

Comparative assessment of the challenges faced by the solar energy industry in Ethiopia before and during the COVID-19 pandemic.

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Abstract

The COVID-19 pandemic is having an unprecedented impact on social, economic, and political situations of all countries around the world with no sight to its end. Business sectors such as solar distributors, which have been instrumental in supporting the governments' ambitious universal electrification programs, have been negatively affected by the pandemic. The main aim of this paper is therefore to explore and conduct a comparative assessment before and during the COVID-19 pandemic of the key challenges of solar-based businesses in Ethiopia focusing on the distributors and installers and to provide policy recommendations. Qualitative and quantitative assessments were employed during this study. The results show that before the pandemic, finding a skilled workforce, gaining a technical knowledge of the technology, competing in the market, and lack of consumer awareness and initial investment were the key challenges. The importation of solar technologies has been halted by the arrival of the COVID-19 exacerbating existing challenges and threatening the very existence of the businesses. The impact of the pandemic on income levels of end-users of solar

technologies, together with the lack of sufficient supply of technologies to the businesses, most of the businesses are forced to lay off their employees deepening the unemployment rate and, in some cases, forcing businesses to be closed. These circumstances affect economic development and dents the progress made so far in facilitating energy access to remote communities. To protect these vulnerable but very essential small businesses, necessary interventions are recommended.

Key Words: COVID-19; Solar based businesses; Challenges; Interventions

1. INTRODUCTION

Ethiopia has a huge potential to become the hub for solar energy technologies market, considering its suitability for off-grid energy systems. More than 75% of the Ethiopian population lives in the countryside, creating major challenges to fulfill their power needs through the national grid. The dispersed nature of rural populations is one of the key reasons for policymakers to consider the use of off-grid energy systems such as mini-grid and solar home systems to achieve universal access in the country. The current energy access levels in Ethiopia stands at a 44%, where 33% of access is provided through grid connections and 11% through off-grid solutions (MoWIE, 2019). The average across sub-Saharan Africa stands at 43% (Blimpo & Cosgrove-Davies, 2019). To increase access and fulfill the country's demand, the Ethiopian government launched its National Electrification Program (NEP II) in 2019 laying out the country's ambition towards universal access by 2025 through a combination of grid-connected and off-grid energy systems (MoWIE, 2019). With the expected expansion plan, the centralized grid is expected to supply electricity to around 65% of the Ethiopian population and the rest 35% would be met by off-grid systems.

Meeting this access target would see a rapid boom of the solar energy market in Ethiopia, placing the country as the largest regional power market and also the largest PV market compared to countries in the region. Such expansion will play critical role in addressing social development and environmental challenges by reducing the use of traditional fuels such as fuel-wood for lighting consequently reducing deforestation in the country. Ethiopia has considerable solar resources (Drake & Mulugetta, 1996), and coupled with its rapidly growing economy (Seid et al., 2015), the country offers tremendous opportunities to solar PV suppliers worldwide. Encouraged by the government's directives and programmes such as the National Electrification Programme and extensive promotion through its regional and local agencies towards the expansion and utilization of off-grid energy systems, the region is witnessing an increased adoption of solar home systems directly influencing the establishment of solar-based businesses in the region, which is beginning to stimulate the renewable energy market.

The energy industry is considered as the backbone of a country's economic development and requires huge attention by policymakers to create a conducive environment to support the sector. An attractive and enabling business environment such as suitable policies and strategies, regulatory climate, and political leadership are key factors for the success of these businesses. Off-grid

businesses have significant co-benefits as they create good quality employment, contribute to local and national economic development and facilitate energy access to communities living beyond the grid system.

There are many reasons to be optimistic about Ethiopia's potential in off-grid market. Off-grid energy companies have made enormous progress by bringing power to nearly 470 million people according to the Global Off-Grid Lighting Association (GOGLA) (Network, 2020). In the African continent, nearly 60 million people are electrified by off-grid applications according to the International Renewable Energy Agency (IRENA) (IRENA, 2016). On the opportunities created for employment, solar PV based businesses are estimated to employ around 3.9% of the African workforce according to IRENA (IRENA, 2019). However, the sector has several barriers such as lack of resources, lack of knowledge of the technology, lack of clear climate policy, lack of qualified personnel, lack of knowledge and experience in marketing and communication according to a study by (Cagno et al., 2013; Dahlqvist & Söderholm, 2019; Di Foggia, 2016). A study in Malaysia also indicated that project financing and market failures are barriers for the sector (Vaka et al., 2020). Technology risks, policy and regulatory risks, market risks, investment barriers, and capacity constraints are also considered as the key challenges for the development of the renewable energy sector (Amin et al., 2014). COVID-19 is now exacerbating these challenges and has threatened the signs of progress made so far in facilitating energy access to these who are most in need by declining liquidity of the businesses and putting the jobs created at risk.

