Exploring the adoption rationales and effects of off-grid renewable energy access for African youth: A case study from Tanzania

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DECLARATION

I know the meaning of plagiarism as set out by the standards established by University of Cape Town for dissertations and declare that all the work in this document is my own and aspects drawn from other authors are properly acknowledged using the UCT/Harvard referencing format.

Abstract

In addition to being one of the poorest countries in Africa, Tanzania is considered the 13th most vulnerable nation in the world to climate change and climate variability. Currently over 63% of Tanzanians have no access to the national power grid. Instead they rely on biomass and kerosene lamps to provide energy in their homes. In addition, rural youth in Tanzania have limited occupational pursuits other than subsistence farming (both formal and informal). Utilizing a case study approach, this research qualitatively explores the effects of energy access in the form of solar PV for those seeking to secure this public good at a household-level. Face-to-face interviews conducted in the coastal region of Tanzania concentrated on understanding rationales for adopting off-grid energy (adoption rationales), particularly respondent's 'Awareness', 'Motivation' and selected 'Pathways' (the AMP Framework). High rates of rural poverty highlight systemic lack of energy access in Tanzania. In contrast, livelihood transformations through solar PV were observed in the case to couple with energy access. Indicators of improvement in living standards were observed to have cascading influence on other adopters which, in turn, encouraged further uptake. This innovative adoption lead to decreased pressure on the surrounding ecosystems, but environmental factors did not influence initial adoption rationales. Reflecting on the findings, the author develops a framework for better understanding of the role private actors take in transitions from to off-grid energy access in Africa. Reflecting on the case observations, particularly how respondents sought shape the flow of events independent, and sometimes in spite of, the State, the framework extends current understandings of nodes of change in rural communities and provides a more extensive exploration of behavioural theories (the AMP Framework and Diffusion Theory). Novel connections are made conceptually with emerging nodes of change and decision-making theories of change to provide fresh extension of these approaches to understanding poverty arrangements in Africa and what researchers and decision makers might need to consider for targeted interventions towards universal energy access on the continent. The thesis concludes with a range of principles for energy access in Africa distilled from the observations and framework developed. They include environmental principles of sustainable resource management and socio-ecological balance, social principles of equality and participation, and economic principles of access and stability.

Table of Contents

1 Introduction ***6***
1.1 Background and Rationale 6
1.2 Aim and Objectives 6
1.3 Structure and Dissertation 7

2 Literature Review ***9***
2.1 Introduction 9
2.2 Energy and Poverty in Africa 9
2.2.1 Energy Access: Drivers and Barriers to Rural Electrification in Tanzania 9
2.2.2 Unemployment and multiple dimensions of poverty facing Tanzanian youth 12
2.2.3 Entrepreneurial Challenges 15
2.2.4 Poverty and Dependence on Ecosystem Services 16
2.2.5 Renewable Energy and Entrepreneurship 17
2.2.6 Extending understandings of Energy Access 17
2.2.7 AMP: Awareness, Motivation and Pathways 18
2.2.8 Diffusion Theory 19
2.3 Conclusion 20

3 Methodology ***21***
3.1 Research Approach 21
3.2 Rationale for Case Study Selection 22
3.3 Case Study: Sepon LTD and the 'Solar as Capital' initiative 23
3.4 Sampling and Field Work 25
3.5 Analysis and Data Storage 27
3.6 Structuring case observations: Awareness, Motivation and Pathways 27
3.7 Methods conclusion 29

4 Results ***30***
4.1 Introduction 30
4.2 Sepon and the SAC Model 30
4.3 Sepon Beneficiaries: Preliminary Case Study Introduction 32
4.4 Effects of Solar as Capital on beneficiaries' livelihoods 34
4.5 Awareness 36
4.6 Motivation – Business 38
4.7 Pathways 40
4.8 Advice from respondents to solar energy stakeholders and policy makers 43
4.9 Sepon SAC Intended Livelihood Outcomes 44
4.10 Conclusion 47

5 Discussion ***48***
5.1 Introduction 48
5.2 Analytical Framework 49
5.3 Awareness 50
5.4 Motivation 55
5.5 Pathways 59
5.6 Adaptation and Mitigation Co-Benefits 61
5.7 Design principles for inclusive off-grid energy access 63
5.8 Discussion Conclusion 64

6 Conclusion ***66***

7 References ***69***

8 Appendices ***75***

List of Figures

Figure 1: Geographic distribution of Solar as Capital (SAC) beneficiaries…….. pg. 26.
Figure 2: Example of technology used by SAC beneficiaries…… pg. 33.
Figure 3: Example of technology used by SAC beneficiaries…… pg. 34.
Figure 4: Analytical framework for securing energy access……. pg. 49.

List of Tables

Table 1: Potential Solar As Capital (SAC) Packages …… pg. 24.
Table 2: Multidimensional Poverty Index and observed SAC benefits …… pg. 35.
Table 3: Sepon's eight aspirant outcomes and SAC beneficiary response …… pg. 45.

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1 Introduction

1.1 Background and Rationale

There are a range of potential avenues that nations like Tanzania can take to engage in a meaningful transition towards a more climate resilient development pathway (Fankhauser & McDermott, 2016) while realising broader developmental goals. A "business as usual approach" is fraught with negative environmental externalities, increased exposure to the impacts of climate change and variability, and would likely entrench existing inequality and inequities (Lusambo, 2016, Sarakikya et al., 2016). State capacity is low in Tanzania with poor service delivery of key public goods such as electricity, health, education and water (Pueyo, Carreras & Ngoo, 2020, Simpson, Shearing, Dupont, 2020). Further, there is a lack of understanding of the role the private sector can play in Tanzania's developmental trajectory, or in the country's energy sector in particular (AFDB, 2015). There is no clear roadmap identifying how private actors might contribute towards a low-carbon and climate resilient future for Africa. Private sector innovations, such as the case study examined here and others emerging globally (for example, Harrington et al. 2020), provide valuable examples of how such transformative measures can be implemented. This case study is therefore an important study in recognizing the gaps in rural energy access and how private sector innovations can make a difference in communities and individuals seeking to achieve alternative energy solutions for their livelihoods.

This research set out to explore individual's rationales for adopting off-grid energy (adoption rationales) and personal effects of access to household-level renewable energy for youth (ages 18-35) in Tanzania in eastern Africa. This case study explored the relationship between a locally owned and operated business and rural youth who engaged in a micro-capital investment program that the business established known as Solar as Capital (SAC). The researcher was able to engage these young entrepreneurs through field visits and interviews in the coastal region of Eastern Tanzania and examine how off-grid energy systems impacted multiple dimensions of the lives of respondents and their rural communities.

1.2 Aim and Objectives

By using structured interviews with the SAC beneficiaries, the research was able to examine in depth the relationship between energy access and socioeconomic poverty along with the various

intertwined links and interactions that these two elements play in the transformation of rural communities. The study focused on rural areas as impact on livelihoods from enhanced access to energy is more pronounced in these settings than in urban settings where energy access is more widespread. The research set out to:

Explore alternative energy options that are available to youth in Tanzania that provide both individual and socio-economic benefits.

It reviews emerging literatures on poverty, unemployment and energy access in eastern Africa and, innovative frameworks and theoretical models exploring the provision of key public goods where private actors are supplementing State inefficacy.

Through a case study approach, the research investigates how private actors (SEPON/CAN) are targeting the dual challenges of energy access and unemployment and how these two initiatives impact the lives of early adopters.

The method concentrates on rationales that inspired the participants of this case study to adopt and continue to utilize off-grid technology. The research incorporates and extends the Awareness, Motivation, and Pathways (AMP) Framework and Diffusion Theory through reflection on case observations.

Finally, the research explores what principles can be distilled from the case study which might inform how nodes of change occurred for these case study individuals, both personally and in the community around them.

1.3 Structure and Dissertation

This dissertation is structured into five main sections. Following the introduction, Section 2 provides a literature review that outlines the current status and most recent findings regarding energy access in Tanzania. It highlights the environmental and governance context of energy together with various challenges and benefits to youth in Tanzania in pursuit of entry into the economy. Section 3 presents the methodology used in capturing and structuring the data contained within this dissertation and outlines the approach to analysis of data. It also highlights the steps that were taken to carry out the data collection as well as protect and secure the identities of the individuals who participated in the case study. Section 4 presents the results of this thesis. It highlights the information that was gathered during the case study in various rural and urban

locations in Eastern Tanzania. Section 5 presents the discussion chapter of the thesis. It highlights the key points and narratives that were presented in the results section and examines the findings in relation to the literature and theoretical frameworks presented in Section 2. The dissertation concludes with a brief breakdown of the key findings which highlight the significance of the study as well as its relevance to future research that may be carried out using this research as a foundation for further exploration.

2 Literature Review

2.1 Introduction

This section presents an overview of energy in Africa and situates the challenge of universal energy access within the wider context of climate change mitigation and adaptation. Against this backdrop, recent approaches to overcoming energy access that have seen varied degrees of adoption success are highlighted. Barriers and enablers to energy access identified in the literature are highlighted considering a range of the identifiable contextual challenges from the selected Tanzanian case study. A range of emerging theoretical frameworks and governance notions are then identified, and their relevance highlighted in order to situate current energy access innovations within broader advancement of our understanding of complementary and requisite governance arrangements. These frameworks include firstly, the AMP model (Petersen, Shearing & Nel, 2015) which seeks to explore the imperatives of Awareness, Motivation and Pathways in pro-environmental decision making. Secondly, drawing on recent scholarship which aims to understand how and why people secure essential public goods at a household-level, the notion of 'nodal governance' is presented (Drahos, Shearing & Burris, 2005) and (Simpson, Shearing & Dupont, 2020) . Finally, Rogers (2010) notion of 'diffusion' is presented as a way to conceptualise how areas of energy access influence other decision makers adoption. These three theoretical conceptualisations are presented separately in this Literature Review but integrated in the discussion to provide a novel consilience between them and potentially advance what their consilience affords for our understanding of energy access in Africa. Focusing on recent developments in the field for off-grid energy access in Tanzania, the review begins with an introduction to the developmental context wherein the field work took place.

2.2 Energy and Poverty in Africa

2.2.1 Energy Access: Drivers and Barriers to Rural Electrification in Tanzania

While energy access is just one aspect of the multiple dimensions of poverty faced in Tanzania, energy access holds the potential to instrumentally influence many other dimensions in a positive direction. Tanzania has an abundance of renewable energy sources, ranging from biomass, solar, wind, geothermal and hydropower. Unfortunately, the majority of these resources have not been harnessed by the national government or individuals and are often underutilized (AFDB, 2015).

The African Development Bank (AFDB) states that there is expected to be an increase in energy demand throughout Tanzania where currently only 36% of people are connected to the main electrical grid (AFDB, 2015). Capacity will need to increase at a rapid rate in order to achieve the current target of seventy-five percent connectivity by 2035 (AFDB, 2015).

According to the OCED (2013), Tanzania needs to focus on improvements to the national investment structure in order to attract businesses and Foreign Direct Investment (FDI) into the country. These challenges are also felt in the energy sector where the private sector is often deterred by a range of challenges, inter alia, the dominance of state-owned infrastructure (specifically in the energy sector) (OCED, 2013:22). The incapacity of the State to provide the essential public good of energy to a growing population base will likely continue to prove challenging for decades to come. It is crucial going forward to explore the complementarity, viability and scope of role players that hold potential to address the lack of energy access facing key segments of the Tanzanian population (OCED, 2013) to potentially include private and decentralized entities.

Sub-Saharan Africa has significant renewable energy resources, yet these are often not utilized (Mohammed, Mustafa & Bashir, 2013). This lack of utilization is often due to inadequate technology and incomplete infrastructure that would encourage renewable energy retention rates throughout the region (Mohammed, Mustafa & Bashir, 2013). Due to a multitude of contextual challenges, such as limited financing options and complicated business environments (as demonstrated in Tanzania), scholars have recognized that, although desirable, fossil fuel will not be immediately replaced with off-grid energy alternatives (Mohammed, Mustafa & Bashir, 2013:462). Examples of this abound and can be seen in the limited acceptance of energy efficient stoves in areas where they have been introduced (Mohammed, Mustafa & Bashir, 2013). Barriers to acceptance have been identified to include lack of awareness, market weakness, inadequate financial resources, and challenging technological aspects (Mohammed, Mustafa & Bashir, 2013). With specific relevance to the adoption arrangements of the selected case study, Nieuwenhout et al. (2001) list nine conclusions drawn from their research on solar home systems in developing countries, namely:

(1) Limited understanding of the home performance of rural solar systems and lack of recording system failures.
(2) Lack of infrastructure is a hindrance to the adoption of renewables by entrepreneurs in rural areas.

(3) Subsidy policies need to focus on distribution and promoting widespread product awareness.
(4) Often there are limited options available to the consumer in terms of system choice.
(5) Government involvement usual has a detrimental outcome when it interferes in the similar market segments as the private sector by heavily subsidizing products.
(6) It is important that there are is monitoring and evaluation of pay for service schemes as often data collection around return of investments are not captured fully.
(7) Credit provision is essential for product adoption within developing nations. By facilitating access to financing the consumer is able to choose the ideal system and individual components.
(8) Failure of components is widespread with batteries tending to be the most common problem.
(9) Many developing nations tend to struggle with market transparency.

Evidence of the nine conclusions are visible throughout a wide range of literature on the subject (Ahlborg & Hammar, 2014, Guta, 2018, Njoh et al., 2019, Ondraczek, Janosch, 2013). They therefore provide an entry point and potential baseline with which observations in the field can be considered. The case study to be described in the following section will highlight in varying degrees the importance of all nine of these aspects.

