover, most of the restaurant owners increased their income significantly after the installation of the PV systems because they attracted more customers through music and sale of refrigerated/cold drinks. This increase is attributed to the fact that having a good meal accompanied by a soft cold drink and some sweet music in the background is super relaxing, especially after some hectic work. The devices used to enhance this improvement are radios, televisions and fridges that are definitely powered by the PV systems. (Scott, et al., 2017) argue that PVs are capable of empowering enterprises to use low-wattage televisions and run refrigerators to sell cold drinks, both of which attract customers This increase is indeed regarded as a ripple effect of the dissemination of solar energy systems inthe rural communities of Uganda.

Employment Opportunities

The diffusion of solar photovoltaic systems in the rural communities of Uganda has accelerated the creation of jobs, though at a low rate. A few respondents reported that after the installation of the

solar panels, they created new jobs for different people. The number of jobs crated ranged between 1 and 3. However, most of these jobs were informal ones, ranging from running barbers‟ shops, selling cold drinks, attending casino betting machines to operating mobile money kiosks and mobile phone charging stations. In fact, there are formal jobs involved also; the technicians responsible for the consultation, assembling, installation and repair and maintenance of the systems are also employed in the sector. More to that, there are a variety of independent shops selling the solar equipment both in urban and rural areas, implying that their attendants are also employed in the same sector. In fact, a number of people have been able to generate income by working in this sector. The diffusion of solar energy technologies has great potential to create various employment opportunities such as installation, repairs and mantainence for the local communities thereby increasing expertise. These jobs can be a weapon to combat poverty among these communities by enhancing income generation in the rural areas of Nigeria (Ohunakin, et al. 2014).

Presentation of general perspectives on the overall benefits of solar powered streetlights

In this section, this study presents the general opinions of the various focus group discussions by the respondents in various focus group discussions in form of boxes 1 to box 10.

Box 4.1: The Municipal Officers' opinions about the main reasons why some Ugandan towns/cities choose not to connect to the grid and instead opt to use solar power for streetlighting.

"Solar powered street lighting systems are relatively cheaper than the grid connected ones in the long run because of reduced electricity bills. They are also cheaper to maintain. In addition, they are environmental friendly, besides being more reliable than the grid."

"They are cheap to maintain. In addition, they are not only reliable, but also convenient to use"

"It is not as costly as the grid one (UMEME). It is always there for the people when they need it unlike the grid electricity which is always on and off."

"It is one of the tools to mitigate climate change and protect the environment yet providing energy services to the population. On the other hand, building and maintaining grid connectedelectricity is far more expensive."

Source*: Primary data, 2019; Focus group discussions group A*

Although the solar powered street lighting systems have huge upfront costs, they are ideal in energy savings in the long run thus reducing electricity bills and they come along with various benefits as discussed in the above box. Therefore, the public-private sector should consider investing more in such systems.

Box 4.2: Hoima Municipal Officers' evaluation on the importance of solar power solutions asstreet lights in the coming years.

"They will promote environmental sustainability by reducing the carbon footprint and reduce power tariffs."

"Although they are very important technologies, they may not last longer because some solar power system components are not that much durable in use."

"If more investment is made in the development of solar power technologies, there will be reduced greenhouse gas emissions, so climate change will also reduce."

"It will increase the percentage of energy mix to a greater extent, thereby reducing the depletion of conventional energy resources."

Source: *Primary data, 2019; Focus group discussions B*

According to the respondents, the continuous use of solar powered street lights may have a significant impact on the reduction of climate change effects since they involve less greenhouse gas emissions and reduce the depletion of natural resources. However, there may be concerns of the durability of the components since it is a new technology.

Box 4.3: Respondents' views on whether solar powered street light systems are feasible solutions.

"Solar powered street lights are feasible solutions because with proper planning, they can reduce electricity bills to zero in the long term."

"Yes, they are feasible. Although they require high upfront costs, they are cost effective in the long run because they are recharged freely using the natural sun which is inexhaustible. Therefore, they are inexpensive in terms of maintenance."

"The source is always available, so the only requirements are the components of the system that can be installed to harness the energy. Therefore, it is a feasible solution."

"With financial support from private partnerships such as Non-Government Organisations, it is feasible."
"Solar powered street lights in the short run aren't feasible since it is an expensive venture. The cost of acquiring a single solar street light is equivalent to acquiring two (2) Hydro Electric Power lights. With

Source: *Primary data, 2019; Focus group B*

Accordingly, for solar powered systems to be feasible, they demand preliminary studies and proper planning which involve financial, technical, environmental and social issues. Provided these are in place, the source of energy is free and inexhaustible, making it a feasible solution.

Box 4.4: Respondents' opinions about the major benefits of being connected to the solarpower systems for street lighting.

"The system saves money on electricity bills, and this money is used to meet other needs of the Municipality. They are also more reliable especially during peak hours; we are not worried of power cuts, not at all. Apart from being easy and cheap to maintain, they promote a healthy environment."

"It generates huge savings on energy costs that can be used to finance other services and developmental projects like agriculture."

"These systems require less operation and maintenance costs. They are more reliable than the grid due to limited power shortages. They are convenient to use and install."

"It is cheaper in the long run. It is also reliable since there are no blackouts."

"Solar power is generated from a renewable resource that is available free of charge. The sun does not require any cost to recharge the system"

Source: *Primary data*, *2019*; *Focus group discussion group C*

There are various compelling reasons for opting to connect to solar power as highlighted by the responses above ranging from low maintenance costs to enjoying a free source of energy. In relation to these concepts, (Panwar et al., 2011) argue that the sunlight is free of charge yet the generation of electricity is very costly. In addition, there is a probable reduction in Co2 emissions through the employment of the PV systems and the electricity generated in this process neither involve noise nor vibrations which makes it ideal.