With the Ethiopian government's ambitious plans of universal access in 2025, the policymakers need to have comprehensive knowledge of the key challenges of the suppliers and installers of solar energy technologies in Ethiopia to develop evidence-based policy interventions. At present, there is a lack of such studies in the country, which is affecting the development of evidence-based strategies and policies to overcome the business's challenges and facilitate the diffusion of the technologies to the end-users. This paper endeavours to comprehensively examine and identify the key challenges of the distributors and installers of solar energy technologies in the region before and during the COVID-19 pandemic. It specifically seeks to explore the source of solar technologies, the market growth of the distributors and installers and related challenges, the current regulatory and political climate for solar-based businesses, incentives, etc. The results from this assessment would serve to make robust and informed policy recommendations.

2. METHODOLOGY

The methodology followed for this study involves a review of related literature and survey questionnaires from solar energy technology suppliers. This study was conducted in the Tigray regional state, located in the Northern part of Ethiopia. Excluding Mekelle town the state capital, there are six administrative zones: comprising a total of 53 districts and 814 sub-districts. According to the 2016/17 projection of the Central Statistics Agency (CSA), the state's population size was 5,247,005 with 73% of the population live in rural, while 27% live in the urban areas.

Both primary and secondary data were collected for this study. Primary data was collected through questionnaires and interviews of solar technology distributors and installers to assess the business environment before the COVID-19 pandemic. A structured questionnaire was employed to gather the necessary primary data from solar-based businesses. A total number of 27 questionnaires were collected from the last mile distributors and installers. The survey has covered all available suppliers and installers of solar energy technologies in the study area and therefore there was no need to use sampling techniques considering the small number of enterprises involved in this business. To understand the business environment of the solar based businesses during the COVID-19 pandemic, the study was conducted solely based on secondary data and observations. The secondary data was gathered through internet search from national and international research results and reports, government policy statements, and websites of international organizations.

3. SOURCES OF SOLAR ENERGY TECHNOLOGIES

The source of technologies has huge consequences both on the quality of the products if there is no strong quality control in the receiver country and the price of the technologies because of the supply chain charges to import the technologies. Considering these implications to the businesses, it was important to understand the source of solar technologies and according to the survey results, 68.6% of the respondents indicated that they import the technologies from China, with 21.6% of the respondents getting their technologies from the United States, 7.8% of them getting it from Germany and the remaining 2% of the respondents getting the solar technologies from India as shown in Figure 1.