World Bank funded energy projects usually have successful adoption rates of around sixty-eight percent globally, within East Africa this success rate falls to under thirty-seven percent (Barry, Steyn & Brent, 2011). Low adoption rates may occur because, "factors that need to be taken into account during the selection of a renewable energy technology in Africa have not been investigated in depth" (Barry, Steyn & Brent, 2011:2845). Over forty-eight percent of small business owners within the region state that lack of financial accessibility is the largest impediment to their business becoming a success (Fjose, Grünfeld & Green, 2010). In their review, Barry, Steyn & Brent (2011) identified simplicity of maintenance, governmental initiatives, technological awareness, and properly supporting a local individual to manage project leadership after implementation are critical success factors for the assimilation of renewable energy technology. Due to the fact that most individuals suffering from lack of energy access are in rural areas, more effort is required to encourage local economic growth opportunities in such locations (Mohammed, Mustafa & Bashir, 2013). It is also important to note that every society has distinctive norms and practices that should to be considered and the end goal should be the establishment of locally championed energy innovation at local scale (Mohammed, Mustafa & Bashir, 2013).

Having access to a stable energy source has been proven to both improve livelihoods and bolster economic growth (Alloisio et al., 2017, Gray et al., 2019, Rao & Pachauri, 2017, Bamati & Raoofi, 2020). Unfortunately, renewable energy adoption by both public and private adopters in Tanzania

has been slow (AFDB, 2015). There are traditionally various political and developmental drivers that impact rural electrification rates in the developing world (Ahlborg & Hammar, 2014). In Tanzania, as in other Africa countries, this process has been observed to usually involve off-grid solutions being promoted by external international stakeholders that support continued green energy adoption within the power sector. Usually this process leads to national governments or utilities responding only with policy or legislative measures (Ahlborg & Hammar, 2014). Unfortunately, this sort of process only aids in fostering donor dependency and having ambiguous effects in long term rural energy transformation (Ahlborg & Hammar, 2014). While both external international stakeholders and the national government often advocate for, or declare they will provide, financial incentives to individuals for pursuing off-grid solutions, they tend to provide limited support in skills development at the local level (Ahlborg & Hammar, 2014). In order to foster adoption of renewable energy scholars have argued for greater encouragement of "bottom-up initiatives to complement the top-down implementation" (Ahlborg & Hammar, 2014:123). The ultimate goal being to bolster the growth of entrepreneurial ability in rural society and promote economic value chains throughout Tanzania and of Sub-Saharan Africa (Ahlborg & Hammar, 2014).

2.2.2 Unemployment and multiple dimensions of poverty facing Tanzanian youth

Although they are related, energy access and socioeconomic poverty are two distinct things. Energy access is distinct from socioeconomic poverty, and is a driving or compounding factor in cycles of socioeconomic poverty. Tanzania, the region in question, experiences high rates of both. An increasingly useful way of understanding socio-economic poverty has been afforded by the Multidimensional Poverty Index (MPI), described as "a measure of acute poverty, understood as a person's inability to meet minimum international standards in indicators related to the Millennium Development Goals and to core functioning's" (Alkire & Santos, 2014:251). One dimension of the 'Standard of Living' criteria of the MPI is energy access, which makes up one eighteenth of the weighted composite index of poverty. The proxy indicator used for energy access is connection to the electricity grid. A report by the Oxford Poverty and Human Development Initiative found that around 62.7% of Tanzanians were not connected to the main grid and thus fell into the category of energy deprivation (OPHI, 2010). In terms of overall MPI in Tanzania, a recent report by the United Nations Development Programme states that 55% of Tanzanians fall under

the MPI thresholds and approximately 49% of the population live on less the US$1.90 per day which places them below the income poverty line (UNDP, 2019). Lack of energy access has therefore been understood to be one dimension of poverty, distinct from socioeconomic poverty.

A study conducted in rural Nicaragua found two interconnected links preventing socioeconomic poverty alleviation: (1) lack of access to energy and, (2) environmental shocks due to ongoing climate change (Casillas & Kammen, 2010). The authors state that improved access to electricity increases both economic and educational opportunities for energy-impoverished people, with a disproportionate effect upon children, women, and minorities (Casillas & Kammen, 2010). They found that, "electricity catalyses rural economic activity and increases the quality of services available to meet basic business and domestic needs through improved lighting, labour-saving devices, and access to information through TV, radio, and cellular telephones" (Casillas & Kammen, 2010:1181). This link between economic development and energy access was also observed by González-Eguino (2015). An example of this can be seen in China where over the course of four decades energy access and consumption rose by a factor of 20. (González-Eguino, 2015). The author states that, "in some African countries where there has been little or no economic progress energy consumption has hardly increased at all" (González-Eguino, 2015:379) However, although aggregate indicators of energy consumption and economic growth correlate at national levels, this often cited "sign of progress" may hide equity concerns in the distribution of winners and losers for both income growth and energy access. It is therefore important to consider the inclusivity and exclusions of such changes (Benner et al., 2018, LaBelle MC, 2017)

Energy access has been observed to spatially overlap with socio-economic poverty where large parts of Africa's rural population are excluded from progress in both access to developments in Africa's urban economies and electrical grid connection. In Tanzania, according to the African Development Bank (AFDB) 64% of the Tanzanian population does not have access to the electricity grid (AFDB, 2015). For the purpose of clarity, this research draws distinction between energy access, as a sub-set or one dimension of poverty, and the broader notion of socio-economic poverty. Although energy access has been conceptualised for measurement purposes, albeit crudely, as accounting for 1/18 of poverty assessment, the instrumental nature of energy to transform livelihoods (empirically demonstrated in the findings here to affect cooking, health, education and income outcomes), locates observations of progress in energy access and the

associated impact on people's lives as an important area of investigation (Alloisio et al., 2017, Gray et al., 2019, Nussbaumer, Bazilian & Modi, 2012, Rao & Pachauri, 2017).

Unemployment is a critical dimension of poverty in Tanzania. High rates of population growth have resulted in a high number of Tanzanian youths seeking employment. With, "half the population under the age of 25, it has the world's 10th largest youth population" (Banks, 2016:441). Even though the Tanzanian economy has been expanding rapidly over the past 10 years this has not resulted in substantial job creation or inclusive economic arrangements in the formal sector. This has led to the majority of the youth to seek employment in the agricultural sector, which is the, "main source of livelihood for Tanzania's youth, employing (though often as unpaid helpers) 65.2 per cent of its youth population" (Banks, 2016:441). Many of the youth in countries such as Tanzania see that self-employment within the agricultural sector is the only option available to them with barriers to the formal sector preventing access to official jobs (Haji, 2015). The majority of this labour force is however not formal; which hides a large vulnerability within the local labour market (Haji, 2015). Haji (2015:5) therefore argues that Tanzania faces severe vulnerability as "90 percent of the employed population is self-employed — mostly in the informal sector — with less than a tenth of the population in wage work". The foreseeable future does not seem to be leading to much change within the above workforce distribution (Haji, 2015). Future population growth of around 2.5% leads to over 1 million individuals entering into an already stressed labour market per annum (Haji, 2015).

Lack of, or limited educational options contribute to the unemployment dimension of poverty. Even though the majority of Tanzanian youth complete a primary school education, less than half of these students go on to receive a secondary school diploma (Banks, 2016). Higher learning institutions become prohibitive to most Tanzanians due to expensive cost (Banks, 2016). As a result, only "3 per cent [of Tanzanian youth] enrol … in college or vocational training institutes, despite additional qualifications being critical to securing a 'good job'. Leaving school, therefore, is often followed by prolonged unemployment" (Banks, 2016:443). Employment and education are linked in Tanzania to create a series of barriers to accessing formal employment for the majority of Tanzanians.

Another dimension of poverty recognized in the MPI is cooking fuel. This is of relevance to the case study because increased income from SMEs can bring about a reduction in dependency on

biomass consumption due to disposable income at the individual household level. In the Tanzanian context, more than 85% of the population depends upon wood-based energy to service their cooking needs (Okoko et al., 2018:2). This in turn impacts additional MPI elements like child mortality and health related issues. Smoke generated from using wood based fuel sources are comprised of a complicated mixture of known harmful pollutants (Wylie et al., 2016). According to a study conducted in Dar-es-Salaam Tanzania, Wylie et al (2016:134) found that "During pregnancy, exposure to biomass cooking smoke has been linked with a reduction in birth weight, an increase in stillbirth, and a rise in preterm births in a number of epidemiologic investigations".

2.2.3 Entrepreneurial Challenges

Scholarly literature for the purposes of this research focused on entrepreneurial barriers in the developing world and barriers to energy access barriers to energy access. The majority of the literature regarding these challenges has focused on, (a) entrepreneurial management, and (b) renewable energy solutions (Gabriel, 2016). A comprehensive journal review by Gabriel (2016:362), postulated six key challenges, "access to institutional finance; the price of renewable energy technologies (RETs); the lack of skilled labour; underdeveloped physical infrastructure and logistics; power/dominance of incumbents; inadequate government or policy support". These findings concurred with the majority of the literature reviewed for this study as well as discussions with the interviewees and key stakeholders within the Tanzanian renewable energy service industry (AFDB, 2015, Ahlborg & Hammar, 2014, Amuzu-Sefordzi et al., 2018, Bauwens & Defourny, 2017, Fjose, Grünfeld & Green, 2010, van der Ven, 2018, Vinci et al., 2015).

Within Tanzania, as in much of Africa, solar home system (SHS) demand has been growing over the past decade. Initially driven largely by the desire to power radios and television sets in off-grid regions that were unconnected to the main power supply lines (Ondraczek, J., 2013)demand for SHS has increased with the widespread adoption of mobile phones and need for home lighting solutions. The Tanzanian market is largely reliant on NGO funding, governmental agencies, and partnerships with international agencies (Ondraczek, J., 2013). The current Tanzanian government agenda is to focus on largescale projects such as large hydroelectric power stations, natural gas plants, and coal, as opposed to microgrid solutions that are proving popular and successful in other nations (Ondraczek, J., 2013). This means that, regardless of adoption, solar will likely not feature strongly in official government policy or have a prominent position in the Tanzanian electrification

agenda (Ondraczek, J., 2013:411). While Tanzania has taken a consolidation of governmental control in the supply of energy, their Kenyan neighbours have allowed the free market to influence both the inclusion of renewables and private actors in their energy mix with great success. This has resulted in Kenya seeing benefits through the rise of their own distribution and manufacturing solutions for solar energy technology (Ondraczek, J., 2013). This innovation in Kenya has resulted in off-grid energy solutions becoming accessible for the majority of their population for the first time.

Another obstacle entrepreneurs face in East Africa, is the pervasiveness of corruption and bureaucracy involved in establishing a business. This results in many small and medium business owners choosing to remain in the informal sector (Fjose, Grünfeld & Green, 2010). They do this in order to evade taxes and challenging regulatory procedures (Fjose, Grünfeld & Green, 2010). These and similar challenges have a ripple effect on a nation, and formal employment becomes challenging to trace creates limitations for national revenue collections.

2.2.4 Poverty and Dependence on Ecosystem Services

A fine balance is needed to maintain appropriate poverty reduction while also preserving the environment. Robards et al. (2011:472) however, highlight an immediate challenge to countries like Tanzania, arguing that focus should be made on poverty reduction before regional biodiversity goals can be obtained. This requires a key understanding of how poverty cycles work in order for public initiatives to respond to the pending ecological crisis at hand (Robards et al., 2011:472). Unfortunately, in Tanzania there is extreme pressure placed on the environment due to lack of human development and cooking fuel needs that are readily met through the exploitation of biomass. A report by the Food and Agricultural Organization (FAO) states that this has led to a deforestation rate in Tanzania of, "372,000 ha per annum, which results in heavy pressure from agricultural expansion, livestock grazing, wild fires, over-exploitation and unsustainable utilization of wood resources" (FAO, 2014:4). With over 85% of the Tanzanian population reliant on wood fuel for their cooking needs this pressure is not expected to reduce any time soon (Okoko et al., 2018).

Certain approaches can be implemented to alleviate some of the damages caused by climate change. One approach can be seen through the establishment of 'design principles' which is a means of learning from one case study (such as the SAC model), reflecting on the lessons, and then applying

those lessons to the next iteration of interventions. Such innovative measures focus on bolstering the environmental principles of sustainable resource management, improving socio-ecological balance, social principles of equality and participation, and stable economic principles (Liu & Simpson, 2019:35).

2.2.5 Renewable Energy and Entrepreneurship

Limited financial access is widespread and detrimental throughout the business environment in Sub-Saharan Africa, including, but not limited to, Tanzania (Fjose, Grünfeld & Green, 2010). Scholars have argued that measures should be taken to improve financial systems and allow small business owners to access capital or else there will be continued market stagnation (Fjose, Grünfeld & Green, 2010).

There is currently a gap in the literature that evaluates the effect large energy providers have on entrepreneurial entities, particularly when such entities are constituted by young entrepreneurs, and to what extent the rules and norms in society impacts entrepreneurial pursuits on a regional level (Gabriel, 2016). In developing nations, like Tanzania, it is important that further analysis of the legislation implemented by the government occurs in order to gauge the rate of reforms implemented at a national level (Gabriel, 2016). Ideally, such a procedural approach to the above problem will provide steps in the right direction in order to achieve meaningful societal transformation in the field of energy access. The case study selected for this research aims to provide preliminary findings that might explore this knowledge gap and identify future directions.

2.2.6 Extending understandings of Energy Access

There is an evolving literature on energy access and how scholars, governments and development practitioners have come to understand the associated emerging technical and governance arrangements. For example, the role that institutions and governments have played in establishing rules and policies that affect society as a whole are influenced by both the private and public sectors (Rennkamp, 2016). In contrast to the capitalist influences seen governing changes in society within the western world, African states are better understood through the concept of neopatrimonialism, “which refers to a political system with formal structures of rule that co-exist along with strong informal institutions” (Rennkamp, 2016:7). Neopatrimonial political systems are much more informal than what is seen in capitalist democracies (Rennkamp, 2016) These states, of which

Tanzania has been included, “show high levels of insecurity about the behaviour of state institutions. The political system reflects this insecurity, which makes institutional change difficult to predict and governments actions not calculable” (Rennkamp, 2016:7). This distrust of state institutions could explain why many Small and Medium Enterprises (SMEs) tend to stay in the informal sector and communities depend on each other rather than state intervention to provide them with a social safety net.

