SOLAR ENERGY IN SUB-SAHARAN AFRICA

HOW CAN THE CHALLENGES THAT INHIBIT THE IMPLEMENTATION OF SOLAR POWER IN SUB SAHARAN AFRICA BE OVERCOME?

FF & CL

2023

Date: 2.2.2023

Name: CL, FF

Group: Macro

Title: Assessment Paper

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Course: EBP 2002 sustainability project

Faculty: SBE, School of Business and Economics

Word count: 5237

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1. INTRODUCTION

It is estimated that about 775 million people worldwide lack access to electricity, of which 620 million live in Sub-Saharan Africa (IEA, 2022; Tomala et al., 2021). Sub-Saharan Africa consists of all 47 countries south of the Saharan desert (Broad, 2016) (view Figure 1). The region is noted for its numerous natural resources, including minerals, oil, and arable land, as well as its diverse population and culture. However, the region has multiple challenges, such as poverty, political instability, and inadequate infrastructure, causing economic growth and development obstacles (Mohammed et al., 2013).

Figure 1: Sub Saharan Africa map, (Broad, 2016)

Sub-Saharan African countries are highly dependent on fossil fuel imports from other countries, which poses several problems. Importing fossil fuels is expensive and makes these countries exposed to global fossil fuel price swings. Dependence on fossil fuel imports can also limit these countries' potential to produce renewable energy (Moner-Girona et al., 2021; Tomala et al., 2021). This increases carbon emissions and climate change, harming the ecosystem and local people. If no action is taken, in 2030, one-third of the world's population will still lack clean fuels and technologies, severely impacting their health and the environment (UN, 2021).

Those with access to electricity have to pay, on average, twice as much for electricity as consumers in other parts of the world. The annual loss to the continent's GDP due to electricity shortages is about 2 to 4 per cent (Schwerhoff & Sy, 2020). Soon, the already considerable demand for electricity will increase even more. With the population of sub-Saharan Africa expected to increase from 1 billion in 2018 to over 2 billion in 2050, electricity demand is expected to grow by 3 per cent per year (Schwerhoff & Sy, 2020). This considers both a steady increase in the number of people with access to electricity and an overall increase in energy efficiency. This will be very hard to achieve, considering that Sub-Saharan Africa is the region where energy is globally lacking the most, as seen in Figure 2.

The burning of coal, oil and other types of traditional biomass, such as wood, makes up the bulk of Africa's current energy mix. This energy mix, while very cost-effective, is insufficient to meet

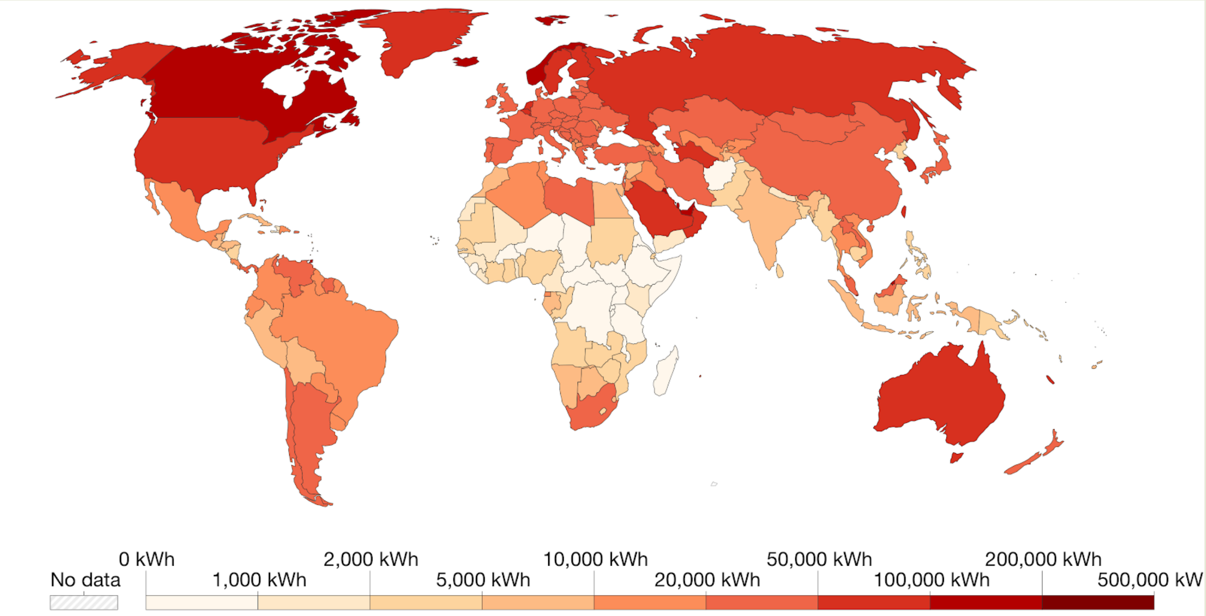

Figure 1: Energy use per Person, 2021 (World Bank, 2021)