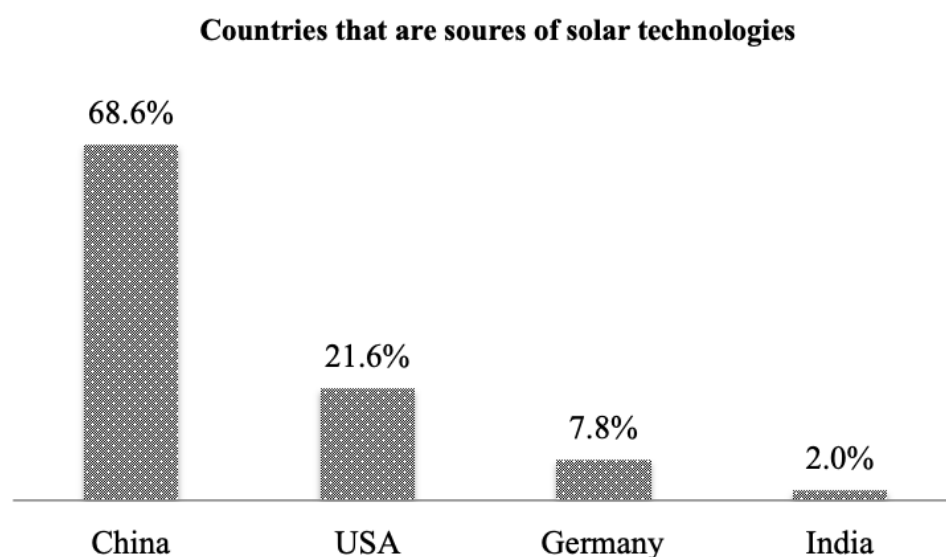


Figure 1: Sources of solar energy technologies to the region

4. MARKET GROWTH OF SOLAR ENERGY BUSINESSES

All the business surveyed indicated that the solar energy market is growing helping their businesses to grow. It is believed by 48.6% of the respondents that the main reason for the solar energy market growth is greater public awareness with increased customer buying capacity ranked as the second

reason by 21.4% of the respondents with the other reasons have a varying degree as shown in Figure 2. This is a clear indication that public awareness of the utilization of solar energy technologies is increasing and is an opportunity for businesses to exploit.

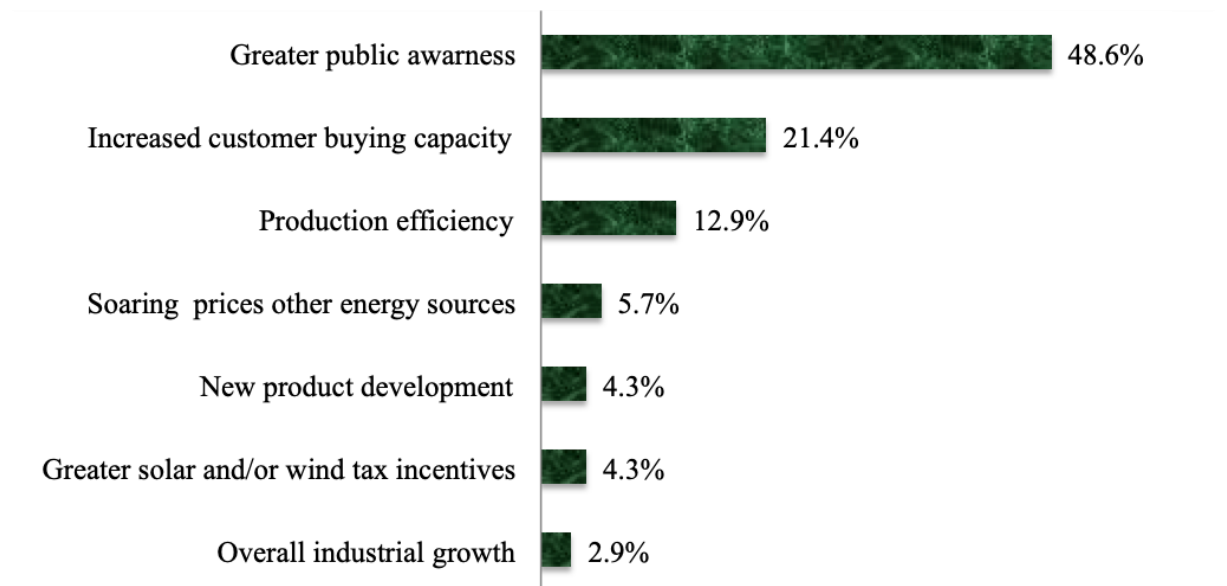


Figure 2: Key reasons for the growth of solar business

End-users' confidence in the utilization of solar technologies can be improved based on the type of after sales services provided by the enterprises. This was investigated in this study and the businesses were asked if they provide after sales services to their customers. More than 30% of the respondents indicated that they provide training on the installation process, maintenance, and care of the technology with 26.5% of the respondents providing spare parts but only 12% provide continuous maintenance as shown in Figure 3. During a separate engagement with the end-users, they indicate that a lack of continuous maintenance is considered as one of the key problems affecting the sustainability of solar power supply.