Central to the challenge of energy access is the State’s legibility and measurability of those not connected. Depending on a community’s location, policy makers can encourage off-grid communities to independently access energy and the economic benefits associated through it, by conducting a comprehensive cost benefit analysis for bringing them onto the main grid. This can help governments to determine which communities cannot be connected to the grid without incurring high extension costs (Szabó et al., 2013). In order for regional governments to achieve goals of between 50% and 100% modern energy access by 2030 there must be an emphasis on effective mobilization, strategic fundraising, and innovative policy frameworks (Brew-Hammond, 2010). Without reliable power being accessible to the public, then socioeconomic growth and development will likely remain stagnant (Kolawole, Adesola & De Vita, 2010). Access to energy has been shown to alleviate many health issues caused by indoor air pollution as well as promote autonomous national development and reduce environmental degradation by limiting natural resource consumption (González-Eguino, 2015, Sovacool, 2012).

The following section identifies three emerging literatures that, although highly relevant, have yet to be applied, or extended to, the peculiar characteristics of energy access and off-grid energy in sub-Saharan Africa. They are identified here for the purpose of presenting concepts and frameworks that leading scholars in the various fields are using. Drawing on essential aspects of each identified concept, their operationalization and integration in a novel conceptual framework is demonstrated in the discussion section below reveals that innovative insights and sheds new light on how private entities on the continent endeavour to overcome energy access.

2.2.7 AMP: Awareness, Motivation and Pathways

The work of Petersen, Shearing & Nel (2015) aims to elicit the rationales of individuals or groups of people that transition towards more pro-environmental behaviour through exploring their Awareness, Motivations, and selected Pathways (the AMP Model). Confirming the choice of the

AMP model as a means to explore energy access, recent work by Harrington et al, (2020) found that individuals decisions to adopt household-level solar technologies in low-income communities in India were heavily influenced by their awareness of the technology. Drawing on Petersen, Shearing & Nel (2015), this research understands and uses AMP in the following manner, 'Awareness', is the understanding of individuals or companies of the impact their actions and engagement have within their specific sector (Petersen, Shearing & Nel, 2015). It is important to note that their definition of awareness, "is broader than the acquisition of knowledge, but includes a sensibility or frame of reference out of which action emerges (Petersen, Shearing & Nel, 2015:4). 'Motivation' is described as the reasons provided to take specific actions or decisions in pursuit of their goals (Petersen, Shearing & Nel, 2015). The term 'Motivation' can also be demonstrated in the reasons people have for why they make particular decisions and can include notions of potential rewards for doing a particular action (Petersen, Shearing & Nel, 2015). Their framework assumes that all actions taken by an individual towards a desired outcome requires a practicable 'Pathway' to succeed. For example, an individual may be motivated, but lack the resources, technologies or capabilities (Pathways) required to accomplish their goals. Therefore a 'Pathway' enables a desired outcome to occur. Petersen and her colleagues found it important to consider what barriers are in place that militate against success and what actions are therefore necessary to remove or surmount any obstacles in an individual's way (Petersen, Shearing & Nel, 2015). This valuable methodology builds on research conducted by Honig et al (2015) which concluded that three elements are crucial to the facilitation of pro-environmental behaviour, namely a) an awareness of key issues and an, "understanding that society and earth systems are connected", b) a motivation to act which, "involves the personal and operational drivers that encourage an individual or organization to respond to new levels of awareness and c) a way to act or a pathway which recognizes, "the practical solutions and opportunities that facilitate actual change" (Honig et al., 2015:664).

2.2.8 Diffusion Theory

Affording the potential to gain understanding of adoption rationales, Innovation Diffusion Theory (IDT) describes adoption as a decision for, "the full use of an innovation as the best course of action" (Rogers, 2010:177). Rogers IDT model goes on to recognize five specific innovation attributes (1) advantage, (2) compatibility, (3) complexity, (4) ability to trial, and (5) observable traits (Rogers, 2010). Rogers (2010:15) states that the success of these adoption attributes is based

upon, “the degree to which an innovation is perceived as better than the idea that precedes it”. This mentality takes into account the innovation’s role in community values, experience, and requirements of individuals choosing to adopt alternative services or technological solutions (Rogers, 2010). This is potentially useful for research exploring how and why individuals test new innovations at a grassroots level and the effect of their experimentation, if any, on adoption choices by others in the community.

2.3 Conclusion

Energy access remains a central challenge to disparate populations not connected to the central grid. Additional solutions will need to be developed in order to foster national economic growth as well as small and medium enterprises. This will enable nations like Tanzania to learn from emerging case studies that demonstrate ability to overcome general and contextually concentrated challenges to energy access. Solar PV systems are emerging as an innovative off-grid pathway to the public and currently is one of most accessible options. If appropriate interventions are made, solar solutions could have a large impact on individuals’ livelihoods and even potentially reduce of anthropogenic forcing. National policy and initiatives should realize that the youth of the nation need to transition into the formal job sector or be able to establish independent business enterprises. Without the availability of such pathways, many will suffer the effects of disruptions in the agricultural sector. Not only does off-grid technology empower youth, but can also lead towards a reduced environmental degradation in Tanzania.

The following section sets out the methodology wherein notions of AMP were operationalized. Although introduced in the literature review, aspects of nodal governance and diffusion theory were not operationalized (methodologically) but provide general framing to the interpretation of the findings, discussion and emergent theoretical framework drawn from field observations.

3 Methodology

3.1 Research Approach

The goal of this research is to explore adoption rationales and perceived effects of off-grid energy access on the livelihoods of rural youth in Tanzania. A case study approach was used for this research and an exploratory and qualitative methodology was adopted. According to Creswell, "qualitative research is an approach for exploring and understanding the meanings individuals or groups ascribe to a social or human problem" (Creswell & Creswell, 2017:4) A social constructivist approach was adopted to accommodate differences of individual opinions and their surroundings (Creswell & Creswell, 2017). Social constructivism is the appreciation that individuals seek to comprehend the world they live in and the meaning that their surroundings instil in them (Creswell & Creswell, 2017). This approach brings focus on the settings that people operate in and attempts to see how individual's context influences the formulation of their beliefs or recognition of certain situations.

Yin describes case studies as a way to, "investigate a contemporary phenomenon in depth, in its real-world context" (Yin, 2014:237). It is understood that case studies can be considered too parochial or narrow in what they provide in terms of general theory (Bell & Morse, 2018). Contextual factors that situationally make one case study feasible may not be applicable under different conditions. Even though there are potential weaknesses in the case study method they are still an important aspect of understanding and gathering data, especially in under researched and data poor contexts where qualitative cases can indicate new findings. These challenges notwithstanding, "case studies can provide early examples of experiences which may become general trends, weird results which provoke curiosity, even contradictions to the established opus of 'truth'" (Bell & Morse, 2018:5).

Subjects construct meaning to what is occurring around them as they interact with the world and such meanings can be uncovered, if only in part, through qualitative appreciation of what sense they make of the intentional actions taken and decisions made (Crotty, 1998). This requires flexibility of interview processes and qualitative questions to be broad in scope. Such broad questions enable the individuals participating to share whatever they feel is most suitable from their own viewpoint. In addition, meaning attributed to gathered data relies heavily upon society and community relations. This has informed the largely inductive approach to the research

(Creswell & Creswell, 2017). The researcher therefore aims to extrapolate key themes from the data gathered at the field level. Data gathering was conducted in a way that allowed respondents to make reflections upon their world through the reasons they provided for actions and choices taken, namely why they chose to adopt off-grid renewable technologies and what self-reported effect the technology has had on the research subject's life (Crotty, 1998).

The following section presents the research rationale for the case study selection. It provides reasons for the case study selection and the iterative process that was involved in narrowing down the potential points of interest to those most salient and relevant to the research aim. Key stakeholders such as Sepon LTD and their business model are introduced. Explanation is provided as to how interviewees were selected, contacted and how their confidentiality and anonymity was assured. Justification is provided for how the sampling of the interviewees took place and the scope of the geographical focus within which the research was conducted. Data analysis and storage methods are discussed together with their research purpose. The Awareness, Motivation, and Pathways (AMP) model is presented as a non-normative analytical framework with which to consider case observations.

3.2 Rationale for Case Study Selection

A preliminary desk study identified key themes in the literature and identified knowledge gaps relevant to Africa's current and future challenges of poverty, energy and climate change (Amuzu-Sefordzi et al., 2018, González-Eguino, 2015). One key theme identified was the role which off-grid renewables can play in providing a potential solution with co-benefits to poverty, energy and climate change (Alloisio et al., 2017), how it aligns with the need for a low carbon transition (Fang & Wei, 2013, Venema & Cissé, 2004), and how it provides employment for youth (Banks, 2016, Deichmann et al., 2011, van Gevelt et al., 2018). The review highlighted emerging uptake of Solar PV technologies in disparate communities of East Africa currently lacking access to the central energy grids.

Concentrating on market dynamics in Tanzania, the research then explored and analysed a range of potential case studies for off-grid renewable energy businesses. This was followed by in-depth exploration of both peer-reviewed and grey literatures on Solar PV in East Africa, business models of Solar PV providers, and government energy policies. Semi-structured interviews with key stakeholders in Tanzania then narrowed the research towards three potential case studies with the

necessary characteristics of entrenched energy access (with potential for off-grid energy access) and business opportunity.

The research aim required a business that focused on youth and could facilitate introductions between the researcher and those willing to participate in the study. In order to make a strong case the organization needed to be a viable business that had been in existence for at least five years and not reliant on donor funding or government grants. This aimed to insulate the case study findings from external or donor-reliant influences common to many renewable energy providers in the region and better portray the reality of conducting business for everyday Tanzanians. As an added precaution the business model needed to be developed and owned by Tanzanians and display a degree of embeddedness in the communities in which they operate.

In order to identify an appropriate case study, a preliminary visit to the field facilitated a face-to-face discussion with the key actors involved in the sector. Field work planning was informed by the literature, preliminary interviews with relevant stakeholders and the researcher's personal experience in the emerging off-grid renewable sector in Tanzania. After preliminary exploration with several institutions concerning how appropriate and feasible they were, together with consideration of their potential to yield valuable insights, Sepon Limited (hereafter Sepon) displayed characteristics likely to fit with the kind of case study required. Furthermore, they were willing to share appropriate data and facilitate a working relationship between the researcher, their partners, and beneficiaries. After further correspondence and exploration with Sepon, their youth empowering 'Solar as Capital' program (hereafter SAC) stood out as worthy of further investigation and aligned with the research aim.

3.3 Case Study: Sepon LTD and the 'Solar as Capital' initiative

Sepon LTD was founded in 2013 with the stated objective to create jobs and bring energy to rural communities. With only a small percentage of Tanzania's population connected to the main power grid, Sepon saw a business solution that might impact thousands of households across the country. One of the major constraints to individuals purchasing solar PV systems is the high cost inputs and lack of knowledge about what equipment should be purchased. This led Sepon to establish their 'Solar as Capital' initiative where youth (18-35) could send in an application with a request for an interest free small business loan to be paid back within a six-month period. Once the plan is

approved, Sepon provides the youth recipient with one of two packages, Bronze, or Silver. Two examples of these packages can be found below:

> **Bronze Package**: 150W solar panel, 100AH battery, 10A charge controller, 4 DC 12V lights and 1 19" TV. This kit is capable of the following:
>
> - Charge 50 mobile phones or batteries per day.
> - Power four lights for approximately six hours per day.
> - Power the television for approximately 6 hours per day.
>
> **Silver Package**: 2 200W solar panels, 1 200AH battery, 1 19" TV, and 2 haircutting machines. This kit is capable of the following:
>
> - Run two haircutting machines simultaneously.
> - Power the television and a DVD player for approximately 6 hours per day.
> - Charge 50 phones per day.
> - Power 4 lights for six hours per day.
> - Power one laptop.

These packages have been issued to over 204 clients since 2013 who are spread across Tanzania. Sepon also caters towards youth with differing interests and has over 21 variations of the above packages, ranging from agricultural to 'mini-information' and 'technology centre' systems. Potential income from these businesses above is show below:

PACKAGE	ACTIVITY	DAILY INCOME	MONTHLY INCOME
Bronze pack	Phone charging (50) x (300tsh)	15,000 (US$6.50)	450,000 (US$195.00)
	Showing football games or movies	10,000 (US$4.00)	300,000 (US$130.00)
TOTAL		**25,000 (US$10.50)**	**750,000 (US$325.00)**
Silver pack	20 individuals at barber shop (1,000tsh)	20,000 (US$8.50)	600,000 (US$260.00)
	Showing football games or movies	10,000 (US$4.00)	300,000 (US$130.00)
	Phone charging (50) x (300tsh)	15,000 (US$6.50)	450,000 (US$195.00)
TOTAL		**35,000 (US$15.00)**	**1,050,000 (US$455.00)**

Table 1: Standard off-grid solar PV Packages available to SAC participants

The SAC goal is to build and expand the use of renewable energy in a productive way. Aligning with SAC's goal and recognizing the potential market therein, the company aims to enable over ten thousand youth and women-managed businesses that are entirely off-grid. The key qualifications to be considered for this program are as follows; local Tanzanian resident, living in

an area without electricity access, has access to a space for their business, willing to discuss and develop a small business plan, and is known for being of good standing and reliable within the community. Women are particularly encouraged to apply. According to Sepon, the ideal scenario is for the SAC model to have multiple positive co-benefits in the areas where implemented. These includes improving communication, shared business plans and ideas, stable lighting solutions for better security and childhood wellbeing, creation of direct employment opportunities, reduced poverty, and a weaning off of the dependence on biofuel use. These are all secondary objectives set by Sepon as intended outcomes and secondary effects on society (Okech, B. 2019). The above anticipated outcomes are further explored within the results section.