current needs and ignores the harmful effects on the environment. Suppose African governments want to create a healthy environment for their citizens and meet the greenhouse gas emission limits set in the 2015 Paris Agreement. In that case, they must change the energy sources used on the continent. This is especially true if the Paris Agreement is to be respected. One energy source that has great potential in Sub-Saharan Africa is solar power (Schwerhoff & Sy, 2020).

However, numerous challenges make solar power implementation in Sub-Saharan Africa difficult. Therefore, this paper will address the research question: How can the challenges that inhibit the implementation of solar power in Sub-Saharan Africa be overcome? The challenges will be examined to answer this question, and potential solutions to these challenges will be assessed. Process tracing assessment will be used for this purpose.

A macro perspective on the deployment of solar energy in sub-Saharan Africa is significant since it offers a comprehensive overview of the different factors affecting the region's broad acceptance of solar energy. The macro view considers how numerous variables interact, including those relating to politics, finance, society, and technology, in order to gain a broad understanding of the challenges to the uptake of solar energy in Sub-Saharan Africa. By evaluating the macro perspective, it is possible to understand the complex interactions between these variables and identify a practical solution for resolving the issues preventing the widespread use of solar power in this area.

2. BACKGROUND

SOLAR POWER IN SUB-SAHARAN AFRICA

Due to the high levels of solar radiation present in the region, Sub-Saharan Africa holds great promise for using solar power. 80 per cent of Africa's land surface receives annual radiation greater than 2000 kWh/m2, significantly greater than the average worldwide value (Lei et al., 2019). Therefore there is great photovoltaic power (PV) potential in Sub-Saharan Africa, as seen in Figure 3. Meaning a great potential to convert solar light into electricity. Compared to other renewables, such as wind energy, hydro-energy, and geothermal energy, solar power resources in Africa have a significant advantage in terms of total potential (Lei et al., 2019). Because of this, it would be an ideal place to generate solar power. Especially Solar photovoltaics is a clean energy source that does not emit greenhouse gasses, making it a great way to lessen carbon emissions and combat climate change (Moner-Girona et al., 2021). Decentralized Solar systems are especially ideal for usage in rural regions because they enable electricity generation from a trustworthy and self-sufficient source. Therefore, it does not require a connection to the national power grid, making them more independent (Tomala et al., 2021). Given Africa's inadequate grid infrastructure, decentralized distributed PV solar systems may be the more cost-effective option (Lei et al., 2019). Investments in solar power, in general, would make countries less dependent on imported fossil fuels (Moner-Girona et al., 2021).

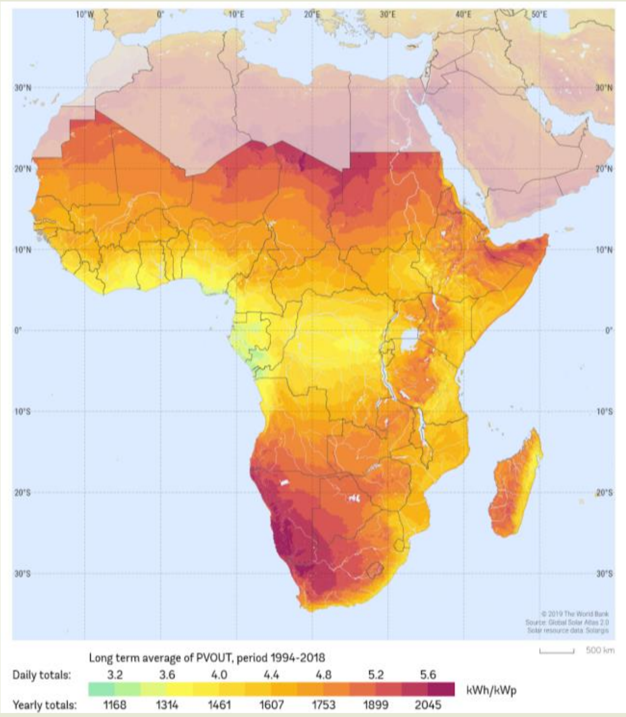

Figure 2: Photovoltaic Power Potential Sub-Saharan Africa, 2019 (African World Bank, 2019)