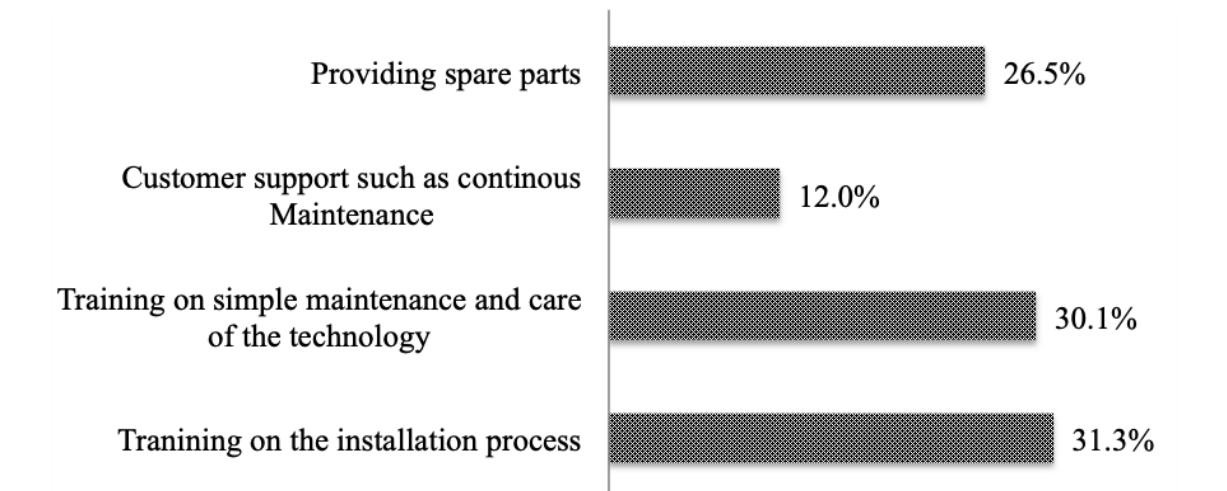


Figure 3: After sales services

5. CHALLENGES OF SOLAR BASED BUSINESSES AND MEASURES

INTRODUCED

Solar energy technology businesses are considered instrumental to realize the ambitious National Electrification Program (NEP II) of Ethiopia. Because of the increased availability of solar energy technologies combined with the huge market potential in Ethiopia, the solar energy businesses have been flourishing creating jobs and facilitating renewable energy access to the communities living beyond the grid systems. For example, in the Tigray region, nearly 2% of households have installed solar home systems and about 10.5% of the population have lanterns predominantly used for lighting. The main reason for this progress is the availability of solar energy technology-based businesses and the increased consumer awareness of the advantages of solar-based energy systems. The use of solar based energy systems is having significant co-benefits; on one hand improving the life standard of the rural communities and on the other hand reducing the utilization of traditional fuels minimizing deforestation and reducing the negative environmental impacts. It has been clear though that the businesses have had challenges before the pandemic and they are also experiencing huge challenges during the pandemic, which is threatening their existence. Detailed comparative assessments of these challenges before and during the pandemic are discussed in detail in the subsequent sections.

5.1. Challenges before COVID-19

A wide range of researches on the perceived challenges of solar-based businesses have been conducted considering that it is the fast-growing business and government's ambition to fulfill the needs of communities particularly in the rural setting. A research by (Ambepitiya, 2015; Hafner et al., 2019) indicated that lack of consumer awareness has been a barrier for the businesses growth. However, the survey result from this study showed that a lack of awareness of using solar energy is considered as the key challenge by only 1.5% of the respondents. This is a clear indication that communities/end-users currently have a reasonable awareness of the perceived advantages of having electricity at their homes through off-grid energy systems from clean energy technologies. In the remaining part of this section, some of the key challenges that solar businesses face are discussed.

5.1.1. Finance

High initial investment: Nearly 7.4% of the respondents consider getting initial investment as the main challenge, which is contrary to several research findings. For example, Initial investment is considered as one of the key barriers to the sector's growth according to a study by (Hafner et al., 2019; Horváth & Szabó, 2018). There could be justifiable reasons for this contradiction. Since the survey was focused on the established businesses, the owners may have sufficient fund to start with and consider initial investment not one of their challenges but the findings could have been different had the survey conducted on the general public as people interested to enter to the energy business commonly struggle to secure initial investment, which has been the case based on the findings of several types of research (Hafner et al., 2019; Horváth & Szabó, 2018).