Box 4.5: Respondents' interpretations on how urban street lighting by solar power systemsaffect private households.

"It reduces their privacy. Such households are affected by lighting pollution. However, it stimulates their safety."

"The system increases security for both their property and lives. It also enhances their trade since it allows business transactions to be extended to or carried out even at night time. This increases per capita income"

"It promotes security and safety by providing light to the nearby households. They also boost their businesses by allowing business owners to extend their working hours in the night."

"It increases safety and security as there are no dark corners and areas. It also relieves the nearby households of the burden of security light costs by providing free lighting to them and they use the money that would finance security for other developmental projects."

Source: *Primary data, 2019; focus group discussion group C*

Box 4.6: Respondents' thoughts about the extent to which solar power systems as street lightshelp in environmental management as compared to on-grid electricity.

"Solar powered systems help in environmental management to a larger extent because they emit less or no co2 emissions after installation. Therefore, they involve less degradation of the environment compared to the grid-connected electricity."

"The solar power systems help in environmental management to a great extent because they involve limited or no environmental degradation; less radiation is emitted from solar power."

"They reduce the risks of environmental degradation because less pollution is experienced after installation."

"They lower greenhouse gas emissions."

"They reduce deforestation as the wooden electric poles for electricity transmission are not required. They also increase energy efficiency and security."

Source: *Primary data, 2019; Focus group discussions Group D*

Globally, climate change is becoming a menace, and one of the reasons for the occurrence of this "giant" is the utilisation of fossil fuels in the name of development. A shift to renewable energy sources is, therefore, one of the pronounced weapons in fighting it. The above ideas from various respondents confirm

the three pillars of sustainable development: environmental, social and economic aspects; they imply that connecting to solar powered street lighting systems is one of the indicators of thriving a sustainable economy, putting into consideration of the safety and well-being of the public together with development (people, planet and profits). The reduction in deforestation by adopting solar energy to reduce the construction of transmission lines with poles from wood willenable the carbon sinks (forests) to continue playing a great role in absorption of the carbon emissions while there will be less carbon emissions from the solar power systems after their installation unlike in the case of continuous utilization of conventional energy sources for electricitygeneration. The strategy is very significant in improving people‟s health and quality of life as well as promoting sustainable development in a healthy natural environment.

Box 4.7: Respondents opinions about if they intend to improve energy efficiency and reduceelectricity bills to zero and the modalities they plan to achieve it.

"Yes, we intend to improve energy efficiency. Since the sun shine is readily available, we intend to adopt the clean energy source by ensuring the use of solar power on all roads in the Municipality and office buildings for modern efficient lighting systems, phone charging and other energy services so that we can cut operational costs."

" It is the Municipal's plan to invest more in green energy and energy efficiency to reduce on the grid related challenges such as overloads and load shedding."

"We aim to increase the use of solar energy everywhere so that we can increase energy security and improve efficiency."

"It is not practical to currently reduce bills to zero, but our future intention is to switch to green energy as an alternative to hydro power supply."

Source: *Primary data, 2019; Focus group discussion Group D*

According to the opinions given, switching to renewable energy is a long process that requires patience and capital during the various stages of transition. It can be achieved after a long while.

Box 4.8: Respondents' views on the changes experienced since the installation of solar streetlights.

"Businesses have been boosted through the increase in the number of working hours at night due to provision of illumination. They have also increased safety and functionality of streets during night hours."

"Security has improved and theft and rape cases are not common as before the installation of the solar street lights. They have also extended working hours for business people because of free movement at any time since the roads are lit."

"Reduced fatalities and accidents for road users due to the lighting systems at night and increased movement of different people at night."

"Increased safety mostly among women and children, increased business hours and reduced robbery cases on the streets."

Source: *Primary data, 2019; focus group A*

All the above-mentioned changes experienced after the installation of solar street lighting systems are important indicators of inclusive sustainable development which is essential in this modern era.

Box 4.9: Respondents' opinions about the major challenges so far faced since the start of theproject.

"The major challenge so far is theft of batteries. Batteries, especially those near the bottom of the poles are stolen during the night. This has affected the project negatively. The other challenge is inefficiency from some lights, especially those installed in the first phase of the project, where panels with polycrystalline cells were used. Also some batteries were placed underground to mitigate theft, but they are affected by heat which results in malfunction of some lights."

"Some solar lights are non-functional implying that some batteries on the market are sub-standard; moreover, some produce less light."

"When it rains heavily, the solar batteries do not charge properly leading to insufficient lights."
"There is poor response and attitude from people because they are ignorant about the system."

"Theft of the solar equipment such as batteries and lights as well as installation of sub-standard

Source: *Primary data, 2019; Focus group discussion Group D*

Similarly, Ghana is facing some challenges in its installed solar street lighting systems; many of the solar powered street lights connected in towns are non-functional partly due to insufficient viability studies. Moreover, due to theft security, most of the batteries were positioned underground and therefore were damaged by floods (Teves de Almeida, 2014). Therefore, more research and technology development is required to mitigate or solve these problems.

Box 4.10: Respondents' recommendations suggested to overcome the challenges faced in thesolar powered street lighting systems.

"*Installation of panels with monocrystalline cells would be more effective and routine mantainence is recommended to improve the performance of the system."*

"Use of better and standardized quality solar lights and batteries which are effective and can give more light."