THE RELEVANCE OF SOLAR ENERGY IN ACHIEVING SUSTAINABLE DEVELOPMENT GOALS

Solar energy has the potential to significantly contribute to the Sustainable Development Goals (SDGs) achievement by encouraging sustainable growth and addressing some of the most urgent global issues, such as poverty, climate change, and energy access. Sustainable Development Goal 7 ensures everyone can access modern, affordable, reliable, and sustainable energy (UN, 2015). This goal is strongly linked to the use and implementation of solar energy in sub-Saharan Africa. Other side effects of this goal could be: Firstly, renewable energy can enhance the standard of living for residents in these locations and encourage economic growth (Chirambo, 2018). Secondly, solar energy can help achieve SDGs like SDG 13 (Climate Change Mitigation) and SDG 9 (Industry, Innovation, and Infrastructure). For instance, using solar energy can lessen reliance on fossil fuels and help reduce greenhouse gas emissions, which is a crucial component of SDG 13 (UN, 2015). Thirdly, SDG 1 (to end poverty) and SDG 3 (healthy lives and well-being for all) can benefit from solar energy's widespread adoption in sub-Saharan Africa. This is due to the fact that having access to electricity can enhance access to services like healthcare, education, and other necessities for eradicating poverty and fostering well-being (UN, 2015).

3. METHODOLOGY

This research paper conducts a literature review as a data collection method. Qualitative and quantitative research papers from databases such as Jstore, google scholar, web of science or UN and World Bank report were analysed and categorised. Criteria of the paper selection were whether the research was conducted in sub-Saharan Africa and was concerned with solar power or SDG7. Furthermore, papers written between 2014 and 2022 were preferred. Overall, 26 papers were reviewed and analysed.

One main limitation of process tracing in sub-Saharan Africa is that data gathering infrastructure and capacity may be restricted. It is challenging to obtain a large quantity of precise and fine-grained data, which is necessary for the process tracing method (Ibeh & Walmsley, 2020). In addition, it is difficult to generalise the findings of the research because the individual countries that make up sub-Saharan Africa each have unique causes and challenges that make the deployment of solar power difficult (Moner-Girona, 2021).

(I) METHODOLOGY FOR ASSESSING THE CHALLENGES:

Data classification was used as a process to categorise and summarise the results of the different studies. Based on the research, the challenges of installing solar energy in sub-Saharan Africa could be categorised into four domains (Hossin & Sulaiman, 2015). (social, political, technical and financial challenges). To assess the four identified challenges, process tracing was used. It is a method used in qualitative research to identify causal links between variables. Based on the causal relationship, a model analysing the challenges was created to visualise the links (Kittel, Kuehn, 2012).

(II) METHOLOGGY FOR ASSESSING THE INTERVENTION:

Process tracing was further used to propose an intervention that could solve the challenges in the long run. Various research results, laws and hypotheses were linked together to identify the runoff benefits and causal relationships of the paper's proposed solution. This paper proposed education as a possible intervention to overcome the challenges that inhibit installing solar energy in sub-Saharan Africa. Process tracing can identify the precise reasons that have favoured or hindered the adoption of solar energy and propose solutions (Kittel, Kuehn, 2012). This helps to develop efficient policies and regulations that will help the region of Sub-Saharan Africa successfully introduce solar energy while overcoming its problems. The methodology also evaluates the effectiveness of solutions by tracing the process of applying solutions to identified difficulties, reviewing progress in implementation and suggesting areas for further improvement.

4. ASSESSMENT OF CHALLENGES LITERATURE REVIEW

Figure 4 illustrates the four main challenges that inhibit the implementation of solar power in sub-Saharan Africa (SSA). Those four domains emerged from reviewing and categorising primary, secondary qualitative, and quantitative research. The order and formation of the model are divided into structural and practical challenges. Structural challenges describe the social and political sphere and conditions that determine the regions underlying practices and norms. The structural domain concerns how the government and public view, value, and prioritise solar energy. Structural challenges influence practical challenges. The practical challenges are barriers that prevent the installation of solar energy in terms of lacking funding and human resources. Before diving into each variable of the challenges in more detail, it must be highlighted that this model is very simplified. Depending on the particular region, the importance and effect of the problems can differ significantly. This model is used to help the reader understand the challenges in an organised manner. Therefore, it is not recommended to apply this model to real-life cases.