3.4 Sampling and Field Work

To gather appropriate data a purposive sampling method was utilized for the selection of the participants (Patton, 2002). This method requires identification of people who have a rich understanding and specific knowledge of the sector that is being studied. Key participants were chosen due to their knowledge and expertise in the renewable energy sector. The 'youth' cohort that were chosen for this interview all fall within the ages of 18-35 (UN, 2020). They were selected as they were the first beneficiaries of Sepon's 'Solar as Capital' initiative.

Interviews with beneficiaries took place in Tanzania for a two-week period from June 26th to July 9th, 2019 with a range of stakeholders and selected interviewees. Over one thousand kilometres were covered traveling to rural communities in order to meet the geographically disparate SAC candidates. As the researcher was fluent in Swahili, all interviews were conducted in Swahili and translated to English for coding and analysis. To ensure translation accuracy a research assistant, present during the interviews, aided in the transcription process. Once themes were identified, interviewees were contacted a second time over the phone to confirm the interview was correctly captured and to follow up on clarification questions. The above steps were taken in order to reinforce the research and limit information gaps. Nine interviews were conducted in Tanzania during June-July 2019. Two interviews involved in-depth supplementary discussions with key operational stakeholders from Sepon LTD and their partner organization Climate Action Network (CAN), and seven interviews were conducted with beneficiaries of the Solar as Capital initiative. Solar as Capital Participants were chosen based on their differentiating geographical locations and due to the fact that they were the first participants in the SAC model.

The major focus for this research is primarily rural. Therefore, the list of 204 Sepon beneficiaries was scoped down significantly to a population that only included rural beneficiaries – excluding those who are living in urban and electrified areas. Of the 204 SAC beneficiaries, 42 were classified as rural (see Appendix 1). Six of the seven chosen interviewees therefore account for a sample of 17% of the rural beneficiaries and one urban interviewee was also selected to acquire knowledge of reasons for urban off-grid energy adoption. All seven interviewees had been operating for more than 5 years and were part of the early rural adopters of the SAC model. It was considered important to gather knowledge from successful beneficiaries as Sepon had indicated not all beneficiaries were able to make a sustained business work.

The map below is included to provide a visual context for where these discussions occurred:

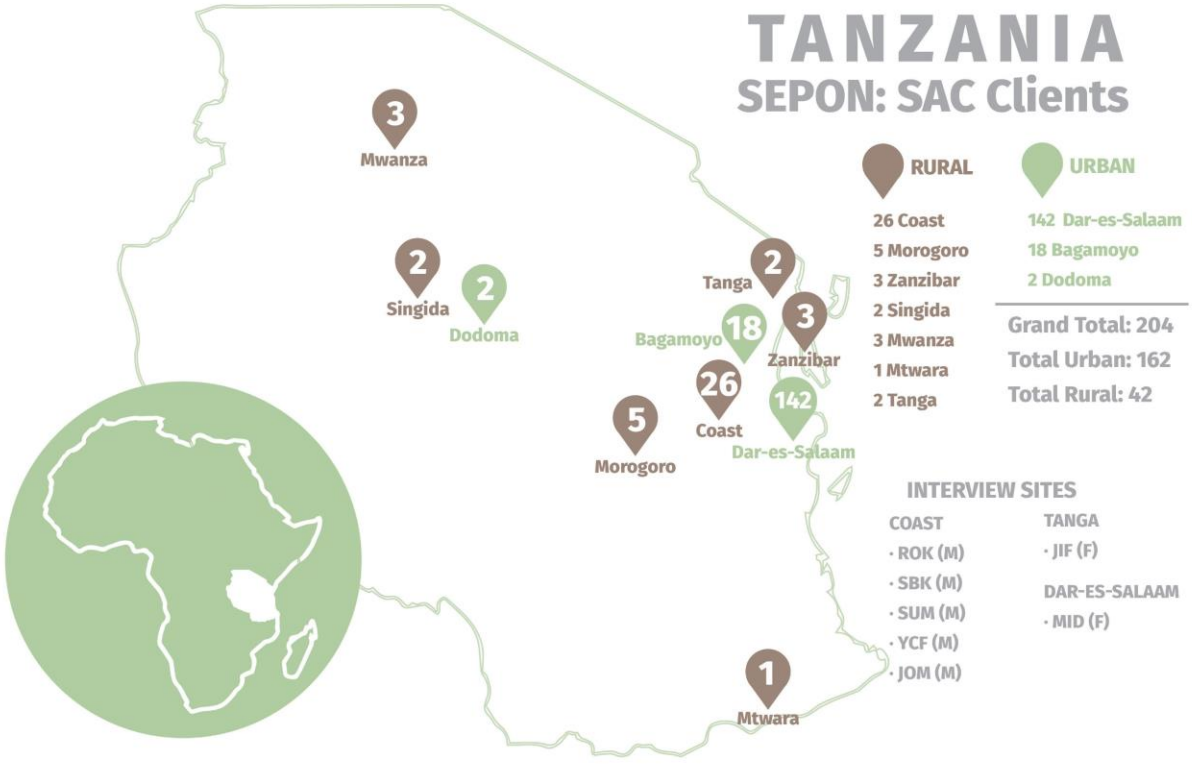


Figure 1: Geographic distribution of Solar as Capital (SAC) beneficiaries and interview sites

Interviews were conducted with six rural interviewees and one urban interviewee in Dar-es-Salaam who was selected as a supplementary individual to provide insight into an urban experience. All respondents who participated in this study were coded to ensure confidentiality and anonymity.

When referring to interviewees this research refers to the number of selected rural individuals who chose to adopt the SAC package in order to gain off-grid energy access. The participant from Dar-es-Salaam will be referred to as the urban interviewee. The interviews were conducted within the following areas, Dar-es-Salaam, Kibindu, Mkuranga, Fukayosi, and Kiwangwa which aside from Dar-es-Salaam are all classified in the rural Coast region listed above. The interviewees responses were then placed into a table to track both the Multidimensional Poverty Index and observed SAC benefits that occurred in these individuals lives (Table 2).

3.5 Analysis and Data Storage

The data used for this research was collected through the course of interviews with respondents along with documents provided by Sepon and Climate Action Network (hereafter CAN). CAN works at the grassroots level in rural communities spreading awareness of climate change and mitigation methods through seminars and practical trainings. Interviews were transcribed via hardcopy and an audio recording was made by the lead researcher. Once the interview was concluded both the lead researcher and the research assistant reconvened and created a cohesive summary of the interview onto a soft copy. The hard copy was then disposed of and audio recordings deleted after both researchers were satisfied the content was appropriately transcribed. Each individual soft copy of the interview was made password protected and for additional security stored in a private and password protected storage drive with names anonymized. Documents provided by Sepon and CAN are also kept in the password protected folder and were deleted after information pertaining to this research was extracted.

3.6 Structuring case observations: Awareness, Motivation and Pathways

Aligning with a social constructivist approach and providing conceptual framing to the methods selected, the research explicitly set out to empirically consider respondents rationales for adoption of the SAC package and what the self-reported effects renewable energy access provided for respondents. Extending the work of Petersen, Shearing & Nel (2015) field observations, interview guide and interviews aimed to elicit such rationales and effects by considering beneficiaries' Awareness, Motivations, and Pathways (AMP) to utilizing off-grid PV energy, the AMP model. This approach was used as a lens through which field observations were structured. Not being epistemologically predisposed to a particular theoretical frame, this analytic created space for how

autonomous people are, the risks they face, and what they are able to do about it. The AMP methodology has not been applied to research on energy access in rural and low-income communities before. For the purpose of this study the AMP term 'Awareness' refers to the individuals understanding of renewable energy technology, how they heard about it, knowledge of how it works, and what educational background (if any) is required for its utilization. The AMP term 'Motivation' will be used to describe reasons respondents give for taking a specific action or decision point (Petersen, Shearing & Nel, 2015). Within the case studies 'Motivation' is demonstrated in the reasons people have for why they make particular decisions and are evidenced in the steps respondents took to adopt solar PV systems. Motivation can also include notions of potential reward (Petersen, Shearing & Nel, 2015). All actions that individuals take require a pathway. For the purpose of this research the AMP 'Pathways' term involves an avenue that facilitates the steps young entrepreneurs take to become energy independent and sustainably run their own business such as a particular technology or governance arrangement. An individual could be motivated but lacks the resources or capabilities to do so, in this sense, a 'Pathway' enables the realization of a desired outcome. In addition to facilitating potential pathways, it is important to consider barriers in place which militate against potential success and therefore the actions necessary to remove or surmount these obstacles (Petersen, Shearing & Nel, 2015).

This research is less interested in the businesses the individuals are running and more concerned about the role that their business plays in the understanding and influencing of the circumstances surrounding the social, economic and ecological imperatives of their situation. The AMP model has recently been used to explore how businesses might embrace more pro-environmental behaviours (Honig et al., 2015). The research hypothesizes that gaining such an understanding of people's awareness, motivations and pathways relating to low carbon and renewable energy sources, if realizable at scale, holds potential importance for climate mitigation and adaptation. Adaptation may or may not be a primary objective of the beneficiaries, but their understanding of the technology and the actions they take directly impact the potential for transition to a low-carbon future in energy access for rural Tanzania.

The interview guide presented below (see Appendix 2 for complete interview guide) was designed to give the participants flexibility in their answers. These were further divided into four sections; technology, energy, business, and empowerment with corresponding AMP categories for each:

Awareness

Technology

- What sort of equipment do you have?
- How does the technology work?
- What education do you have, certificates? Technical or electrical trainings?

Energy

- What energy requirements do you currently have?
- Other than solar what additional energy options do you have access to?

Motivation

Business

- What is your current business (how does the tech above enable you to do this)?
- What business strategies do you employ, what are operations like?
- What sort of customer base do you have and what do you charge per service?

Pathways

Empowerment

- What sort of employment opportunities are available to youth in the community?
- How has this business changed your life?
- What enabled you to access this technology and what might inhibit others?
- Closing statement? (Advice for entrepreneurs and policy makers?)

The above questions were developed in order to guide the case study participants while also giving them room to freely discuss the conditions outside of the set parameters. While remaining open-ended, the above AMP structuring guides the data into a format that can be easily digested and compared with the other respondents in the survey.

3.7 Methods conclusion

This chapter outlined how and why participants were chosen for this study. Data collection methods and steps taken to ensure anonymity of confidential source material were reviewed in detail, in order to demonstrate that the exploration conducted for this paper followed conventional procedures for a qualitative research methodology. The AMP methodology was discussed and the interview guide developed for the interviewees was presented. The following chapter will present the results of the above research and discuss the findings from the selected interviewees and stakeholders.

4 Results

4.1 Introduction

The overarching aim of this study is to explore the adoption rationales and personal effects of renewable energy access for African youth in rural Tanzania. This chapter will present the key findings of the field work. First, the results from in-depth interviews with two key stakeholders, Sepon and Climate Action Network (hereafter CAN), will be presented as this will provide contextualization and the foundation for further exploration of themes arising out of these interviews. The results are structured according to interview topics and further divided into AMP relevant themes, but balance is provided to aspects to which respondents gave greater emphasis.

This results chapter is structured under the following themes: an exploration of the Sepon and SAC model, and what sort of effect Solar as Capital has on the beneficiaries livelihoods. It then breaks down the beneficiaries Awareness, Motivation, and Pathways (AMP) to achieving their goals, the beneficiaries advice to energy stakeholders and policy makers, Sepon's intended livelihood outcomes as per the SAC model, and finally the chapter conclusion.

4.2 Sepon and the SAC Model

Sepon has seen an increase in the number of companies in Tanzania that are expanding into off-grid communities where demand for energy solutions is on the rise. A critical area of their business is in awareness and technical capacity building for individuals seeking energy options and extending energy access to individuals living in energy disadvantaged locations. Policy makers and organizations have had limited success within this area. This is illustrated by the lack of a currently effective national framework or a collaborative body to facilitate productive energy usage or distribution. Dialogue within the Tanzanian energy sector calls for increased connectivity, yet only limited physical solutions are being presented. It is within this gap that Sepon is establishing itself and attempting to address energy challenges facing these rural communities.

Sepon's operations began in early 2013 as an energy product supplier dealing in small solar lights and energy efficient cooking stoves. As their customer base grew demand increased for more advanced products and systems. In late 2014, Sepon decided to create a business model that might replicate similar successes on a much wider scale across the country. The 'Solar as Capital' (SAC) program began with the purpose of enabling youth (18-35) to start and manage their own

businesses with a focus on sustainable operations and economic stability. According to Sepon the reason they are targeting youth is twofold. Firstly, the young population base is the majority of the population and they are the most likely to be without jobs. They also tend to possess an observed eagerness and ability to embrace new technology, unlike older members in a community. Secondly, there are more external funding opportunities if youth are targeted directly. While Sepon has yet to get any external grants, their aim is to acquire them over time. The goals and intended effects of the SAC model implementation are as follows:

- Improved communication
- Shared business plans and ideas
- Stable lighting solutions for better security and childhood wellbeing
- Creation of direct employment opportunities
- Reduced poverty
- Limiting dependence on biofuel use
- Promotion of a healthy and sustainable environment

Over the past 6 years Sepon has installed over 204 SAC systems in a wide range of communities in both urban and rural areas. Out of the 204 systems approximately 80% are solar home/small business solutions and the remaining 20% are cooperative commercial entities. Due to differing needs by their clientele Sepon has designed over 11 custom packages ranging from refrigeration and phone charging to larger agricultural solutions. Smaller systems have proven not to be as popular due to limited cash returns. Learning from these experiences, Sepon aims to screen beneficiaries according to, and facilitate a balance between, immediate equipment needs and good investment return.