5.1.2. Governance and regulation

Business environment: The business environment has a huge impact on businesses as it either enhances or retards investment. Unfortunately, the business environment of Ethiopia lacks behind many peer countries and is deteriorating from time to time according to the World Bank annual report. For example, Ethiopia is ranked 176th out of 190 countries in protecting minority investors and 167th in trading across borders. According to the Logistics Performance Index (LPI), Ethiopia lags behind peers like Kenya and Rwanda in the logistics infrastructure. Clearing customs may take nearly 44 days driving costs of products and all documentation shall be done in person, as there is no legal framework to approve documents electronically (Geiger, 2015). It is also reported by private sector actors that there is a lack of staff with sufficient experience in customs procedures, and those who officiate have limited mandate for decision making. The tax administration of the region is also costly and time-consuming. On average, firms make 30 payments per year and spend 306 hours per year filing, preparing, and paying taxes (Geiger, 2015) .

Access to foreign currency: Finding foreign currency is however considered a huge challenge by the established businesses, as they are mainly dependent on imported solar energy technologies. For example, delays in accessing foreign exchange have been reported as increasingly critical problems faced by the manufacturing firms. At times of declining foreign exchange reserves, banks rationed foreign exchange, limited to imports of basic commodities such as medicine and petroleum. Waiting time for foreign exchange authorization creates long and uncertain delays. To make matters worse, the businesses complain that they do not often get a sufficient amount of foreign exchange even after the long wait and delay making their planning uncertain.

5.1.3. Marketing and price fluctuations

Marketing issues: Competing in the market is considered as the third key barrier by 25% of the respondents as shown in Figure 4. For small businesses, competing in the market is a key challenge because of the lack of effective and fair market access compared with large businesses. Large businesses have all the tools and financial resources to promote their products and creating an unfair environment affecting small businesses to equally compete in the market. Limited experience in networking and lack of technical knowledge for searching, organizing, processing, and using information related to product marketing is considered as the key barrier of the last mile distributors and installers affecting their competition in the business.

Price fluctuation of imported technologies: Price fluctuations of the imported technologies that occur either due to currency fluctuations within the country or price fluctuations at the technology source countries are also considered a huge challenge as it is a key parameter for the sustainable existence of the businesses. Such price variation can significantly influence the operational capacity, growth, and sustainability of the businesses. The discussions with the distributors and suppliers also revealed that the poor supply chain of the region is also directly affecting the timely arrival of the products to the end-users

5.1.4. Human power

Skilled human resources: Finding or training the workforce is considered as the key challenge by nearly 36.8% of the respondents, which is in line with the findings by (Da Silva, 2015). In the developing world, finding a well trained and technical workforce is frequently raised by different sectors and the main reasons are because of the low quality of educational institutions coupled with the unmatched educational resources and enrolment of students at these institutions.

Technical knowledge of the technologies: Gaining technical knowledge of the technology is considered as the second key barrier by 29.4% of the respondents as shown in Figure 4. The lack of knowledge on the technologies has a propagating impact in developing the businesses as some of them are unable to fulfil the needs of the customers in terms of after sales services.