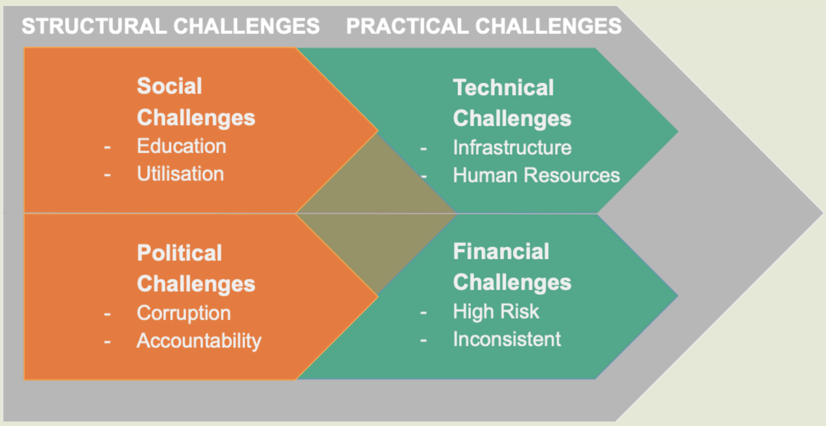

Figure 4: Process tracing model of challenges (made by author, 2023)

(I) SOCIAL CHALLENGES

The first challenges needed to be overcome are social challenges focusing on education and lacking solar energy utilisation. Mohammed et al. (2013) state that there is limited understanding and awareness about the benefits of renewable energy technology in Africa, particularly in Sub-Saharan Africa. This is partly due to high levels of illiteracy in the region, which results in a lack of education and understanding about renewable energy among the population. In fact, 33% of the population above the age of 15 in Sub-Saharan Africa is illiterate. Most of them live in rural areas. (World Bank, 2020). Due to high illiteracy, people have never read about solar energy as a viable option. Therefore, the installation of solar energy in rural areas could be faster. This is especially the case in rural areas where the demand for energy is the highest and education about solar energy is the lowest (Mohammed et al., 2013). Chirambo (2018) also states that education about climate change and solution-orientated learning could convince people to implement solar power. The first social challenge is that people will have to learn about solar energy.

Limitation 1 (education): limited education about the benefits of solar energy in society

The second step is utilising solar energy. Bishoge et al. (2020) found that some societies are hesitant to adopt renewable energy due to concerns about its reliability. They do not trust the benefits of solar power. Therefore, knowledge about how to use renewable energy technologies among local and rural populations is crucial. Another underrated constraint of the utilisation of solar energy is cultural habits. Mohammed et al. (2013) state that some cultural practices and beliefs may hinder the adoption of renewable energy technology. For example, the preference for cooking at night in Kenya and Nigeria has led to the failure of solar cookers in these areas. The solar power that was installed there could not store electricity. Thus they could only cook when the sun was still shining. To be able to maintain their traditions, traditional generators are preferred to be able to cook during the night.

Limitation 2 (utilisation): limited use of solar energy in society

(II) POLITICAL CHALLENGES

The next challenge that prevents the implementation of solar power is in the political domain. The main barrier is corruption. In fact, according to the corruption perception index (scale of 100 (no corruption) - 0 (highly corrupt)), 44 out of the 47 countries in Sub-Sahran Africa are marked below 50 (Transparency International, 2022). This point ties directly with the problem of finance. As long as governments are corrupt, there are less likely to receive funds for installing solar energy. For example, corruption is a major problem in South Africa, which has significantly impacted the country's ability to develop its renewable energy sector. According to a Public Affairs Research Institute report, corruption has hindered South Africa's ability to attract investment in renewable energy projects, leading to delays and cost overruns (PARI, 2022). Another study by Global Witness found that corruption in awarding contracts for renewable energy projects has led to the country missing out on potential investments worth billions of dollars (Global Witness, 2020). Despite efforts to address corruption, it remains a significant challenge for the South African government and the private sector as they work to develop the country's renewable energy sector.