A major challenge encountered by Sepon is that usually rural youth do not have capital to purchase systems outright. As their customer base expanded and SAC recipients have increased, there have been difficulties in effectively managing extended loans. Such finance experiences have taught Sepon to tighten criteria for SAC candidates. This sometimes requires a 50% system cash payment up front and the remaining 50% within the next 6 months. This prevents company capital becoming too tied up in outstanding loans, resulting in limited recipient numbers. These challenges notwithstanding, Sepon is working on partnerships with various microfinance institutions to create a variety of packages for these young entrepreneurs in order to facilitate access to start-up capital. First and foremost, Sepon considers itself a technical solar company, and the loan aspect is not something that they pursue. This is why the company is facilitating external companies to work

alongside them. For example, the local branch of the international Climate Action Network CAN assists Sepon with follow up training for program participants on best business practices and responsible financial management. Sepon does not currently enforce a strict timeline on reimbursement, which is why to date, only 204 SAC clients have been approved, as the return on financing places barriers on rapid program scale. Sepon attempts to ensure that third party institutions are providing financial training in order to assist them in not playing the role of a financial institution. The need in Africa for advancing connections for individuals to leverage microfinance in order to emancipate poor people is a key element of Sepon's business strategy going forward.

The Climate Action Network (hereafter CAN) is an international network whose Tanzanian branch was founded in 2011. CAN was specifically established for assisting local community-based organizations and businesses, through enhancing capacity in information sharing and managing community-based projects based on mitigation, adaptation and coping strategies of climate change impacts. This network is a foundation for the advancement of a society that is equipped to handle the impact of climate change. Their major focus is in rural communities vulnerable to climatic changes.

The Climate Action Network has a strategic partnership with Sepon and provides focused training to recipients of the SAC business model. Once a solar system is installed for a young entrepreneur, CAN offers them follow up training on best business practices and responsible financial management. Two additional youth from the community are invited to participate in these intensive trainings so as to increase awareness of renewable energy in the community. This enables them to learn more about the technology and troubleshooting required for issues that may arise with the equipment. Topics such as simple maintenance of the equipment and ecological responsibility are embedded in the seminars offered.

4.3 Sepon Beneficiaries: Preliminary Case Study Introduction

The SAC beneficiaries who participated in the program had a wide range of business pursuits and their customer bases vary widely. Four of the seven interviewees stated that the majority of their customers and profit margins stems from cell phone charging. This business is conducted in two main ways, through charging of phones directly, and the charging of batteries. The majority of

clients tend to have two batteries, one is always in their phone, and the other is for charging in the shop. Clients would rather leave their batteries in the shop to reduce risk of loss from petty theft.

Equipment needed for this sort of operation is simple and affordable. Aside from the solar system, the only other items required are charging kits. These come in two primary forms, one is the multiprong phone charging kit, locally referred to as ‘pweza’, or ‘octopus’, due to its shape and many dangling cords. The second option is a battery charging kit referred to as ‘kobe’, or ‘turtle’, due to its rounded shape.

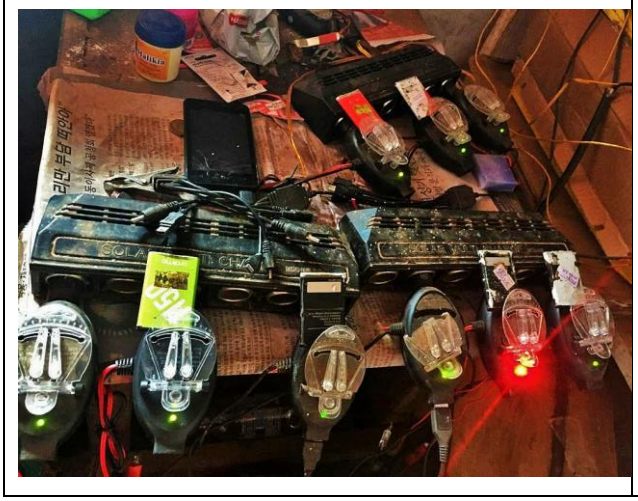
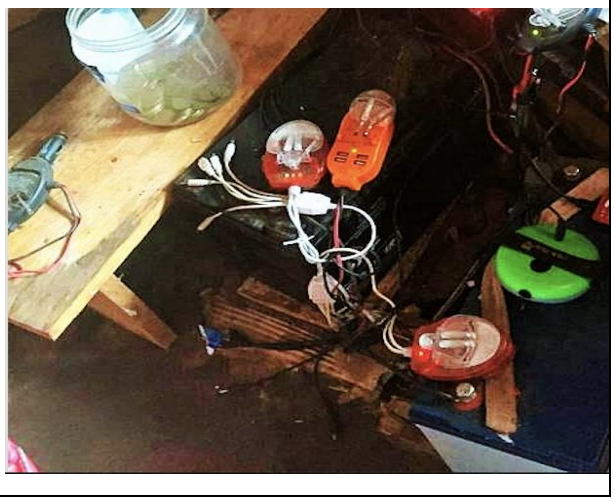
Kobe battery charging kit	Pweza phone charging kit
	

Figure 2: Example of technology used by SAC beneficiaries.

One beneficiary (YFC), who does not adopt the more common practice of phone charging, leases rechargeable solar lamps. These lamps are equipped with a USB port for supplemental cell phone charging off the lamp’s charge. This serves a dual purpose in providing both a light source and the ability to charge several phones all from the customers home. Energy requirements for YCF’s operations are low as they only require one solar panel with 150w capacity and one N100 battery. YCF has a server connected to the solar lights programmed to switch off the lamp’s power automatically at 10:00am each day. Even if there is power remaining on the lamps, they will not function and must be returned to YCF to be recharged. This technology prevents theft of the lamps by removing the ability to be repowered independently. YCF customers come from a broad range of backgrounds, households, and other businesses. Each lamp is rented out for 500tsh (US$0.22) per day. YCF has 35 lamps and rents out 25 per day at a minimum. At the lowest point, YCF brings

in 12,500tsh (US$5.50) per day, 375,000tsh (US$160) per month, and 4,500,000tsh (US$1,960) per year. Photos of this system for reference are below:

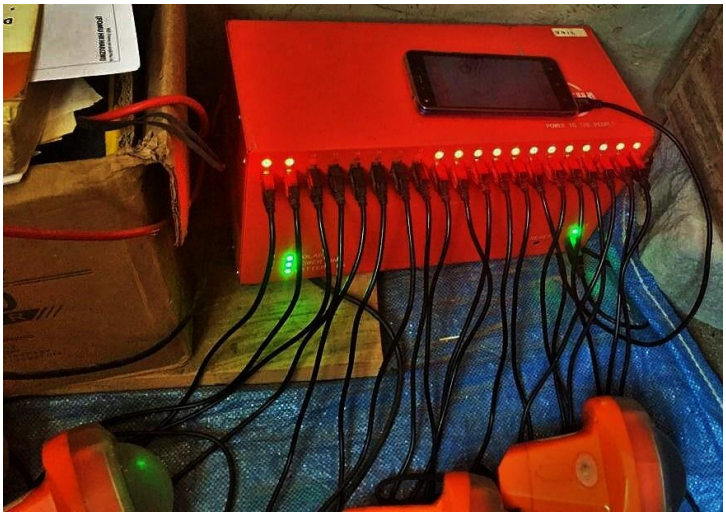
Lamp Charging Station	Lamps
	

Figure 3: Example of technology used by SAC beneficiaries.

SUM also has business operations that are outside of the phone charging business. Currently SUM uses solar energy to power water pumps at their plantation which generates more than 2,500,000tsh (US$1,080) per month in income from combined papaya and cassava sales. Their cashflow is projected to increase when the fruit trees reach maturity. The solar pumps help with watering the plants and running drip irrigation in a greenhouse for seedling propagation. Seedlings are also sold to the local community and range from traditional forest trees to various fruits and nuts.

4.4 Effects of Solar as Capital on beneficiaries' livelihoods

All six rural and one urban interviewee were asked about the decisions taken and barriers they and others faced in achieving energy access. The table below outlines self-reported changes that occurred in beneficiaries' lives, structured according to the multidimensional poverty index, which will enable consideration of how these observations relate to the intended outcomes of Sepon's SAC model.

Table: 2: Multidimensional Poverty Index and observed SAC benefits

BENEFICIARY	HEALTH	EDUCATION	COOKING FUEL	SANITATION	DRINKING WATER	ELECTRICITY	HOUSING	ASSETS
ROK Coast Region	Improved: Afford medical bills, less burn risk	Improved: (school fees / study at night)	Improved: Gas for cooking	No indicated change	No indicated change	Improved	Improved: Tin Roof and cement bricks	Improved: Motorbike, smartphone, computer, security
SBK Coast Region	Improved: Afford medical bills and less burn risk	Improved: (school fees / study at night)	No indicated change	No indicated change	No indicated change	Improved	Improved: Tin Roof and cement bricks	Improved: Motorbike, smart phone, security
SUM Coast Region	Improved: Afford medical bills and less burn risk	Improved: (school fees / study at night)	Improved: Gas for cooking	Improved: Indoor plumbing	Improved: Clean water from well	Improved	No indicated change	Improved: Motorbike, car, security
JIF Tanga Region	Improved: Afford medical bills and less burn risk	Improved: (school fees / study at night)	No indicated change	No indicated change	No indicated change	Improved	Improved: Tin Roof and cement bricks	Improved: Motorbike, security
YCF Coast Region	Improved: Afford medical bills and less burn risk	Improved: (school fees / study at night)	No indicated change	No indicated change	No indicated change	Improved	Improved: Tin Roof and cement bricks	Improved: Security
JOM Coast Region	Improved: Afford medical bills and less burn risk	Improved: (school fees / study at night)	No indicated change	No indicated change	No indicated change	Improved	Improved: Tin Roof and cement bricks	Improved: Motorbike and security
MID Dar-es-Salaam	Improved: Afford medical bills and less burn risk	Improved: (school fees / study at night)	Improved: Gas for cooking	Improved: Indoor plumbing	Improved: Solar water filter	Improved	No indicated change	Improved: Security, Motorbike, car, computer, smart phone

The above table shows that seven out of seven beneficiaries experienced a positive change in health, seven out of seven experienced a positive change in education, three out of seven experienced a positive change in cooking fuel, two out of seven experienced a positive change in sanitation, two out of seven experienced a positive change in drinking water, seven out of seven experienced a positive change in electricity, five out of seven experienced a positive change in housing, and seven out of seven experienced a positive change in assets.

The following section presents the findings from interviews with established Sepon beneficiaries. Each section is structured according to the Awareness, Motivation and Pathways (AMP) Model. These are the observed and stated results from the interviewees on how the they became knowledgeable of the SAC program and what compelled them to continue down the route of pursuing solar energy access, both from a personal and business standpoint.

4.5 Awareness

All six of the rural, and one urban interviewee, were asked about their prior and developing awareness of the technology they had adopted. Six of the seven respondents had similar solar PV systems. This included on average 2-3 panels and 1-2 batteries. Technical training was given to all of the participants by Sepon and CAN, although, there were some gaps evident upon examination. A summary of their responses is provided below:

When questioned about how they first became aware of solar technology the interviewees stated that they heard from a variety of sources. For example, the first time ROK heard about solar technology it was being discussed on a bus on his way to sell maize in Bagamoyo. SUM first began using it as a student in university but did not realize until years later how it could provide enough energy to power water pumps on his papaya farm.

SBK was also using a generator to power his business and struggling to make a viable living off it. After seeing how ROK's solar system was succeeding, SBK wanted to do the same. Other interviewees first came upon off-grid solar energy within their surrounding town centres, where it had spread from large scale traders in Dar-es-Salaam. When asked who the main contact point was for questions or issues surrounding their solar systems, the interviewees all stated that Sepon was their first point of contact. If, for some reason, Sepon were unable to assist them in resolving the issue, they would seek help from other SAC clients in nearby communities.

Agriculture proved to be the number one employer across all rural communities that interviewees were selected from. With major coastal crops such as maize, beans, cassava, and pineapples, the majority of youth either cultivate their own fields or are employed as field workers. The second most common sector of employment was charcoal production. These field observations are reinforced by literature showing that the above breakdown and heavy trend towards informal agricultural employment are common in Tanzania (Banks, 2016). Due to the proximity of the interviewees to Dar-es-Salaam, which is the largest consumer of charcoal in the country, extensive pressure is being placed on traditional forests to supply high charcoal demand. Individuals involved in this trade are required to travel further into remote areas to furnish a supply. They increasingly find themselves receiving diminishing returns as a result. The encroachment on protected forest reserves was also a concern. A smaller portion of the youth operate taxi services with motorbikes ('bodaboda'). These usually belong to local businessmen or an older family member. Other than the above options there are limited revenue streams for individuals in these rural communities. The participants (except for the urban interviewee) were all involved in one, or several, of the above occupations before becoming a SAC recipient.

Although multiple trainings were provided to the interviewees, when they were asked technical questions about how their equipment worked, the majority of the respondents showed limited knowledge beyond connecting and powering the batteries. Often there was evidence of systems being overloaded. Unit care was also of limited concern with excessive dust covering panels; showing that they had not been cleaned for some time, reducing the efficiency of the panels. Sepon provides guidelines on maintenance and equipment care, but, when the participants were asked why they were not following proper procedures many stated that they had simply forgotten.

All seven interviewees started by accessing another form of energy and becoming dissatisfied with it. Six of the rural interviewees all started with generators. The urban interviewee had access to the main grid but became dissatisfied with its lack of dependability. In 2010, when ROK first acquired a generator, he saw the potential energy could have to change his life. Operating his business at a profit proved to be challenging due to high fuel consumption. It was also time consuming as he had to walk over 20kms to purchase fuel for powering the generator. This resulted in him having to close the phone charging business while he was gone, losing valuable time and money. Over the course of a few years operational costs became higher, until he could no longer afford to continue using his generator for power. Once ROK had access to electricity he was unsatisfied

with not having a reliable source of power. He eventually became aware that solar could give the same results for a cheaper price, opening up a new avenue of opportunity.