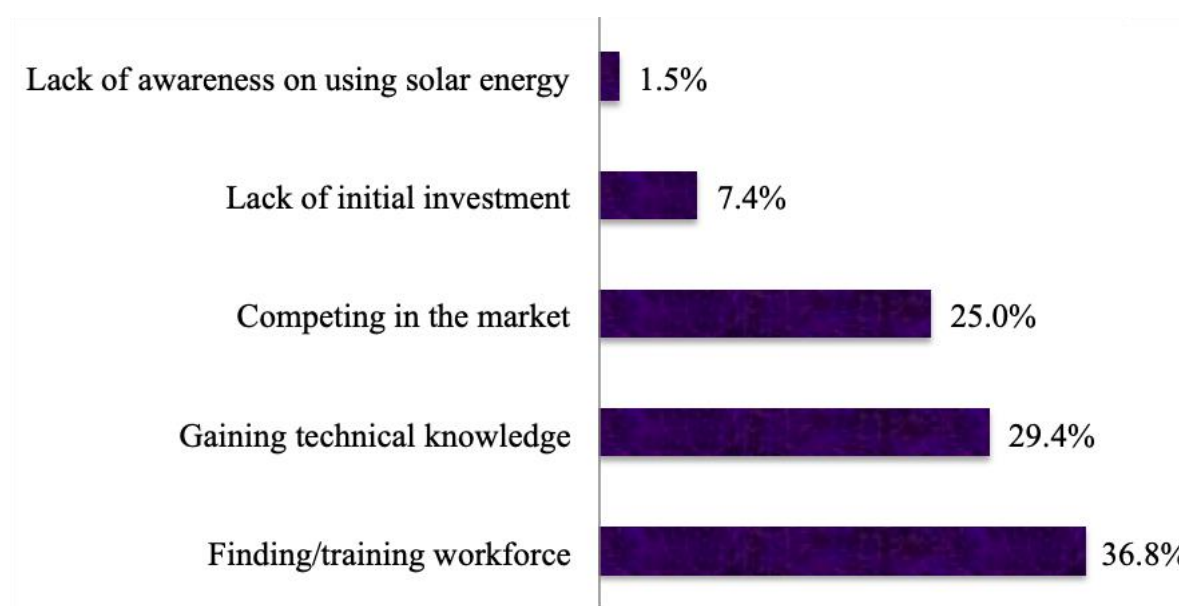


Figure 4: Key barriers of the solar energy based businesses

5.2. Challenges during COVID-19

The first COVID-19 case was recorded in China in December 2019, with the virus quickly spread to the rest of the world. The first recorded COVID-19 case in Africa was in February 2020 in Egypt with Algeria and Nigeria followed to report their first cases in the same month (Akrofi & Antwi, 2020). In Ethiopia, the first case was reported in March 2020 and spread steadily over the following months. To stem the spread of COVID-19, several countries started putting different measures such as travel restrictions including the closure of borders, closure of risky areas such as services and physical distancing and furthermore damaging measures were taken such as lockdowns to contain and stop community transmission of the virus. Though such travel restrictions and temporary closure of industries reduced CO₂ emissions and pollution (Chen et al., 2020), it has brought disruptions to the worldwide supply chain of solar energy technologies and other commodities. With Ethiopia being dependent on imports of the technologies from China, USA, and Germany (See Figure 1), importing of these technologies were essentially halted as these countries were dealing with the outbreak when the pandemic started and continue rising on their respective countries with the main source of COVID-19 being China itself. Since most of the manufacturers in China were closed, the deployment

of renewable energy technologies is essentially halted in Ethiopia and other similar countries such as in Pakistan that are dependent on imports (Aslam et al., 2020).

As the pandemic spreads, the federal and local governments in Ethiopia introduced restrictions on the movement of people and goods at national and local levels. These restrictions meant that all economic activities were closed and there was no exception for the solar energy technology distributors and installers. The key market base of the distributors and installers are the rural communities and the travel restrictions between the rural and urban areas meant that the market is essentially closed. The community's ability to buy solar technology also depends on the generation of income by selling their agricultural products. The restrictions on the movement of people have a double impact leading to the reduction of the community income and affecting their purchasing power consequently halting the purchase of solar technologies from the distributors. This has caused the reduction of customer liquidity for the distributors and installers because of the decrease in sales making it difficult to maintain their businesses.

Recent studies in several countries of the world also highlighted similar impact of the pandemic on several business sectors. According to Havenhill Synergy, a clean-tech utility company in Nigeria, obtaining equipment and access to project sites is becoming a key challenge of the off-grid energy businesses affecting the completion of several renewable energy projects (Synergy, 2020). The closure of factories in China during the first quarter of 2020 resulted in 6.8% decline of gross domestic product compared to the previous year where the corporate performance of the energy industry has been badly affected by the pandemic (Fu & Shen, 2020). A policy brief by (Wigand et al., 2020), showed the high risks of the COVID-19 pandemic in delaying renewable energy procurement, projects, auctions, and higher renewable energy financing risks affecting the ambitions of several countries such as the European Union members states in achieving their 2020 renewable energy targets. A study in the United States also indicated that the pandemic has created delays in the supply chain, difficulties in tax stock markets, and the delay of government incentives (Birol, 2020).

The progress made on employment by solar energy businesses has also been heavily affected. A survey conducted on workers in the solar industry showed that more than 55% of the respondents said that they are either laid off from their work or suffer cutbacks (SEIA, 2020). In the same survey, delays in construction, supply chain, equipment, permission, and customer acquisition are the major problems faced by the solar industry due to the pandemic. A study by (IEEFA, 2020), projected that the pandemic is likely to slow solar PV installations.