Limitation 3 (corruption): Political corruption prevents the installation of solar energy

The second challenge is weak political accountability and coherence. Bishoge et al. (2020) state that a successful implementation of renewable energy technologies is heavily dependent on the strength of institutions and government policies and regulations. Robust institutions, policies, and regulations can attract private sector investments in renewable energy development. However, many countries in sub-Saharan Africa struggle with weak institutions and policies for renewable energy development and promotion. Furthermore, in some countries, multiple government institutions dealing with the renewable energy sector introduce incoherent policies, leading to a lack of coordination when building energy grids. (Ibeh, & Walmsley, 2020). Poorly coordinated long-term strategies among institutions and other renewable energy stakeholders significantly hinder RE development in the region (Chirambo,2018).

Limitation 4 (accountability): weak political accountability and coherence policies for installing renewable energy

After outlining the more fundamental issues that prevent the implementation of solar energy in sub-Saharan Africa, the following section focuses on the technical and financial challenges.

(III) TECHNICAL CHALLENGES

The variables concerning technical challenges are the lack of human resources and infrastructure for a successful implementation of solar energy. Mohammed et al. (2013) and Bishoge et al. (2020) identified the need for more professionals with technical backgrounds as a major barrier. Renewable energy technologies require developing technical skills, but there is a shortage of qualified personnel in sub-Saharan Africa. Technical knowledge from environmentalists, engineers, economists, policy and research analysts, and accountants is needed to build long-term renewable energy solutions. These professionals are essential for managing all aspects of renewable energy development and utilisation. Furthermore, there is lacking labour in local communities to maintain and repair solar panels if needed (Mohammed et al., 2013).

Limitation 5 (human resources): a shortage of technicians for building and maintaining solar energy grids.

The other technical challenge is insufficient infrastructure and equipment for solar energy. According to the report by the International Renewable Energy Agency (2022), infrastructure is a significant challenge in introducing solar energy in Sub-Saharan Africa. Many areas in the region lack basic infrastructure, such as reliable electricity grids, which makes it difficult to connect and distribute solar energy. This is particularly true in rural and remote areas, where access to grid-connected power is limited. Additionally, many communities in the region are located in remote or rural areas, which can make it difficult and costly to install and maintain solar energy systems. Furthermore, Bishoge et al. (2020) identify inadequate physical facilities and equipment as a challenge. Most of the manufactured equipment for installing solar panels needs to be imported from developed countries, which leads to high costs.

Limitation 6 (Infrastructure): limited basic infrastructure preventing the installation of solar energy in rural areas

(IV) FINANCIAL CHALLENGES

The main challenge is the lack of finance. Inadequate funding is a critical barrier to introducing solar energy in Sub-Saharan Africa. $45 billion is needed to install efficient energy in Sub-Saharan Africa. However, they only receive $9 billion (Moner-Girona, 2021). The lacking finance is directly related to government corruption, lacking transparency and monitoring facilities. If the government is corrupt and funds can not be traced, making them unlikely to receive funding from international organisations (Bishoge et al., 2020). Similarly, it is difficult for sub-Saharan countries to attract private investors if the economy is unstable. An unstable economy poses higher risks for investments. Therefore, investors prefer to provide many small investments to minimise their financial risks. However, large funds for development programs are needed for installing solar energy with the related infrastructure. Inconsistent small-scale funds inhibit long-term transformations in the energy sector (Moner-Girona, 2021).

Limitation 7 (financial): high financial risk (and corruption) result in inconsistent funds for solar energy

5. RECOMMENDED INTERVENTION:

The development of solar energy in sub-Saharan Africa has the potential to deliver reliable and sustainable energy to 471 million people who lack access to energy in rural sub-Saharan Africa (UN, 2021). The different challenges to implementing solar energy in the region are closely interrelated, making it difficult to discover methods to overcome all of them at once. Therefore, it is difficult to discover a solution that assists all sub-Saharan African nations in using solar power, as each nation faces unique obstacles. There are many levels on which intervention could be taken regarding implementing solar power in Sub-Saharan Africa.

Furthermore, due to the diverse needs and conditions of Sub-Saharan countries, this paper does not specify which type of solar energy source should be preferred. This decision depends on the supply and price options as well as expert suggestions. Based on prior research, decentralised solar energy systems are advised since most remote areas are not connected to the national energy grids (Chirambo, 2018). This approach was inspired by the NGO Power For All. Power For All is a non-profit organisation devoted to bringing electricity to rural Africans through decentralised renewable energy sources. Rather than prioritising a single type of renewable energy, Power For All seeks to promote a combination of strategies to increase energy efficiency and availability globally (Power For All, 2022).