"Installation of a hybrid system for back up in case one system experiences a fault to ensure effectiveness and reliability of power supply."

"Educating the public about the importance of solar powered street lighting systems.

"Award the contract of solar street lighting system installation to companies that are more competent with authentic equipment. Sensitising the society about the importance of the systems and engaging the communities to safe guard the street lighting systems."

Source: *Primary data, 2019; Focus Group Discussions Group A, B, C & D combined*

All the above strategies may be significant in the improvement of solar powered street lighting systems, especially
during project replication in other areas for effective sustainable development in the country.

Social Benefits

Improved Lighting Facilities

The study found out that the solar photovoltaic systems are a source of safe, healthy and excellent illumination. The systems come along with special lanterns that are ideal replacements of candles and or locally manufactured kerosene tin lanterns commonly known as "tadooba" in Uganda, which have been hazardous for a long time as they have been widely used for lighting in rural areas. The majority of the population in rural areas of Uganda use kerosene tin lanterns with wicks which produce poor lights and are responsible for in-door pollution due to smoke that has caused many health issues. According to UBOS 2017, the „Tadooba" remains the most common source of lighting being used by 52 percent of the households in Uganda. (Esper et.al. 2013) reported that solar technology has the ability to improve in-door air quality as a positive impact on the users. Besides, kerosene can be more expensive compared to solar energy in the long term perspective. This declaration was proven by (Jella, 2017) when he established in his study that light produced by candles is of a very poor quality save for the high prices of paraffin as well as batteries, yet only one solar panel already provides enough power to illuminate three bulbs. According to research, rural communities in the developing world spend a substantial amount of money on kerosene, candles and other traditional energy products ranging between US$3 and US$20 every month on kerosene, candles, or other energy products (Plastow & Goldstone 2001). This is in confirmation to what one of the household respondents declared:

"*My family used to spend a lot of money, over PVs. 25,000, on kerosene alone every month, but now that is history. We are enjoying a very bright light, yet we no longer pay any money for fuel; this solar energy is a free resource that has made us forget about fuel costs; in fact,we save the money that would be used to buy fuel for other needs*"

SOURCE: *(Focus group discussion Group E); June 2019 at Kibiro landing site*

Therefore, solar energy has saved many users the monthly costs of the toxic fuel, which would moreover pose health hazards to them. The money saved on fuel costs is used to meet other needs of the

households, hence improving the quality of life. Economic savings on lighting expenses increase reusable income, thus increasing expenditure on other goods and services (Khandker et al., 2014). It can as well be channeled to other developmental projects. Consequently, Solar photovoltaic systems have profited households, health centres, schools and religious centres by providing comfortable illumination to the occupants, thereby outshining the kerosene lanterns. Gradually, rural communities are turning to green energy for better illumination, thus stepping out towards sustainable development.

Information and Communication Facilities

In this era, ICT plays an important role in the day today activities of every society. It is very evident that solar power systems have tried to advance the access of information and communication in areas that once relied on traditional methods of communication. Isolated communities are now networked to the rest of the world because of the development of solar energy, a thing that could not be possible with the reliance on the national grid. The stand-alone photovoltaic systems are used to operate telecommunication masts that help to transmit signals clearly between service providers and cell phone users in an instant. Without the masts being operated by electricity, cell phones can be of no use in an area.

In addition, the people in remote and isolated communities are benefiting from stand-alone photovoltaic systems by charging their cell phones, which they use for communication for different purposes, including business activities. (Jella, 2017) affirms that solar electricity facilitates the charging of cell phones and purposely for enabling communication. It therefore, stimulates and improves the access to information through cell phones. Similarly, radios and televisions, the gadgets that are essential in the facilitation of information worldwide are powered by the solar energy system as an off-grid solution to keep the rural communities abreast of what is happening in the country and the world at large. It is actually through radios and televisions that governments tend to communicate its progammes to the citizens. According to (Greenstar, 2004; Amankwaah, 2005), Solar energy is an ideal alternative to power computers, radios and televisions to boost information and communication as an off-grid solution for rural communities. These devices provide the population with crucial information about businesses, education, health, environment, and other

programmes that improve their standards of living. This can further be evidenced by photo plate 4 in the appendix.

Entertainment and Leisure

The study established that the rural communities were enjoying a variety of entertainments and hobbies due to the diffusion of stand-alone photovoltaic systems in the area. These range from football shows to films and other live programmes. The shows are a significant achievement in the digital world, which has an implication that the world is becoming a global village; through different digital channels, a match that is played in Europe or elsewhere is watched live by people all over the world (even in rural areas of Uganda), just by the magical power of mere stand-alone photovoltaic systems. This innovation is quite impressive. Some people often gather to watch movies at football show centres, commonly known as "ebibanda" in the local language of the area of study. Furthermore, those who are connected to Solar Home Systems listen to and watch different matches, programmes as well as movies for entertainment, leisure and educational purposes comfortably from their homes. These activities have significantly improved the people"s quality of life. Therefore, the diffusion of PV systems can influence the quality of entertainment in rural areas by powering devices such as radios, televisions, computers and smart phones as reportedby (Bahauddin & Salah, 2010) in their study. Also, (Obeng & Kumi 2014) recognised that the availability of solar PVs in the rural communities of Ghana not only lowered the prices of listening to radios and watching television, but also increased the ownership of these devices which enhanced entertainment at household levels.