SUM began with three generators dedicated to pumping water into storage tanks. After installing solar, SUM kept the generators as backup due to their high operational costs. However, since the solar installation SUM has also been able to save over 8,000tsh per day on fuel delivery and associated maintenance costs.

The interviewees were questioned about alternative sources of energy and, aside from solar energy, there were no other options available to them. While the government has plans to roll out energy to some of these communities there is no approximate timeframe for their connection to the main grid. It is important to note that all stakeholders (Sepon, CAN, TANESCO) highlighted that even when the Rural Electrification Authority (REA) brought power to a rural community, individuals still needed to pay an installation fee to bring lines to their businesses. This often proves to be cost prohibitive and explains why many people, even in areas with potential power access, remain unconnected. A contacted TANESCO employee stated that every pole in rural communities' costs between 100,000tsh – 200,000tsh (US$45-US$90). He suggested that groups should join together to afford the costs for connecting, as they are prohibitively high unless a home is directly on the road. When interviewees were asked about the REA program, they were not aware of individual costs and assumed power was easily accessible once brought to the village.

4.6 Motivation – Business

All six rural and one urban interviewee were asked about their motivations for initially installing and continuing to utilize solar energy. A summary of their responses is below:

Six interviewees had only acquired a primary school education, with one outlier having attended university. Four out of the seven interviewees in this study used their initial income from the system to purchase a driving license, even if initially they did not have access to a vehicle or motorcycle. They stated that possession of a driving license was a good status symbol in the community and gave them an alternative official ID which was also helpful in opening bank accounts and operating in other official capacities. Only one participant chose an alternative method of official technical training (masonry) for which he holds a certificate. He stated that it would give him an alternative revenue stream should his solar business fail.

Of all the interviewees only one, the urban interviewee, had existing energy access to the national grid. The urban interviewee chose to have solar access as a selling point for their business based on the unreliability of that grid. When power was out for other businesses, they could continue operations. This was especially important as they ran a restaurant and bar where people would come and watch football matches.

Five out of the six rural interviewees had similar businesses with their operations including cell phone charging, football match screening, and/or barbershops. Only two interviewees, ROK and MID, used refrigeration to draw clients to their shop. They stated that the positive increase in customers due to using solar energy at their place of business was invaluable. All of the interviewees, including the urban participant, focused on the positive aspect of the stability solar lighting and energy provided for their business operations. The average monthly income of five of the interviewees was in excess of 500,000tsh (US$220). One of the interviewees (SBK) uses a laptop to download songs for people in the community and burns CDs for them. This is all self-taught knowledge that he states he would have been unable to acquire had he never gained access to solar power. The interviewees all stated that solar energy gave them the ability to improve their families lives through their businesses. Without having an off-grid connection, they believe that their conditions would have been unchanged.

When asked about the environment, ROK stated that it is being decimated by the high charcoal demand in the capital. People need to be educated so they can be more vigilant in protecting their surroundings. Unfortunately, until jobs are created, or alternative revenue streams are discovered, deforestation will likely continue. In addition to the deforestation, pastoralists and their cattle are coming into conflict with settled farmers. There have been violent disputes in the area resulting in several individuals being killed.

SUM is passionate about ecosystem restoration and long-term benefits of reforestation in the community. He states that solar energy is the key to a successful business as well as to the rejuvenation of the environment. His operations currently also support community-based initiatives that involve planting indigenous species of trees and assist in providing erosion control. All of the interviewees commented that people diversifying their occupations with a focus on solar energy as a revenue stream would lead to less charcoal production and reduced pressure on the

environment to clear existing forest for agriculture. The reduction in charcoal consumption is a result of improvements to their livelihoods due to enhanced energy access.

Rural clients expressed interest in expanding their business by purchasing additional solar panels in an effort to increase revenue streams. They also made clear an overall dissatisfaction with exclusion from the national energy grid as they feel left out of national development initiatives. Despite recognition of the benefits of solar in their own experience, five out of the six rural interviewees desired the Rural Electrification Agency (REA) to connect their villages to the national power grid. Five out of seven interviewees desired to operate either a milling or welding machine as an added component to their business operations which could not function on solar due to high energy requirements. These expressed desires indicate the beneficiaries are not necessarily committed to solar power as an exclusive source of energy, understand its limitations and see its immediate value for their current needs. All of which may change over time.

It is interesting to take note that no major observable gender difference was found between male and female beneficiaries. Most women who were working with Sepon were single and were the primary caregivers in the family, yet the playing field between genders seemed even. The lack of observable gender difference is interesting as most changes in society tend to drive inequality. Solar PV seems to be an equalizer and is an exiting aspect of the study that was unexpected.

4.7 Pathways

All interviewees (except for the urban participant) responded that they enjoy having the flexibility to remove themselves from total reliance on farming. Solar power has given them the ability to have a steady income source that is not reliant on rainfall or land access, which they all agreed was of utmost importance. They are also able to send their kids to better schools, provide three nutritious meals per day to their families, and gain access to better medical treatment when needed. In the case of SUM and ROK, solar energy provided a gateway to political access and strengthened their influence in local governance within their communities.

Several of the interviewees, such as SBK, stated that costs associated to install solar technology are high, inhibiting other villagers to gain access and succeed. It often takes extensive time and resources to raise the initial capital for the purchase of this technology. This is why they were happy to be provided with initial upfront equipment by Sepon. Although, other interviewees such

as ROK and SUM, stated that compared to alternative energy sources there was nothing as affordable as solar energy. Even if they did acquire access to the national grid, they would still need to make weekly, or monthly, payments. Once the initial capital is saved for purchasing a solar kit, the costs to maintain it going forward are relatively inexpensive.

According to SUM, there is a lack of awareness raising provided to the community by the government and solar providers in regard to the benefits and affordability of solar. SUM believes that people need to be educated on the benefits of solar as most are intimidated by the technology. Some systems are expensive. However, there are smaller kits available that are more affordable and easier to use. In order to afford his initial solar equipment, SUM took out a loan to purchase some of his agricultural land. SUM could only do this by using his incoming salary from contract work with his company as collateral. After SUM paid off the loan, he used the land purchased as collateral for an additional loan, which he then used to install the solar power and water drilling on the plot. He acknowledges that not everyone has access to the same benefits that a steady job provided to him.

Overall the interviewees responded that their standing in the community has improved after they began using solar power. Their businesses have become gathering points where people come to access an energy source, discuss relevant issues, and have a cold beverage. Neighbours often ask them about solar and even occasionally place an order through them for simple solar lighting solutions that can be purchased from nearby towns. Knowledge about solar is spreading fast at these convening nodes facilitated by solar energy and the interviewees are proud to be early participants in this form of technology.

SUM has been able to employee 10 people on his plantation and continue expanding operations. Without solar power providing the ability to expand the business and save money, community members needing work would not have been hired. This employment creation has provided higher standards of living and income security for their families. SUM also managed to buy two used cars, one for his field operations and another for product delivery to Dar-es-Salaam. Solar energy gave SUM the ability to increase the plantation size, build several homes, and gain influence in the community for employment creation, environmental concerns, and seedling propagation. It is interesting to take notice of how the beneficiaries access to Solar PV created a multiplier effect in terms of downstream employment. This is evident through a range of the beneficiaries, such as

SUM above, overall with Sepon supplying seven individuals with solar energy around 20 other jobs within these communities were created.

JIF believes that if people are confident and work hard, they can achieve their entrepreneurial goals. She stated that solar energy is a technology accessible by all, regardless of educational level. She believes that there is no better catalyst to increase economic development within the community. JIF currently makes over 675,000tsh (US$290) per month - more than she used to make in an entire year of farming. She recommends that the government subsidize solar in the country and reduce taxes on its components in order to make it more accessible to lower-income families. In her view, if everyone had access to just one small panel to light their homes, it would be a significant benefit to families and children. High cost is proving to be a barrier to the spread of this technology, but JIF is encouraged as over the past several years other community members are taking initiative by following her example and using solar.

ROK states that starting his solar business has been life changing in multiple ways. They have been able to expand their capital, add onto the buildings they own, upgrade their roof from grass to tin, feed their family three meals per day instead of two, and their children are now able to use a smart phone which helps them with school and keeping up with current events. They are also able to cover bills for their educational and medical expenses.

SBK managed to build a house which is among the "nicest and most modern houses in the village", of which he takes great pride. Due to his financial stability, SBK was able to purchase land and employ people to farm on his behalf. Without his solar business, SBK believes he would be in the same position as many in his community. He is steadily increasing his land holdings and remains one of the only people in his community with a steady income stream. SBK has also purchased two motor bikes which he rents out as 'taxis' to young men in the community. This generates an additional income of 10,000tsh (US$4.30) each per day.

JIF stated that the profit from phone charging and a football match business has enabled her to purchase a motorcycle for 1,700,000tsh (US$740), which she then rents out to others for an additional income. She also managed to build a house for her family. Before gaining access to the SAC program JIF and her family lived in a two-room house with a grass roof. They now have access to a variety of foods, pay school fees and afford medical bills. Their children are able to

study at night using lights which has resulted in improved grades. SUM has also been able to add a small light bulb outside his home as a security measure to deter petty theft.

One area of particular interest to the author was that no major observable gender difference was noted between male and female beneficiaries. Most women who were working with Sepon were single and were the primary caregivers in the family, yet when it came to success and pursuit of energy independence the playing field between genders seemed even. The lack of observable gender difference is an interesting outcome of this study as most other things drive inequality. Solar PV seems to be an equalizer and leads to a different and exciting result that most would not anticipate to find.

4.8 Advice from respondents to solar energy stakeholders and policy makers

ROK advises that the government considers bringing all villages onto the national grid. This would permit people to use bigger machinery, such as welding, and operate mills, all of which use large amounts of power that is not attainable through solar. ROK believes solar companies should continue lowering their implementation costs. He recommends they should also develop technology that is more efficient and more accessible to people in low income situations. The most pressing issue, according to ROK, is the price and quality of batteries for solar. A majority of these batteries in the market are of poor quality, resulting in very short power life. This creates discouragement in people who have taken initiative and saved up to buy equipment, only to see their investment fail. After this happens, they are more likely to give up and return to farming or charcoal production.

SUM states that people should focus on educating each other, especially youth. SUM left a traditional job and is now more successful working in the field than at a company. When SUM first decided to leave his job, everyone was sceptical he would succeed. Now they view his initiative and accomplishments as an inspiration. In SUM's view, people need to focus on the future and think on a larger scale. The government should invest in education and knowledge sharing. SUM believes the mindset of having a white-collar job in order to have a good life is a concept of the past and believes agriculture should be considered a competitive sector for the economy. Electricity is rarely brought out to rural areas, which is where the best farmland is located, so communities and individuals, specifically in farmland and rural areas, need to be innovative and take ownership of energy solutions.

YCF states that people should not view living in a village as a negative thing. YCF sees solar energy spreading rapidly to rural areas and bringing opportunities with it and believes earlier acceptance and adoption will lead to more financially stable communities. In order to improve energy access YCF believes links must be made between rural and urban settings, and in particular infrastructure must be improved to enable easy flow of products and knowledge to and from rural communities, as this is an important first step in expanding knowledge and moving away from agricultural dependency. YCF is discouraged to see that these links are not forming at a more progressive pace.

Six out of the seven interviewees (excluding the urban participant) stated that there were three main aspects that allowed them to positively access solar energy, the most important was initial exposure to this option as an alternative business platform. Exposure was mostly through word of mouth or seeing an example while traveling outside of their community. The second aspect was the initial facilitation to a specific package from Sepon. Since solar is a fairly new technology (from the interviewees perspective) it was vital to acquire a preinstalled kit that got their business up and running instantly. They stated that if they had to cobble a system together themselves, they would have failed and given up out of frustration. The third and final important step in their initial acquiring of solar systems was access to capital investment and microfinance. For all respondents, except for ROK, the SAC model was a vital entry point into operationalizing their business ventures.

4.9 Sepon SAC Intended Livelihood Outcomes

It is useful to see how Sepon's self-described eight aspirant outcomes were relevant in the interviewee's lives. These eight goals aside from creating a sustainable busines model also contain secondary objectives that contribute to society, environmental sustainability and poverty reduction. The below table contains these 8 elements and gives a brief overview of how the intended outcomes were achieved.

Intended Sepon Outcome	Outcome
Improved Communication	Passively enhanced local networks and communication by creating a node for meeting and discussion in the community.
Shared business plans and ideas	Five out of seven beneficiaries described positive effects.

Stable lighting solutions for better security and childhood wellbeing	All seven beneficiaries described positive effects. Seven stated that they had better lighting, five stated better security, and seven confirmed benefits to their children and even extended families.
Creation of direct employment opportunities	All seven beneficiaries described positive effects. Five stated that they were able to indirectly employ others, and three stated that they were able to directly employ others.
Reduced poverty	All seven beneficiaries described positive effects. This included better improvements to housing, more purchasing power, and three nutritious meals per day.
Limiting dependence on biofuel use	Limited success: only three beneficiaries moving to gas for cooking
Promotion of a healthy and sustainable environment	All seven beneficiaries described positive effects. Four were able to reduce dependency on biomass and all seven reduced harmful agricultural practices.

Table 3: Sepon's eight spirant outcomes and SAC beneficiary response

All of the interviewees stated that their transition to solar power did not necessarily provide them with better communication. Aside from the fact that they were able to now charge their own cell phones, their communication networks and abilities remained relatively the same as before installation of solar at home or at their business. Although the interviewees stated that there was a passive connection between with solar energy providing more communication access, it did promote a sort of informal meeting place node which inadvertently impacted and enhanced their networks and communication as well as the frequency of these communications.