5.3. Measures introduced to overcome the challenges

The government has been very slow in taking actions to solve the challenges for different reasons that stems from weak governance. The businesses were also not implementing any solutions but operate in the form of business as usual, which is understood as most of the challenges are related to the unfriendly businesses environment caused by the government's administration systems and financial institutions. During the COVID-19 pandemic, there was no different action taken by the

businesses to overcome the challenges in order to continue and sustain their operation leading to closure of some of the businesses.

However, during the COVID-19 pandemic some regional governments such as the Tigray regional state has introduced bills forbidding any households to either evict renters or increase both residence and business rents with recommendations for renters to cease receiving rents for two weeks of the peak emergency time, which was a huge relief for all businesses. These injunctions of regional laws were critical to avoid eviction of the solar business from their rented shops and helped some of the businesses to continue their operation. However, such policy interventions were limited to this region and should be scaled up to other regions of the country and beyond during such a crisis.

6. RECOMMENDED POLICY INTERVENTIONS

The challenges faced by the solar-based businesses discussed are very troubling for Ethiopia and the African continent at large in the sense that there are no clear interventions in place to revert the damage because of very weak and/or no sufficient supporting institutions and lack of strong preparedness for such crisis. The lack of sufficient support and lack of preparedness is a combination of several factors such as weak economic development, lack of clear policies and regulatory frameworks to safeguard small businesses, political instabilities, and bad governance, corruption, etc. The arrival of the COVID-19 pandemic has created an opportunity for the challenges of the businesses to be heard by the policymakers, which was even not possible for some of these challenges to be recognized before the crisis. As per the suggestions by (Steffen et al., 2020), developing new policies and approaches is important to withstand any similar shocks in the future. A study by (Kuzemko et al., 2020) also indicated that the emergency response provided by different governments and entities have the potential to enforce sustainable energy transitions. In light of these circumstances, short and long term policy interventions are recommended to support the solar-based businesses so that the progress made so far towards universal energy access could be sustained and support in facilitating sustainable energy transitions.

6.1. Short term interventions

Short term interventions are very important to solve the liquidity problems of the businesses shortly while working towards sustainable solutions to maintain their business. Because of the shortage of liquidity, payment of utility bills, rents, VAT are becoming critical during the COVID-19 pandemic. Considering that the current energy sector, telecom, and water systems in Ethiopia are controlled and supplied by the government, it will be easier to enact short term policies and cancel any utility-based payments such as electricity bills, water bills, and telephone payments. Such initiatives have the potential to minimize shortage of liquidity and sustain the businesses by providing short relief to have more financial flows instead of paying what they have for the bills. This is one of the key policy interventions that the government should implement as it is one of the easiest methods because the government doesn't need to negotiate with third parties such as the conditions in other countries where such utilities are privatized.

Most businesses commonly pay their income tax at the end of the physical year and the income Tax is estimated based on their business and income level. There is a huge opportunity for manoeuvre of reducing their Income Tax payments with a simple directive for the administrators, which can be enacted in a short period without the need to get approval from lawmakers. For those that pay their income Tax monthly with a registered machine, implementation of such policy may have a limited positive impact on the businesses but it can be implemented on a monthly basis. The government of Malaysia supported affected businesses by providing Tax breaks (Vaka et al., 2020), which is a sign that similar supports are being implemented in different parts of the world and could be effective to resolve the short term liquidity problems of the businesses.

These short term supports have the potential to avoid closure of solar-based businesses and can be used as a transition for more sustainable solutions. Some of these short term interventions are also being implemented in several African countries as indicated in a review study by (Akrofi & Antwi, 2020).

6.2. Long term interventions

Short term interventions alone are not sufficient to reverse the unprecedented damages created by the pandemic on these businesses and thus long term strategic interventions are paramount to sustain the businesses in order to support facilitating the universal energy access plan developed by the Ethiopian government. Therefore, the following long term policy interventions are recommended to guide policymakers and other stakeholders to at least minimize the impacts of the COVID-19 pandemic and other related challenges that have been identified in this research that were being faced by the businesses even before the pandemic.