Improved Primary Healthcare Services

The study affirmed that stand-alone photovoltaic systems have the ability to improve people"s lives in a sustainable way. Most of the time, rural communities are not connected to the national grid, which makes life and health quite demanding. With the diffusion of solar photovoltaic in some rural communities of Uganda, the quality of health has significantly been upgraded. Health stations are now powered by solar panels to operate lamps during the night, refrigeration of medicines and for running some simple machines. A study conducted in India established that solar systems have the capacity to offer refrigeration, lighting as well as water pumping services in health centres (Ramji et al., 2017). The

lamps are a good source of illumination that has saved lots of patients, especially mothers at the time of giving birth, thus improving maternal health. (SolarAid & SunnyMoney,2015) reported that solar lanterns in conjunction with solar phone charging systems have resulted into improved maternal health care in Nigeria; midwives use them to attend to their patients and provide medical aid distantly and at night. Similarly, the same panel systems are used for refrigeration of vaccines, especially for young children, hence reducing child mortality rate. In addition, the refrigeration of the vaccines has also combatted some immunisable communicable diseases among children and adults such as cholera and measles that often break out around the areas near the shores of L a ke Albert. Also, some medical equipment for carrying out disease diagnosis such as microscopes and other simple equipment such as sterilizers are run by electricity. Therefore, the solar lamps, and the refrigeration of vaccines and other medicines, powered by the solar energy systems have served the rural communities in a better way health wise. This is evidenced by photo plate 5 in the appendix.

Healthy Environment

The study revealed a healthier environment as the photovoltaic systems are essentially and gradually replacing conventional energy resources. The implication here is that there is reduced emission of greenhouse gases due to the reduction on the use of kerosene and diesel generators. Most of the people that once used diesel generators as a source of electricity are dropping it for solar energy systems. In fact, none of the people that installed the solar panels still uses kerosene according to the responses given. Therefore, there is improved air quality. The reduction on the use of conventional energy sources signifies reduced depletion of the resources, less pressure onelectricity generation from the same sources, reduced deforestation as well as reduced greenhouse gases and therefore a healthier environment.

Increased security and safety

Another interesting finding of the study is the improved security and safety. The household respondents reported that they were assured of good security after the installation of solar systems. They stated that a number of robberies had occurred previously before the installation, especially at night due to lack of security lights. One of the respondents in the focus group discussion reported.

"The lanterns outside the building provide lights at night, so it is not easy for thieves tocome along. However, before the acquisition of solar power, thieves used to steal our property seriously, especially at night because of darkness. Nowadays, we are secure because of the benign solar power that provides us with security lights. I am even happy that my system is very strong; it does not go off, but I only switch it off in the morning."

Source: *Focus group discussion (Group F). Field data, June 2019*

Similarly, some solar users in other parts of Uganda were found to be utilizing their solar kits for the provision of security lights in their households after sunset (Orlandi et al., 2016). Another research conducted by solar companies in East Africa unveiled that over 60% of customers surveyed enjoyed an improved sense of security (Acumen, 2017). This sense of security is very essential for sustainable development as it makes people and their property secure and safe.

Furthermore, the survey established that solar power energy was used to enhance the security of refugees. In areas near Lake Albert are refugee camps and refugee reception centres. Uganda is a home for many refugees from neighboring countries such as Democratic Republic of Congo, South Sudan, Rwanda, Somalia and others. For different reasons, these refugees have found safety in Uganda. The refugee camps are located in remote areas, and therefore, powered by solar panels for lighting and security at night. (Little Sun, 2016) recognized that solar lamps were provided by Oxfam to the displaced women in Sudan with intentions of enhancing their safety and security, especially at night. The lamps are usually provided by humanitarian agencies such as United Nations High Commission for Refugees to reduce gender based violence especially in the times of recovery after critical disasters (Lavelle, 2015).

In addition to security, the solar PV systems have improved safety in the users" homes. Before their dissemination, accidents arising from candles and kerosene tin lanterns were rampant. (Orlandi et al., 2016) in their research examined that 30% of the burnt patients at the hospitals in Nigeria are as a result of kerosene lantern bursts, yet in Bangladesh 23% of burns among children were due to kerosene lamps. In the same study conducted, it was established that about 80,000 infants in South Africa were victims of kerosene ingestion.

These accidents are commonly triggered by young children and careless mothers trying to light the houses, and under serious cases, they have resulted into the burning of the entire house and/ or death of people as well. The household survey results also indicated that children between the ages of 1 and 5 years would accidentally be poisoned by drinking kerosene that would be kept in containers within their reach. As such, the community expressed their gratitude to the dissemination of solar technologies that further prevents such disasters. In the study conducted by (Jella, 2017), it was identified that electricity access provided by solar technology in rural areas reduces the rate of fire and other accidents that break out as a result of using paraffin candles. Therefore, solar lanterns are ideal replacements of fuel-based lighting systems due to the safety they offer.

Women Empowerment

The findings from the study also show that solar energy technologies have added value to women and girls, hence uplifting their status in society (gender equality). An empirical evidence is in the case where girls‟ performance in schools has highly improved due to the availability of good illumination for studying extra hours unlike before the diffusion of solar technologies where girls would spend long hours walking in search of firewood for both lighting and cooking. Some of them would drop out because the families would prioritize the collection of firewood over girls‟ education. The solar PVs in conjunction with the introduction of improved cook stoves have done wonders to uplift the status of women in rural communities. The women, instead of collecting firewood for several hours, now perform other economic activities such as shop keeping, working at restaurants, running salons and others that have resulted in the increase of income for the households.