Five out of seven interviewees stated that they were able to share their business models and plans with others in their community. They were also able to be connected to other SAC participants when they had questions or problems with their equipment or seeking alternative business strategies. Knowledge sharing was improved by becoming part of the Sepon and CAN network. The two interviewees who did not feel the same way were the two outliers in the traditional business models, SUM and YCF. They stated that since their operations were so different from the others there was not much value in collaboration.

All of the interviewees stated that having a constant light source was beneficial to the security of both their businesses and their homes. Their children were also able to study later into the evening while removing any risk of burns or fires that are associated with kerosene lamps. Having a stable light source was remarked upon as being one of the most important aspects of solar energy. They also noticed their children's grades improved as a result of being able to study in a more stable environment.

Access to solar energy did create direct employment for the beneficiaries themselves. However, the businesses they established usually did not translate into creating jobs for others in their communities. SUM was able to employ 10 people, ROK was also able to employ 2 other individuals, and JIF employed a motorcycle driver. Overall the interviewees acknowledged their lives would have been much more difficult had they not made the transition to solar energy as a catalyst for additional socioeconomic activity. This additional area of downstream employment is quite impressive in areas where formal employment is difficult to attain. In total, Sepon indirectly contributed to creating an additional 20 jobs in these rural areas through supplying these 7 beneficiaries with the SAC model

On average, after adopting solar energy the interviewees made in excess of 500,000tsh (US$220) per month. This amount was far more than they could have earned with their former reliance on subsistence farming. YCF, for example, had only previously been making 1,200,000tsh (US$520) per year from farming. This drastic increase in monthly income was identified by the interviewees as a major success factor in their transition to solar-run business ventures. The link between poverty reduction and access to a sustainable energy source was strongly evident throughout the interviews and follow up discussions with the SAC participants.

Only three respondents (ROK, SUM and MID) changed their use of charcoal and firewood as a primary energy source after access to solar energy. This mixed result is not necessarily in line with anticipated transitions away from charcoal as displayed in the literature and as anticipated by Sepon. In Tanzania the majority of household energy use is entirely dependent on biomass, therefore shift of several individuals towards less environmentally destructive energy sources is encouraging. Unfortunately, due to issues around availability of gas for cooking in rural areas, the interviewees stated that it was still more reliable to continue utilizing energy sources as they had done before gaining access to solar power. The three interviewees who did transition to gas as primary energy source for cooking remarked that it was cheaper and cleaner than using traditional methods. This transition was stated to be especially important to their spouses and children who benefited from less smoke inhalation and more time available without having to physically collect firewood.

All seven respondents commented that solar energy was a major driver in reducing pressure on the local ecosystem. They were all able to reduce their use of kerosene and limit harmful agricultural

practices due to their alternative revenue source. Several of the participants, such as JIF, had previously engaged in the charcoal trade but had been able to stop completely after gaining access to an alternative income stream. The interviewees stated that the more people gaining access to solar power (even just simple lamps) greatly reduced harmful environmental practices and limited the risk of children sustaining burns from kerosene or wax candles.

Overall, significant improvements were made in the interviewees lives according to Sepon's intended objectives. One area that was overlooked by Sepon, and commented on extensively by the SAC participants, was improved security through having a constant source of light. This aspect was stated as one of the most important side benefits of having solar energy. Families felt safer in their homes and business owners felt more secure leaving their shops overnight. According to the interviewees this resulted in overall less theft and break-in attempts.

4.10 Conclusion

The above section reported on the findings gleaned from stakeholders participating in the Sepon SAC initiative and the role that they have in promoting small business initiatives among youth in rural communities. There was also a presentation of the effects that the Solar as Capital program had on beneficiaries' livelihoods and what sort of socioeconomic opportunities, they were engaged in. It further broke down the Awareness, Motivation and Pathways (AMP) model into the questions asked throughout the field interviews and observations that were made during the above study. By doing so the researcher was able to go in depth into how solar energy acted as a node of change and the resultant socioeconomic impact upon the beneficiary's livelihoods. This enabled the interviewer to gauge their responses both empirically and accurately prepare the upcoming discussion section.

5 Discussion

5.1 Introduction

The prior section presented the role that off-grid solar PV systems have in the lives of the SAC recipients. The discussion here will elaborate on the most prominent aspects of the findings as they relate to participation in off-grid renewable energy access with the SAC beneficiary's adoption rationales. This is done by locating the observations in the current Tanzanian development trajectory and the wider literature on the effects of off-grid renewable energy access in developing countries.

Drawing briefly on nodal governance theory (Drahos, Shearing & Burris, 2005, Holley & Shearing, 2016) that seeks to explain how private individuals and entities are securing their lives independently of, and sometimes in site of, the state. The discussion will thus be structured according to the various 'nodes' of change that the research observed to be provided by off-grid energy. This will enable concentration on the effects, both intended and unintended, of becoming energy independent. The research observes nodes of change conceptually. Effects that are highlighted in the discussion below include, improved social capital, economic development, financing, improved knowledge, reliability of energy, flexible operations, and escape from multidimensional poverty (security, healthcare, education, and financial security). Nodal Governance Theory will not be used as a prime theoretical framework, it is merely used to set up the basis for the various 'nodes' (non-state, polycentric actors and infrastructures) that impact the beneficiaries lives and those around them.

The discussion also integrates the AMP framework with the observable nodes providing an innovative conceptual analysis of off-grid renewable energy. To the researcher's knowledge this is a novel consilience. As the discussion demonstrates, integrating the findings from the application of the AMP framework along with corresponding nodes of change provides a salient view on how off-grid renewables affect adopters' lives and enables reflection of these changes within broader development trends and actions people have taken to increase personal security.

Energy consumption and production nodes are generally associated with significant negative environmental impacts (Council, 2010, Rockström et al., 2009). Off-grid options are often only available at a household-level to elites in a society, while this reference is over 14 years old the

interesting aspect to note is that this has not changed over time (Owen, 2006). This is also true for renewable energy types (Owen, 2006). This research found the reverse to be true for beneficiaries of the 'Solar as Capital' (SAC) programme in Tanzania, and in fact nodes of energy access had a wide range of environmental benefits, some intended, some coincidental and some and unintended. The early adopters in these rural communities have shown that through the SAC model there can be affordable and replicable energy transitions available to all segments of a society, regardless of income bracket. For early adopters, transition to solar led to lower charcoal use, due to their increase in disposable income – which represents significant economic and environmental benefit - and opened the door to new and varied occupational pursuits. While there will be some electrical waste generated, the inclusive nature of the economy is evident and the nodes for reliable off-grid energy present generally positive effects. The following section will discuss this further and, reflecting on the findings, theorize potential use of these observations and ways forward.

5.2 Analytical Framework

The Framework below presents the integration of selected aspects the theories utilized for this research, such as, IDT and AMP in Figure 4 in order to establish the discussion framework.

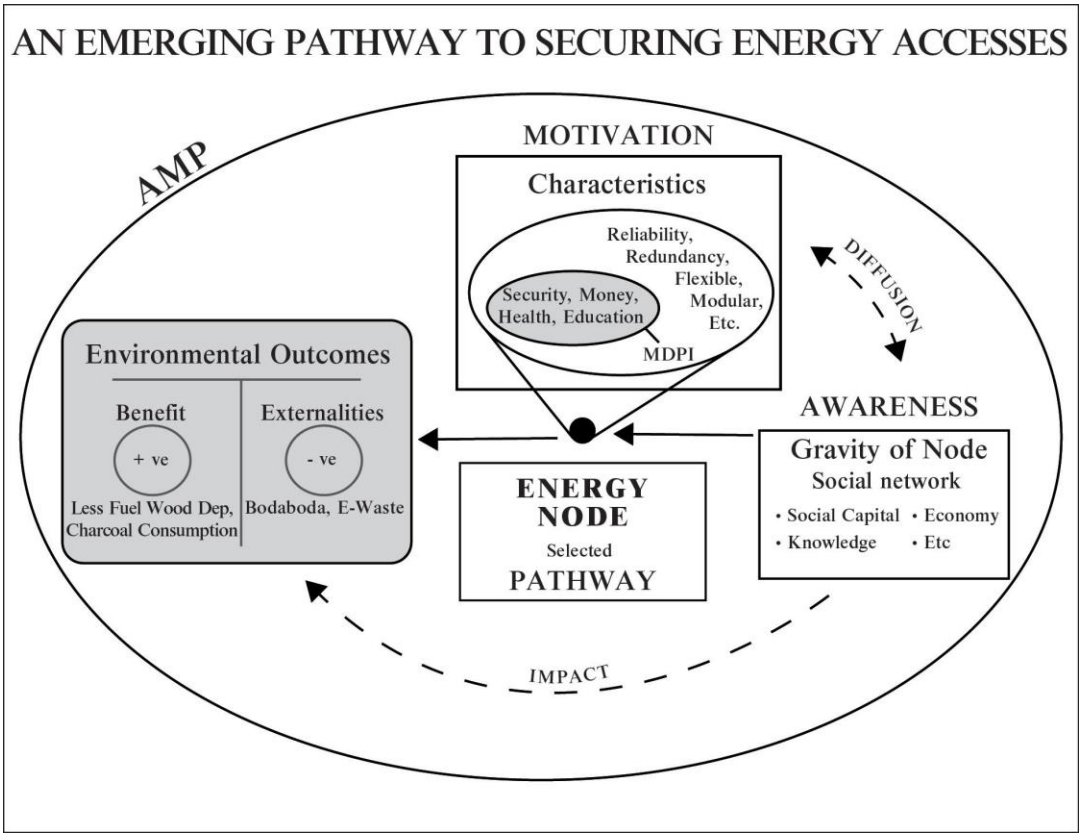


Figure 4: Analytical framework for securing energy access.

- Awareness: The understanding individuals (or organizations) have regarding how their actions or engagement impact a specific sector. Awareness was demonstrated in forming gravity for the following nodes: Improved social capital, resilient economic development, financing, and improved knowledge.
- Motivation: The reasons provided to take specific actions or decisions in pursuit of their goals. 'Motivation' was demonstrated in: Reliability of energy, redundancy of energy, flexibility of operations, MDPI (improved security, healthcare, education, and financial wellbeing), and also environmental impacts (both positive and negative).
- Pathway: What enabled a desired outcome to occur. This is displayed in longitudinal view of testing, adoption and enduring operation of selected technology.
- Diffusion: The above diagram considers diffusion to be, "The full use of an innovation as the best course of action" (Rogers, 2010:177). The diffusion theory describes five specific innovation attributes (1) advantage, (2) compatibility, (3) complexity, (4) ability to trial, and (5) observable traits (Rogers, 2010).

The following sections will discuss the salient findings of the research according to this framework and speak to the larger thematic issues uncovered throughout the research. In doing so it aims to concentrate on empirical observations of the effects realised in people's lives while demonstrating how this framework is a useful lens through which to consider impact and change.

5.3 Awareness

The following section will discuss how the attractiveness or 'gravity' of change at nodes of energy access brought increased awareness to the SAC beneficiaries' livelihoods. This impact ranges from improved social capital, resilient economic development with increased financial security, better financing options (where the individual technology itself becomes the financer), and an improved knowledge base, not only for the individual but also the community as a whole.

Grassroots decisions, investments and movements taken in the creation of a social economy, are an important aspect of sustainable transitions within a society (Bauwens & Defourny, 2017). These processes are often organic and comprised of a wide range of actors, both external and integrated within communities (Defourny & Develtere, 2009). One of the most important influences that individuals have in their communities is the role that their, "personal interactions and social networks typically play in their business models" (Bauwens & Defourny, 2017:204). This has been displayed in the relationship between adopters, Sepon and the variety of communities SAC beneficiaries belong to. Individuals involved in early adoption, like those described of Sepon beneficiaries above, play an integral role in contributing towards sustainability locally through

creating potentials for individual and collective action against contextually specific social, economic and environmental challenges within their communities. This case study has indicated that such action is closely related to an individual's unique placement within their communities and forms an integral part of the social capital node (Bauwens & Defourny, 2017:204).

The improvement of social capital has been demonstrated to have a positive impact on broader community level transformations and linked to elements such as climate adaptation, community development, environmental resiliency, socioeconomic benefits, and improved healthcare (Bauwens & Defourny, 2017). These elements were evident throughout the discussions with the interviewees. Their adoption of solar energy increased not only their financial wellbeing but had a knock-on effect in improving their lives in additional areas. These effects did not go unnoticed to others around them and contributed a level of attractiveness to the node. Due to their placement within the community they became focal points for those around them to gather, learn, and discuss avenues to energy access and thereby a potentially more prosperous and sustainable future. This impact was particularly observed during the interview process, with large volumes of individuals gathering around SAC beneficiary's shops, and in the acknowledgements of the interviewees becoming catalysts for change within their communities which assisted in spreading the node of social capital.

In order to achieve economic development goals, set by national governments across Sub-Saharan Africa, greater understanding is needed of the role energy access - and in particular renewable energy - plays in local economic development. Currently within the region only around one third of households have access to some form of electricity (Deichmann et al., 2011). Through the establishment of off-grid networks and associated social networks, renewable energy has been promoted for its role in bolstering economic development at a grassroots level (Deichmann et al., 2011). This was demonstrated in how SUM was not only able to create a thriving business due to their access to solar energy, but also in creating employment for ten members of the community, contributing greatly to the local node of economic development. The low cost of solar energy, and predictions of continued price reductions over the next twenty years, position this technology as an ideal option for a majority of rural households and businesses across Africa (Deichmann et al., 2011). The transition to solar energy has led to significant alternative revenue streams for all of the interviewees. With initial annual incomes corresponding to the 2016 national average GDP of US$867 per year, interviewees in this research saw their average monthly income boosted from

200,000tsh (US$85) to over 500,000tsh (US$220) (Mganda, 2018). Therefore, the increase to over US$2400 per year is over 200% the income that the majority of their fellow Tanzanians earn, enabling them to have additional access to better livelihoods and further spread the node of economic development. The SAC participants stated consistently that this sort of boost in income would never have been realized had they continued farming or focusing on charcoal production. This observation highlighted the imperative economic inclusivity.