Due to the multidimensional diversity of sub-Saharan Africa, a top-down approach would not be advised. In a top-down approach, decisions and actions are taken by a central authority or by a small group of people at the top of an organisation or government. In the context of solar power, a top-down approach would feature large-scale projects and centralised decision-making, with minimal participation from local communities and companies (Asana, 2022). Because it does not take into consideration the unique requirements and circumstances of the communities it serves, this strategy has the potential to be less sustainable as well as less socially inclusive. When the political difficulties that many countries in sub-Saharan Africa are experiencing are taken into consideration, a top-down approach would not be as effective as a bottom-up approach (Tenenbaum et al., 2014).

A bottom-up approach to solar deployment in sub-Saharan Africa would mean a focus on building local capacity and involving the community in the process. Education has the potential to play a crucial role in this strategy, both in terms of increasing public awareness and comprehension of the merits of utilising solar power (Tenenbaum et al., 2014). Educational interventions in sub-Saharan Africa can be seen as a common denominator in terms of the individual backgrounds and different challenges of the various countries. Due to the limited timeframe for this report, this paper focuses on education as a means to overcome the challenges identified in Figure X; however, there are a variety of different approaches that will need to be explored in future research.

The following section examines how non-governmental organisations (NGOs) could introduce training programs for maintaining and installing decentralised solar energy systems in sub-Saharan Africa. NGOs would aim to achieve self-sufficiency and efficient installation of decentralised solar energy systems in rural areas of sub-Saharan Africa.

For the NGO to reach its goal of achieving self-sufficiency and building decentralised solar energy systems in rural Sub-Saharan Africa, local communities need to be educated and given technical help. The successful implementation and ongoing maintenance of energy systems depend on education and training following the hands-on learning-by-doing approach. The NGO will take the lead in providing this training and technical assistance. Experienced technicians and trainers will provide training and technical support. People who are familiar with the local cultures and norms and speak the local language are preferred. This could avoid miscommunication and encourage better relationships and trust between the expert trainer and the local (Zondi, 2015). The presence of the NGOs should only be a temporary solution because once they have trained enough people, the trainers can move on to the next rural communities.

The installation and maintenance of solar energy is the main emphasis of the NGO's education and training. This includes information on the benefits of renewable energy, technical training, and ongoing maintenance and repair services. Local Adults from rural communities around sub-Saharan Africa can choose to participate in such training programmes. The goal is to provide these communities with the knowledge and skills needed to instal and maintain decentralised solar energy systems.

The NGO is in charge of raising money for the installation of decentralised solar energy in sub-Saharan Africa's rural communities. Diverse funding sources, such as individual donations and international organisations, will be used. In order to accomplish its goals, the NGO must make sure that funds are used effectively. Acquiring high-quality and reliable solar panels from reputable manufacturers is essential to the success of the NGOs' efforts. The goal is to ensure that the energy systems are sustainable and efficient. To make sure that the solar panels satisfy the requirements of the communities, the NGO will collaborate closely with the manufacturers.

6. ASSESSMENT OF THE PROPOSED INTERVENTION

Figure 5 assesses how education could resolve other challenges named in Figure 4 in the long run. Thus, answers the research question How can the challenges that inhibit the implementation of solar power in Sub-Saharan Africa be overcome? Through process tracing, the results and hypotheses based on prior research are linked together to anticipate long-term effects and causal relationships. Before explaining the model, it must be highlighted that this is one ideal hypothetical future scenario model. Since the challenges in Sub-Saharan Africa are multidimensional and diverse, this model is highly oversimplified and cannot explain the actual development of particular Sub-Sahran countries. This model is used as an illustration to justify the benefits of education as an intervention to improve the installation process of solar Power in Sub-Saharan Africa.