Similarly, the (Samad et al., 2013) study, strongly recognized that the amount of time spent collecting wood by women is reduced by 9 percent due to solar technology. Therefore, women utilize this time that was once „wasted‟ by indulging themselves in income generating activities, hence highly boosting them and therefore increasing their ability to meet their families‟ needs such as education, health care, food among others. (Jella, 2017) recognizes that by contributing an additional income to the family, it highly impresses the women and they feel more valuable within the household, which

makes them consider themselves more equal to their husbands. Consequently, this role raises their self-esteem and increases their power to take part in decision-making. In the same study, the researcher also appreciated the prime benefit of solar power in rural Bangladesh as a catalyst in making women‟s life easier by providing them with an opportunity to work even after the sun has gone down without day light. Women are able to perform extra duties or accomplish their day‟s schedules and tasks at home, which is a compelling opportunity, unlike before the solar installation, where they used to rely on the sun light to balance both professional and house chores.

Improved Quality of Education

Education is one of the services that has lagged behind in rural communities of Uganda. This is partly due to lack of electricity access in rural schools, which makes the students day-scholars unlike in some urban schools where students are provided with accommodation at school and get extra academic services. As a matter of fact, the students in rural areas can hardly compete with those in urban areas because the latter have more time to study and their teachers have the opportunity to do more tasks at night unlike the former. Therefore, the findings reveal that the availability of solar power in rural Uganda provides an opportunity for rural students to have more time for studying at night and their teachers to perform extra pedagogical tasks during the night, which has greatly improved performance in schools. (Khan & Azad, 2014), in the study they conducted, asserted that solar power resulted into improved conditions for studying for school children by 52% due to the provision of good illumination at night in rural Bangladesh.

Also in Kenya, Siburi Mixed Secondary School at Homabay, in western Kenya is a typical example of improved school performance due to solar energy. Before 2012, the school ranked 48 out of 67 in the sub county. The girls performed poorer than the boys due to domestic chores after school. However, with the introduction of solar lamps to the school and parents by GIVEWATTS enterprise, students had more time to study and by 2015, the girls‟ performance was better than that of the boys. More importantly, the school now ranks second in the sub-county and the number of students going for higher studies increased from 5% to 40% after the acquisition of solar lamps (Scott et al., 2017). Solar energy also improves education by enabling teachers to carry out

more research and virtually network with their fellows pedagogically through various media such as the Internet, mobile phones and computers all of which are powered by PV systems.

5.0 Conclusions and Recommendations

This study used descriptive statistics to analyse social economic characteristics of respondents and regression model was used to determine the factors influencing accessibility and adoption of clean burning, fuel-efficient cook-stoves among rural livelihoods, level of investment by stove fabricators and the market for clean burning, fuel-efficient cook-stoves, and of socio-economic benefits of solar photovoltaic systems for street lighting, home and institutional uses in the development of rural livelihoods**.**

In this study, a probit regression model was used to identify the influencing factors on accessibility and adoption of clean burning, fuel-efficient cook-stoves among rural communities. The following explanatory variables namely; education level, household income, household head occupation, access to information, training services, technical support have a positive relationship with accessibility and adoption of clean burning, fuel-efficient cook-stoves among rural communities and are statistically significant at 1% level.

The results of study indicated that income level, expenditure level, access to credit, were significant ($p \leq 0.01$) and positively related to the level of investment by stove fabricators. Ready market was found to be significant ($p \leq 0.05$) and positively showed a higher relationship with investment and market of clean burning and improved cook-stoves in study area while household size was found to be significant ($p \leq 0.10$) and positively showed a relationship with investment and market of clean burning, fuel efficient cook-stoves in the study area.

The results from study also revealed that solar photovoltaic systems have socio-economic benefits that support sustainable development in rural communities and contributed positively in different projects such as access to modern energy service, money savings, enhancing business activities and extending working hours, improving income generation, increasing environment sustainability, improving communication systems, improving illumination, reducing emissions of greenhouse gases, effective energy provision, safety and security, increasing employment opportunities, improvement

of study conditions, improved air quality and health conditions, as well as increasing business opportunities. The results indicated that solar PVs have statistically and significantly contributed to access to modern energy services, money savings, enhanced business activities and extended working hours, increased environment sustainability, increased employment opportunities, improvement of study conditions, increase business opportunities (all of them) at 1% level. Improvement of communication systems, illumination, air quality and safety were at 5%, while improved income generation, and reduced emission of greenhouse gases were at 10% level.

According to the findings, solar powered street lights contribute to sustainable development in the following ways: They are cheaper to operate and maintain than the grid electricity. They are more reliable than the grid and convenient to install. They also involve fewer emissions after installation, thus a tool to mitigate climate change. The system promotes environmental sustainability and electricity is generated from a free inexhaustible source (no generation costs). It also Increases energy security through the energy mix. Further still, solar powered street lighting promotes security and safety and reduce crime rates as well as fatalities and accidents on roads. The system also reduces traffic jam, boosts business transactions at night, reduces electricity bills and increases creation of jobs and above all reduces the rate of depletion of natural resources such as forests and water bodies.

The findings also reveal that PVs contributed significantly to economic activities in remote areas by offering the following economic benefits: Enhancement of fishing activity, casino betting, entrepreneurial charging stations, barbers‟ shops and salons, extending working/business hours emergence of new business activities like football show centres („Ebibanda‟) and employment opportunities. Social benefits realised from the use of PVs include improved lighting facilities improved information and communication systems, entertainment and leisure, improved primary health care services, healthy environment, women empowerment and improved quality of education.