Organizing the solar-based businesses in a purchasing group entity could provide them several advantages such as obtaining higher liquidity, profitability, getting more power for negotiating with different stakeholders, and allows them to better manage their stocks with suppliers. According to (Zimon et al., 2020), it is proved that purchasing groups are better off with these advantages compared to companies operating independently. Though it is clear that organizing all the solar-based businesses in such entity requires better management and experience, several organizations such as the chambers of commerce and government offices responsible for the development of small business must start exercising such effective interventions to develop resilient businesses to overcome any potential shocks such as the COVID-19 pandemic.

Access to finance is also another critical challenge of the solar businesses and though there is progress in developing financial models focused on the small and medium scale manufacturing sector (Gebremichael et al., 2020), there is a lack of focus on the last mile solar distributors and installers, which should be changed considering their potential to alleviate the lack of energy access, which is core for supporting the development and modernization of other sectors. As the dependence on imported technology will continue until the region makes a huge effort to change it, making effort to solve the lack and delay of obtaining foreign currency should be equally given attention by the policymakers. The current practice of federally centralized service can be easily decentralized to the

regions, which could have a huge positive impact on timely follow up by the businesses consequently reducing the time and cost spent to get foreign exchange at the federal level.

As the supply chain of technologies that are imported was heavily affected by the pandemic, Ethiopia and other developing countries should focus more on developing and manufacturing technologies locally to reduce the challenges related to international supply chains. This can be achieved by implementing effective tools to advance the existing manufacturing companies and attract foreign companies to the region, which could include grants and Tax reductions for investment in R&D, performance-based financial award, financial subsidies, reduction of income tax, making serviced land available for investors focusing on the development of renewable energy technologies, etc. as recommended by (Gebreslassie, 2020)

Conclusion

This study has focused on a comparative assessment of the challenges faced by solar-based businesses in Ethiopia before and during the COVID-19 pandemic. The study was initiated before the pandemic to understand the key bottlenecks for the solar-based businesses in the Tigray regional state but the arrival of the COVID-19 pandemic during the study changed the dynamics. For this reason, the assessment was expanded to include the challenges during the pandemic and recommended key policy interventions to overcome the challenges. Both qualitative and quantitative assessment through literature reviews, questionnaires, observations and interviews were employed during this study. The results of this research show that before the pandemic, finding a skilled workforce, gaining a technical knowledge of the technology, competing in the market, and initial investment were considered as the key challenges. The solar-based businesses were very much dependent on imports of the solar technologies for their businesses but with the arrival of the COVID-19 pandemic, the supply chain of goods particularly the importation of solar technologies, which are the core commodities of the businesses, is essentially halted taking their existing challenges to the highest level threatening the very existence of the businesses. With the impact of the pandemic on the income levels of end-users of solar technologies together with the lack of sufficient supply of technologies to the businesses, most of the businesses are forced to lay off their employees exacerbating the unemployment rate and, in some cases, forcing businesses to be closed. These circumstances not only affect the economic development of the country but also dents the progress made so far in facilitating energy access in the communities that are most in need. This shows that the COVID-19 pandemic is creating unprecedented consequences on social, economic, and political situations of all countries around the world with no sight to its end. The impact of the pandemic is being worse when it comes to developing countries like Ethiopia where the robustness of their infrastructure, technological advancement, public services, business environment, the supply chain of goods, transport, and other socio-economic development is weak and ineffective. Several business sectors such as solar distributors, which have been instrumental in supporting the government's ambitious universal electrification programme by facilitating energy access to remote communities are being badly affected by the pandemic.

To protect these vulnerable but very instrumental small businesses, necessary short and long term interventions are recommended in this paper that should be enacted by all stakeholders in the country and beyond. The crucial short term policy interventions that can be implemented by the government are canceling of utility payments and relief or reduction of income Tax. For the solar business to develop long term resilience, policy interventions such as organizing the solar-based businesses in a purchasing group entity, developing specific credit models, improving the procedures to obtain foreign currency, promoting localization of solar energy technologies through grants and Tax reductions for investment in R&D, performance-based financial award, financial subsidies, reduction of income tax, making serviced land available for investors focusing on the development of renewable energy technologies can be implemented. Such policy interventions can play an important role in supporting the international efforts of fighting the negative environmental impacts by shifting from the utilization of pollution prone energy resources to more sustainable, clean and renewable energy resources.

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Declaration of Interest

The author declare that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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