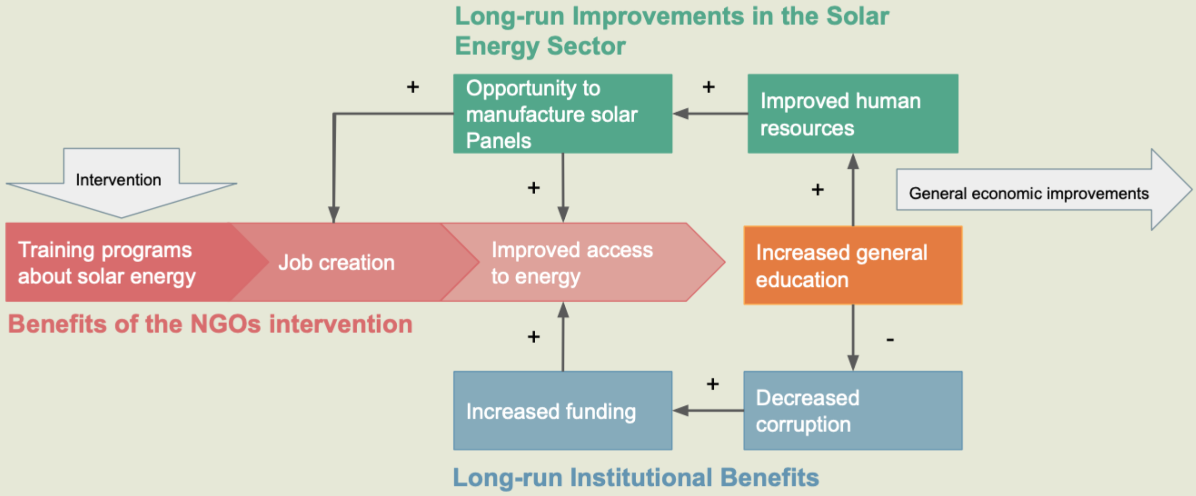

Figure 2: Education as an intervention for introducing solar energy in sub-Saharan Africa (made by author, 2023)

(I) BENEFITS OF THE NGO'S INTERVENTION

If the NGO's intervention is successful and people are trained in installing and maintaining decentralised solar energy grids. It can be assumed that people will be employed in the field of solar energy if they have received sufficient training from the NGO. If there is trained labour in the solar energy field, installing solar energy grids will happen more smoothly. Mohammed et al. (2013) and Bishoge et al. (2020) identified the need for technicians to improve the decentralised energy grid long-term. Local labour is needed to maximise the efficiency and maintain the solar panels. Hence, the NGO's training programmes for local labour will improve access to energy in rural areas. (Chirambo, 2018). Linking this to the challenges identified in Figure 4, the intervention through training programs directly related to the social and technical challenges. It educates people about solar power and provides human resources to make efficient long-term use of solar energy.

Adenle (2020) stated that access to electricity increases the quality of general education. Students need to have access to the internet to obtain better information on their field of interest and conduct adequate research. Additionally, if students have access to the internet, the online schooling sector could be developed, making high-quality education accessible to children living in remote areas. Therefore, the first long-term benefit of improving the solar energy sector is that people have increased general education.

(II) LONG-RUN INSTITUTIONAL BENEFITS:

Interestingly, Forson et al. (2016) found that increased levels of general education increase public participation in politics and awareness about corrupt government practices. A positive relationship has been found between the levels of corruption and the levels of public education. As education increases, mainly secondary education demands on political transparency and accountability increase as well. Therefore, in the long run, corruption, one challenge identified in

Figure 4, would be reduced. The countries with the highest illiteracy in sub-Saharan Africa, South Sudan, Niger, and the republic of Africa are in the bottom 5. Less than 37% of the population is literate (World Bank, 2022). Analysing those countries' levels of corruption, South Sudan is considered to be the most corrupt country in the world and Niger and the Republic of Africa score below 30 out of 100 (Transparency International, 2022). However, this is only an observation. No statically significant test has been conducted yet. Decreased levels of corruption in Sub-Saharan Africa due to increased education could increase funds for solar energy from international actors. If governments are more transparent and reliable, they are more likely to receive funding from international and private investors (Bishoge et al., 2020). In the report Economic Development in Africa, the problem of corruption as a barrier to legitimate legal identified (United Nations, 2020). Therefore, to receive UN funds, countries must meet specific conditions, and requirements will vary depending on the specific UN agency or program providing the funding, but in general, potential recipients must demonstrate a clear need for the funds, show how the funds will be used to achieve specific goals or objectives, and have a plan for sustainability and impact evaluation. This can only be achieved if the government is liable and transparent (United Nations 2020). Hence, increased education can decrease corruption. The less corruption, the higher the likelihood of receiving international or private funding. Therefore, promoting education can resolve the Political and Financial challenges outlined in Figure 4.