Consequently, the respondents would easily compare the benefits of solar PVs whereby the results indicated that the technology contributed significantly to the development of their livelihoods as seen above. In fact, the users were far much

better than the time before installation or better off than the people who had not installed them due to the socio-economic benefits they are now enjoying from the diffusion of solar power technologies. Therefore, more investments in these technologies are required to scale up the diffusion for sustainable development and a transformed modern and resilient society.

References

Abbot, T. & Sotelo, L. S. (2014). *Recognizing the Role of Gender in the Informal UrbanEconomy*. The CityFix

Acumen (2017). *An evidence review: how affordable is off-grid energy access in Africa?*
London.

Adams, S. (2009). *Can foreign direct investment (FDI) help to promote growth in Africa*?

Achimota: Ghana Institute of Management and Public Administration, p. 180.

AfDB. (2013). *Uganda Energy Sector Review and Action Plan*. Tunis: Temporary RelocationAgency.

Agahozo-Shalom Youth Village. (2016). *About*. Accessed on 28 June 2019 from http://asyv.org/about

Akinlo, A. E. (2004). *Foreign Direct Investment and Growth in Nigeria: An Empirical Investigation*. Ile-Ife: Obafemi Awolowo University, p. 636.

Angelou, N., Azuela, G. E., Banerjee, S. G., Bhatia, M., Bushueva, I., Inon, J. G., Goldenberg, J. I., Portale, E. & Sarkar, A. (2013). *Global Tracking Framework,* Sustainable Energy for all. Washington D.C.: The World Bank.

ARC (2011). *Test Results of Cook Stove Performance, Aprovecho Research Center (ARC), Partnership for Clean Indoor Air (PCIA), Shell Foundation, and US Environmental Protection Agency (EPA.* Cottage Grove, USA, pp 128.

Attigah, B. and Mayer-Tasch, L. (2013). *The impact of electricity access on economic development: a literature review. In Productive use of energy (PRODUSE): measuring*
impacts of electrification on micro-enterprises in Sub-Saharan Africa.

Ayenwale, A. B. (2007). *FDI and Economic Growth: Evidence from Nigeria*. Ole-lfe: Obafemi Awolowo University; Department of Agricultural Economics.

Bahauddin, K., & Salah, U. T. (2010). *Impact of Utilization of Solar PV Technology among Marginalized Poor People in Rural Area of Bangladesh*. *Proceedings of International Conference on Environmental Aspects of Bangladesh (ICEAB'10)*, Japan.

Barron, M. & Torero, T. (2014). *Electrification and Time Allocation: Experimental Evidence from Northern El Salvador*. UC Santa Cruz: Department of Economics.

Boomsma, C., & Steg, L. (2014). *Feeling safe in the dark: Examining the effect of entrapment, lighting levels, and gender on feelings of safety and lighting policy acceptability*. Environment and Behavior, 46(2), pp.193–212.

Chant, S. (2013). *Cities through a "gender lens": a golden "urban age" for women in the global South?* Environment and Urbanization, 25(1), pp.9–29

Cresswell, J. W. (2015). *A concise introduction to mixed methods research*. California: SAGEPublication, inc.

Environmental Alert. (2010). *Climate change in Uganda: Insights for long term adoption and building community resilience.* Kampala: Environmental Alert

Eshetu, A.A. (2014). *Factors Affecting the Adoption of Fuel Efficient Stoves among Rural Households in Borena Woreda: North central Ethiopia*. International Journal ofEnergy Science (IJES) Volume 4 Issue 5.

Esper, H., London, T. & Kanchwala, Y. (2013). *Access to clean lighting and its impact on children: An exploration of Solaraid's Sunnymoney. Impact Case Study*. University of Michigan. William Davidson Institute.

Gengnagel, T., Wollburg P., & Mills E. (2013). *Alternatives to Fuel-based Lighting for Night Fishing. The Lumina Project.* University of Bayreuth, Germany.

Gillard, R., Oates, L., Kasaija, P., Sudmant, A., & Gouldson, A. (2019). *Sustainable urban infrastructure for all: Lessons on solar powered street lights from Kampala and Jinja, Uganda. Coalition for Urban Transitions.* London and Washington, DC.

Gustavsson, M., Hankins, M. Sosis, K., & Broad, A. (2015). *Energy Report for Uganda: A 100% Renewable Energy Future by 2050*. World Wide Fund for Nature.

Hansen, U. E., Pedersen M.B., & Nygaard I. (2015). *Review of solar PV policies, interventions and diffusion in East Africa. Renewable and Sustainable Energy Reviews 46: 236-248.*

Heffron, R. J. (2018). *Energy law for decommissioning in the energy sector in the 21st century*. Journal of World Energy Law & Business, 11(3), 189-195.

Heffron, R.J., Hussein, H.I., Yang, C., & Sun, N. (2017). *The global future of energy law*: International Energy Law Review

Hermann, S., Miketa, A., & Fichaux, N. (2014). *Estimating the Renewable Energy Potential inAfrica. A GIS-based approach, IRENA-KTH working paper, International Renewable Energy Agency (IRENA)*, Abu Dahbi, UAE, June, pp 73.

IEA. (2012). *World Energy Outlook*. Paris: International Energy Agency, pp. 538-540.

IEA. (2014) *Technology Roadmap Solar Photovoltaic Energy, ed*. Paris: International EnergyAgency

IEA. (2015). *World Energy Outlook.* Paris: International Energy Agency.

IFPRI. (2014). *Uganda Social Accounting Matrix (SAM)*. Washington D.C.: IFPRI.

ILO. (2013). *Methodologies for assessing green jobs – policy brief. International LabourOrganization.*

International Monetary Fund. (2018). *Pursuing Women's Economic Empowerment*. Washington DC: IMF. https://www.imf. org/en/Publications/Policy Papers/Issues/2018/05/31/pp053118pursuing-womens-economic-empowerment.

IRENA & CEM. (2014). *The Socio-economic Benefits of Solar and Wind Energy: an econValuereport.* Masdar City: International Renewable Energy Agency.

IRENA (2018). *Renewable Energy Auctions: Cases from Sub-Saharan Africa*. Abu Dhabi

IRENA. (2012). *Renewable Energy Jobs & Access*. Masdar City: International Renewable Energy Agency.

IRENA. (2014). *Renewable Power Generation Cost*. Masdar City: International RenewableEnergy Agency, p. 30.

IRENA. (2015). *REthinking Energy: Renewable Energy and Climate Change*. Masdar City: International Renewable Energy Agency.

Jacobsen, A. E. (2006). *Connective Power: Solar Electrification and Social Change in Kenya.* Berkeley: University of California.

Jagger, P. & Shively, G. (2014). "*Land Use Change, Fuel Use and Respiratory Health inUganda."* Energy Policy 67: 713-726.

Jella, H. (2017). *Solar Power Means Female Power? How the introduction of electricity Supports gender needs in rural Bangladesh.* Department of Urban and Rural Development,Uppsala

Johnson, A. (2006). *The Effects of FDI Inflows on Host Country Economic Growth*. Jönköping: Jönköping International Business School.

Johansson, M., Rosén, M. & Küller, R. (2011). *Individual factors influencing the assessment of the outdoor lighting of an urban footpath. Lighting Research & Technology,* 43(1),pp.31–43.

Khan S.-A., & Azad, A. K. M. A. M. (2014). *Social Impact of Solar Home System in Rural Bangladesh [...],* IAFOR Journal of Sustainability, Energy and the Environment 1(1):5-22

Kees, M., & Eije, S. (2018). *Final Energy report Uganda*. Netherlands Enterprise Agency. Lavelle, M. (2015). *Solar lights a healthy – and empowering – path in disasters*. Daily Climate Online. Charlottesville, VA: The Daily Climate

Lenz, L., Munyehirwe, A., Peters, J. & Sievert, M. (2015). *Does Large Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program* Ruhr Economic Papers, No. 555

Little Sun (2016). *Dignity and light for internally displaced people (IDPs) in South Sudan.* LittleSun Online. Berlin.

Mawejje, J. (2014). *Improving electricity access in Uganda.* Kampala: Economic Policy Research Centre. Policy Brief No. 43

McCauley, D., & Heffron, R. (2018). *Just Transition: integrating climate, energy and environmental justice.* Energy Policy, 119, 1-7

MEMD. (2013). *Rural electrification strategy and plan.* Kampala: Rural Electrification Agency. MEMD. (2014). *Statistical Abstract*, Ministry of Energy and Mineral Development (MEMD), Kampala, Uganda, pp 140.

Mills E. (2012). *Health impacts associated with off-grid fuel-based lighting.* Dakar, SenegalMEMD. (2013). *National Biomass Strategy(BEST).* Kampala, Uganda.

MEMD (2015a). Biomass Energy Strategy (BEST) Uganda, Ministry of Energy and MineralDevelopment (MEMD), Kampala, Uganda, pp 114

Mokveld K. & Eije S. (2018). *Final Energy report Uganda*: *Version:6 (final)* RVO.nl: Accessedon 12 July 2019.

NPA. (2015). *Second National Development Plan (NDPII) 2015/16 - 2019/20*, National Planning Authority (NPA), Kampala, Uganda, pp 344.

Obeng, G., & Evers, H. (2010). *Impacts of public solar PV electrification on rural micro- enterprises: The case of Ghana. Energy for Sustainable Development*, (14), 223-231.

Obeng, G., & Kumi, E. (2014). *Quantitative impacts of solar PV on television viewing and radio listening in off-grid rural Ghana.* Energy and Environmental Research, 4(1).OECD/IEA. (2014). *Energy in Africa Today.* Africa Energy Outlook, 13-25. OECD/IEA. (2017). *Energy Access Outlook: From Poverty to Prosperity*. World Energy Outlook Special Report. Intenational Energy Agency: Paris.

Olayinka, O.S., Adaramola, M. S., Oyewola, O. M., & Richard O. F. (2014). *Solar energyapplications and development in Nigeria: Drivers and barriers*. Renewable and Sustainable Energy Reviews 32 (2014) 294–301

Orlandi, I., Tyabji, N., & Chase, J. (2016). *Off-grid solar market trends report*. London: Bloomberg New Energy Finance, Lighting Global, World Bank and GOGLA

Oting, W., Mwarania, F., Wahab, A.A., & Kpatinde, T.A. (2018). *Uganda Solar Energy Utilization: Current Status and Future Trends.* International Journal of Scientific and Research Publications, Volume 8, Issue 3.

Panwar N.L., Kaushik, S.C., & Kothari, S. (2011). *Role of renewable energy sources in environmental protection: A review.* Renewable and Sustainable Energy Reviews 151513–1524.