(III) LONG-RUN IMPROVEMENT IN THE SOLAR ENERGY SECTOR

The NGO's intervention directly attempts to train technicians to install and maintain solar energy sources. However, based on the conducted research, there are only two manufacturing sights in Sub-Saharan Africa. Auxano Solar is the first privately owned solar panel factory in Nigeria, and ARTsolar is the manufacturer in sub-Saharan Africa (Artadmin, 2020; Auxano Solar, 2020). Through increased education, thus improving human resources, Sub-Sahara's manufacturing Sector would further develop. With increased human capital Sub-Sahran Africa could produce its own solar-energy systems. Further research needs to be conducted for a smooth transition from an agriculture-based economy to a manufacturing sector. An opportunity this transition could entail is that the cost of solar energy systems would decrease. This is because importing solar energy systems from China, the US, and Canada is very expensive (World Bank, 2021). The purchasing power of Sub-Saharan currencies is quite low, resulting in high prices for imported goods. If Sub-saharan countries manufactured solar panels themselves, they would create jobs and reduce the cost of solar panels. The low cost of solar panels would make renewable energy accessible to lower-income areas (Bishoge et al., 2020).

This model explained the possible long-term benefits of NGOs' intervention through training programs to improve the decentralised solar energy installation in sub-Saharan Africa, focusing on rural areas. Benefits for institutions and for the energy sector itself have been highlighted.

The consequences of this intervention can, on a big scale, even lead to general economic improvements in Sub-Saharan Africa.

7. DISCUSSION

This research paper identified the challenges faced in developing solar energy systems in Sub-Saharan Africa. It was suggested that NGOs send skilled trainers to rural areas to instruct local communities on how to instal and maintain solar energy systems in order to address these challenges. Since different Sub-Saharan countries have different relationships with international actors, the nationality of the NGOs was not specified. It should be emphasised that the instructors should be solar energy specialists. More research is required to find the best trainers who can encourage long-term energy improvements in rural areas.

Due to the fact that many remote areas are not wired into larger energy grids, the paper focused on decentralised solar energy systems. The types of solar energy systems should be chosen on an individual basis according to local needs, prices, and supply of solar energy systems. The research paper excluded information regarding the kinds of solar energy systems that would be most suitable for nearby communities. Which decentralised energy systems function best in rural areas needs further study.

The scope of the study was limited, as it only proposed a solution to address the lack of energy in rural areas. To maximise the effectiveness and adaptability of solar energy systems, more research is required to conduct a study that asks local communities about their needs and preferences.

The assessment of the intervention is based on tracing and linking prior literature. Figure 5 guides the direction towards possible long-term benefits. It is only a hypothetical causal model. The causal relationship needs to be studied in more detail, and mediating and moderating variables must be identified to make the model more concrete and reliable. Furthermore, since this paper looks at Sub-Sahran Africa and not particular countries, the result of the model can not be used to predict country-specific outcomes.

The research question of this paper has been answered from a macro long-term perceptive. The general summary of the challenges in Sub-Sahran Africa provides the starting point for further research on a more meso and micro level.

8. CONCLUSION

The four challenges that prevent the installation of solar energy in sub-Saharan Africa are social challenges (education and utilisation), political challenges (corruption and accountability), technical challenges (infrastructure and human resources) and financial challenges (high risk and inconsistent). Based on those challenges, the research question focused on a recommended intervention that could solve the challenges that inhibit installing solar energy in Sub-Saharan Africa. (RQ: How can the challenges that inhibit the implementation of solar power in Sub-Saharan Africa be overcome?) Due to political instability and limited governmental interest in sustainability, a bottom-up approach focusing on NGOs was preferred. Introducing training programs in rural areas should enable locals and install and maintain decentralised solar energy systems. This intervention would have long-term benefits and address the challenges mentioned in figure 4. Figure 5 outlines long-term self-reinforcing loops that can solve the financial and political challenges. Having access to electricity leads to a higher quality of education (Adenle 2020). Lack of human recourse was identified as a barrier that inhibits the efficient installation of solar energy (Mohammed et al., 2013). With an educated labour force, this problem can be overcome. Similarly, the more educated people are, the more likely they are to engage in politics, calling for governmental accountability and transparency (Forson et al. 2016). Since corruption was a great hindrance to receiving finance, a long-term spillover effect of renewable electricity, thus education, is that the government is more transparent. This increased the likelihood to receive funding for further develop the renewable energy sector (Bishoge et al., 2020). Hence, an NGO that offers training programs about solar energy can, in the long run, solve the challenges that prevent the installation of solar energy in Sub-Saharan Africa.

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