Rahman, M.A., & Kholilullah, I.Md. (2014). *Use of Solar Panel at Rural Areas in Bangladesh: Impacts, Financial Viability and Future Prospects*. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064

Ramji, A., Patnaik, S., Mani, S., & Dholakia, H. (2017). *Powering primary healthcare through solar in India: lessons from Chhattisgarh*. New Delhi: Council on Energy, Environment and Water and Oxfam

Rehfuess, E.A., Puzzolo. E., Stanistreet, D., Pope, D., & Bruce, N.G. (2014). *Enablers and barriers to large-scale uptake of improved solid fuel stoves: a systematic review.* EnvironHealth Perspect 122:120–130.

Safari, B., & Gasore, J. (2007). *Assessment of global radiation over Uganda.* Huye: NationalUniversity of Rwanda. p. 1.

Samad, H. A., Khandker, S. R., Asaduzzaman, M., & Yunus, M. (2013). *The Benefits of Solar Home Systems: An Analysis from Bangladesh.* Washington D.C.: The World Bank.

Scatec Solar. (2015A). *Annual Report 2014*. Accessed on 14 June 2019 from http://www.scatecsolar.com/Investor/Reports-and-presentations2/Annual-reports

Scatec Solar. (2015B). *Sustainability Report 2014*. Accessed on 17 June 2019 from http://www.scatecsolar.com/Sustainability?id=853

Scatec Solar. (2016A). *Annual Report 2015*. Accessed on 17 June 2019 from http://hugin.info/162249/R/1995957/735337.pdf

Scatec Solar. (2016B*). Fourth Quarter 2015 (Financial report)*. Accessed on 20 June 2017 from http://hugin.info/162249/R/1982150/726325.pdf

Scatec Solar. (2016C). *About Scatec Solar*. Accessed on 28 May 2016 from http://www.scatecsolar.com/About

Scatec Solar. (2016D). Investor Presentation August 2016. Accessed on 3

December 2016 from http://www.scatecsolar.com/Investor

Scatec Solar. (2016D). 2016 *Investor Presentation August*. Accessed on 3 December 2016 from http://www.scatecsolar.com/Investor

Scott, A., Worrall, L., & Honberg, J. (2017). *How solar household systems contribute to resilience*. London: Overseas Development Institute.

SE4ALL. (2016). *Measuring Energy Access: Introduction to the Multi-Tier Framework*.

SE4ALL Knowledge Hub publications.

SE4ALL. (2016). *Our Vision*. Accessed on 27 July 2019 from: http://www.se4all.org/our-vision Sedziwy, A. & Kotulski, L. (2016). *Towards Highly Energy-Efficient Roadway Lighting*. Energies, 9, 263

Smith, W. (2014) *The Impact of Solar Lights on the Individual Welfare and Fishing Productivity of Liberian Fishermen.* The College of William and Mary: Undergraduate Honors Thesis. Paper 17.

Solar Aid and Sunny Money. (2015). *Impact report*: London: SolarAid SSB. (2016). Elektrisitetspriser, 1. Kvartal . Accessed on 27 July 2016.

Teves de Almeida R.H., (2014). *Lumisol: a contribution to solar street lighting in developingcountries*

Tigabu, A., Atela, J. & Hanlin, R. (2016). *Factors influencing sustained use of efficient cook stoves and solar lighting solutions: a case study from Kenya*. Climate Resilient Economies Working Paper 004/2016. African Centre for Technology Studies. Nairobi: ACTS Press

Uganda Bureau of Statistics. (2017). *The National Population and Housing Census 2014* – Area *Specific Profile Series,* Kampala, Uganda

Uganda Country Report. (2018). *Report 2: Energy and Economic Growth Research Programme*
(W01 and W05) PO Number: PO00022908

United Nations Environment Programme. (2017). *Accelerating the Global Adoption of Energy- Efficient Lighting; United for Efficiency (U4E) Policy Guide Series*: Paris, France.

Working Paper 6724. World Bank.

World Bank. (2017). *Environment and social systems assessment* (ESSA). Washington DC World Bank. (2018). *State of Play: Sustainable Energy in Humanitarian Settings*; Washington DC

World Bank. (2016C). Primary completion rate, both sexes (%). Accessed on 30 June 2019 from http://data.worldbank.org/indicator/SE.PRM.CMPT.ZS/countries/1W-RW?display=graph

World Bank. (2016A). *Country Overview.* Accessed on 8 June 2016 from http://www.worldbank.org/en/country/Uganda/overview#1

World Bank. (2016B). *Uganda Economic Update (Uganda at work)*, issue no. 9. WashingtonD.C.: The World Bank, p. 11.

World Bank. (2016D). *Youth literacy rate, population 15-24 years, both sexes (%).* Accessed on 8 June 2019 from http://data.worldbank.org/indicator/SE.ADT.1524.LT.ZS

World Bank. (2016D). *Youth literacy rate, population 15-24 years, both sexes (%).* Accessed on 10 June 2019 from http://data.worldbank.org/indicator/SE.ADT.1524.LT.ZS

World Bank. (2016E). *Foreign direct investment, net inflows (BoP, current US$)*. Accessed on 8 June 2019 from http://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD

wp-content/uploads/publications/03_20182017_Statistical_Abstract.pdf (Accessed 16 March 2023)

William, M. (2020). Symbolic Post-Conflict Recovery in the Rwenzori Sub-Region of Uganda. *Journal of Asian and African Studies* 55(5), 699–715.

Wolfsfeld, G. (2004). *Media and the Path to Peace*. Cambridge: Cambridge University Press

Zakaria, S. M. & Lazim, N. H. M. (2018). The Practices of Conflict Management Styles from Different Perspectives. *Jurnal Psikologi Malaysia* 32(4),18-27