Globally, Sub-Saharan Africa is currently the lowest per capita region for energy consumption; when excluding South Africa (Deichmann et al., 2011). Directly addressing this gap through the continued adoption of renewable energy is considered a prime solution to, "significantly reduce rural poverty" (Deichmann et al., 2011:216). The role that solar energy has played in the lives of the SAC beneficiaries has shown that there is a direct relationship between accessing this form of technology and their financial wellbeing. According to a World Bank (World Bank, 1996) report there is significant evidence to suggest that switching to electricity reduces the use of unsustainable biomass fuels and results in both an individual's economic wellbeing and health. An additional World Bank Report (World Bank, 2001) states that, ''Efficient and clean energy supply is central to the reduction of poverty through many and varied linkages, as well as being important for economic growth" (Deichmann et al., 2011:216). The switch to an alternative source of energy enabled individuals like ROK, SUM, and MID to all afford switching to gas as an alternative. This had a significant reduction in their consumption of charcoal and firewood as a fuel source. All of the interviewees mentioned that since beginning their solar energy powered businesses they were able to financially afford better healthcare alternatives for their families.

While Sepon provides unique financing arrangements with their SAC beneficiaries it is important to examine the role that broader aggregation financing mechanisms have and where this case study is located on a wider stage of energy access. The International Institute for Environment and Development (IIED) recently published a report that frames their view of future energy access globally, with one area of specific focus being East Africa (Garside et al., 2019). They state that there is a significant funding gap currently present within the off-grid energy sector (Garside et al., 2019). There is a recognized need for more effective solutions promoting 'nodes' of financial access to millions of off-grid projects and communities (Garside et al., 2019). They also recognize such financing can open an "attractive pathway for bigger investors to move more money into off-grid energy projects" (Garside et al., 2019:3). IIED highlights SunFunder, as an example of an

organization in Kenya working to facilitate off-grid renewable energy finance. SunFunder's main goal is to provide a pathway for companies, and individuals, to access both private and public financing (Garside et al., 2019). Alongside the provision of financing they also contribute by, "building demand, awareness raising, quality assurance and monitoring, training, data collection and information sharing" (Garside et al., 2019:3). IIED states that key stakeholders in the financing of off-grid energy can learn from their business model and contribute to "tailoring aggregator platforms" in order to accomplish SDG 7 (Garside et al., 2019:3).

There are various challenges associated with aggregation and the financial services provided through organizations like Sunfunder. These sorts of organizations usually require that, "prospective companies must have the ability to service loans with interest, which would require evidence of consistent cash flows. This precludes most start-ups and many early-stage companies" (Garside et al., 2019:42). For poor people, like the interviewees who participated in this study, access to conventional financing mechanisms is limited or non-existent.

Despite many conceptual and practical overlaps, the research conducted with Sepon and the SAC beneficiaries did not find the aggregation assumption promoted by the IIED to be as appropriate nor generalizable as they imply. While promoting nodes of financing is usually a pre-requisite for larger scale projects, in the case of Sepon their SAC model makes the resource itself the financer. This sort of approach, where technology is introduced and goes on to create substantial returns for the adopters, is therefore an alternative to the aggregation model proposed by the IIED and organizations like SunFunder, and potentially more viable for marginalized communities lacking in minimum finance qualification. This creates a valuable node of financing in these local communities and contributes to self-dependence external from third party funding. By circumventing this issue and creating self-financing grids of SMEs, the Sepon business model is well positioned to more appropriately contribute locally and incrementally towards SDG 7 (Affordable and Clean Energy). It is within this economic cohort that Sepon and similar organizations are quickly establishing themselves through nodes of energy finance on the front lines of achieving energy access for the rural poor in energy disadvantaged communities.

The important role that the Sepon beneficiaries play in creating a node for knowledge building and sharing is displayed in the case study as a vital aspect of initial introduction of novel technologies to others in the community seeking energy options. From an external perspective, companies like

Sepon see that small entrepreneurs are "poised to be the interface between energy enterprises and customers as they are able to market and sell products in areas that may be difficult to reach through more conventional retail distribution methods" (Pailman, 2016:141). Throughout the interview process it was noted that there was an important relationship between the SAC candidate's adoption of solar energy and their role in the technology spreading further. This was evident in the relationship between Respondent ROK and Respondent SBK. Without Respondent ROK first accessing this technology, Respondent SBK claimed that they would not have pursued it as a viable option. This observation highlights the imperative of the social principles of equality and participation that occur as a result of the adoption of off-grid technology.

Past initiatives to introduce solar energy solutions from the government or other external actors have not always led to wider acceptance and lack of trust within a community. This is due to a variety of local factors, but in general according to Vinci et al. (Vinci et al., 2015:17),

> A fundamental reason behind this lack of trust is that government programs and NGOs often installed off-grid lighting systems but failed to maintain them. The broken systems remain dysfunctional, setting a benchmark for how these communities perceive the technology and eventually requiring substantial resources to recover lost trust.

This distrust of external and state actors was observed in incidences where uptake in these rural communities did not occur or endure. Examples include a local church receiving funding from the city to install solar lights, and a program run by a third party to establish a microgrid. Both of these projects failed due to technological issues and did not prove a catalyst for solar energy uptake within the community. The influence that individuals, like Respondent SUM, have in spreading this knowledge was evident in the fact that all 10 of his employees purchased solar light solutions for their own homes. When questioned in their place of work, the employees stated that they saw the changes that solar energy brought to their employer and the improvements to quality of life his family experienced. They in turn wanted the same thing for themselves and actively pursued it. Now they state that they owe their better quality of life, described in terms of both financially and health improvements, to SUMs initial adoption of this energy source.

The above results section displayed an important role that small entrepreneurs play within the clean energy value chain. This transition has roots in the inclusive business concept and creates strong nodes of knowledge sharing within the community. While the concept of an inclusive business has been recently promoted, for two examples the World Business Council for Sustainable

Development (WBCSD) and Benner et al. (2018), there is little evidence of sustained and inclusive growth of businesses that benefit the rural poor in Africa. An inclusive economy needs to provide essential services to address the requirements of the poor within a community (Benner et al., 2018). This includes, but is not limited to, improving access to water and healthcare options in addition to energy and is achieved through creating income and employment generating options within poor communities, both directly and through value chain developments and adaptation via local service providers (World Business Council for Sustainable Development, 2012). In varying degrees, the SAC beneficiaries display these elements of an inclusive business, particularly as a node for information and knowledge transmission. The above observation highlights the imperative for economic inclusivity in these communities.

Currently one of the driving factors influencing people to access alternative forms of energy is the unreliability of the national energy provider, the Tanzanian Electric Supply Company (TANESCO). There are often power surges or outages that damage equipment and leave businesses stranded. This has negatively impacted the public and private sector (AFDB, 2015). The government has attempted to alleviate these challenges, but the overall successes limited (AFDB, 2015). The desire of accessing the reliability of alternative energy sources, even when able to connect to the main grid, is demonstrated in Respondent MID's transition to solar power to more efficiently run their business.

Tanzania is a large nation and has a very scattered and low-density population; this often makes connecting to the main grid costly or prohibitive – particularly considering the low productivity of rural areas which present limited cost benefit. It is this very lack of access that creates opportunities presented to the SAC beneficiaries to extend off-grid services to their rural communities. The ability to establish small and medium enterprises (SMEs) through a variety of ventures in order to fill this vacuum is on the rise. The literature suggests this is commonly driven through phone charging stations and televisions that show sporting matches (Ondraczek, 2013). Field observations confirm this holds true for the SAC beneficiaries of whom the majority were engaged in providing one or both of the above services.

5.4 Motivation

The following section will discuss the motivations SAC beneficiaries have towards accessing and retaining solar use. This will explore the nodal characteristics of reliability, flexibility and

modularity of operations. The discussion locates these nodal characteristics in relation to their wellbeing effects considering how they enable beneficiaries to escape from particular dimensions of poverty through improvements in security, healthcare, education, and financial stability, and the environmental impacts solar has, both positive and negative.

Energy security was prevalent throughout the dialogue with the SAC beneficiaries. Even individuals like Respondent MID, the urban participant, stated that their transition to solar energy from the main grid was due in part to the increased reliability this energy node provided to their business operations. The motivations for transitioning to solar PV as an energy source have been observed in this case to include many aspects. These can be synthesized into four main themes: low cost, cleaner energy source, improved energy security, and low maintenance demands.

First, high quality solar packages have limited operational and maintenance costs and can be used for years without having any significant financial burden on its operators (Njoh et al., 2019). This aspect can be clearly seen in the success that Respondent ROK has had by utilizing solar energy for his business operations with limited repairs and maintenance required throughout the years.

Second, with each passing year solar energy is witnessing further cost reductions and has an additional benefit of providing a cleaner alternative to traditional biomass (Njoh et al., 2019). Respondents ROK, SUM, and MID have all succeeded to transition into alternative energy sources for their cooking needs, thanks to their increased income from solar energy-based enterprise. This has reduced the use of dirty lighting solutions like kerosene, and reduced biomass use, creating additional health and safety benefits for their families.

Third, solar PV provides guaranteed energy security, powering homes and businesses that would otherwise not have a stable source of power (Njoh et al., 2019). This was observed through observations all of the SAC beneficiaries. Even in the case of the urban Respondent MID the reliability and guaranteed source of power that solar energy provides to their business is one of the most important factors to adopt this technology.

Finally, and most important of all, “solar PV requires no fuel, and contains no moving parts; it is noiseless, emission-free and requires minimal maintenance” (Njoh et al., 2019:1016). The absence of fuel and complex management of solar technology was identified and consistently lauded by all the SAC beneficiaries. In the cases of many individuals like Respondents ROK, SBK, and SUM, they were able to save time and money by transitioning from generators as a power source to solar

which was far less complex to manage for their businesses. Njoh and his colleagues research collaborates the benefits of solar energy as seen through the lives of the SAC beneficiaries. These benefits place solar PV as likely an ideal energy solution for rural communities, providing the most affordability and least risk possible.

Solar PV systems establish a wide range of personal and business nodes within the communities that they are installed. This can be seen in the variety of occupational pursuits the SAC beneficiaries are engaged in. Provision of such services, such as printing, battery charging, and cold beverages, often required travel distances of over 20kms to more urban settings in order to be accessed. Having these services available locally established these businesses as informal gathering points which served to strengthen social relationships (Hajat et al., 2009). Similar findings were present in additional literature which states that, "The provision of basic electrical services such as cell-phone chargers, word processing, printing and faxing serve to uplift resources of these remote areas" (Hajat et al., 2009:2725). The majority of the interviewees participated in some form of telephone charging shop which strengthened both internal and external connectivity. This resulted in improved social capital and networking opportunities within their communities. When some participants, such as Respondent YCF, saw their revenue stream slowing down they changed their business from simply charging phones to providing solar lights and phone charging stations that individuals could take home with them. This ability to switch from one economic activity and focus on something else as needed presents a wide range of potential revenue streams to the interviewees and create additional nodes through the flexibility and modularity of the solar systems being utilized.

Adoption rationales for solar energy are not only limited to economic benefits but also to the role that they play in improving multiple aspects of their lives. This was evident throughout the field observations, and has been observed in the broader literature, "the user's perception of the benefits of the solar home system resulted in a higher level of adopter's satisfaction; perceived benefits include the quality of equipment and change in household lifestyle, such as an increase in children's study time" (Guta, 2018:194). All of the above SAC beneficiaries mentioned that one of the best benefits of solar energy was that their children could now study later, and more efficiently, with an overall positive development noticed in their academic performance. An additional benefit found through solar energy was in a reduction of biomass use and kerosene lamps for lighting. According to the African Development Bank (AFDB, 2015), household use of biomass leads to

cases of respiratory disease with a disproportionate effect on children and women. All of the SAC beneficiaries stated that solar energy provided not only stability but reductions in the risk of burns associated with kerosene lanterns.

The adoption of solar energy has an impact on the environment as well. These impacts take on a form of both positive and negative disruptions in a community. With positive disruptions occurring through the benefits brought about by the adaptors adopters' newfound lifestyles and improved socioeconomic condition (Amuzu-Sefordzi et al., 2018). On the other hand, negative environmental disruptions can be caused by, "changes in a social system that are perceived as sacrifices or trade-offs to realize the adoption of an innovation (Amuzu-Sefordzi et al., 2018:141). For example, positive disruption can be seen in the transition from biomass to a solar cooking stove or in providing stable lighting for children to study. A negative disruption could include the discarding old solar batteries after using them or in the purchasing of a motorcycle (fuel consumption, spare parts, eventually discarded) due to newfound cashflow.

Tanzania is projected to experience severe negative impacts as a result of climate change and environmental challenges in the near future. The majority of this impact is due to the fact that, "95 percent of Africa's as well as Tanzania's agriculture is rain-fed" (Komba, 2014:2). Most farmers in Tanzania have relatively small landholdings with only 0.3 to 4 acres per family under cultivation (Komba, 2014). Changes in precipitation can have a wide-ranging effect on people's socioeconomic status which revolves around subsistence farming. These small holder farmers are "generally considered to be most vulnerable…because of their reliance on rain-fed agriculture" (Arndt et al., 2012:378). Due to deforestation and other elements of environmental degradation Tanzania has seen a wide variance in rainfall which brings uncertainty in the livelihoods of these small holder farmers (Komba, 2014). The role that solar PV can have in bringing diversification into income streams and bolstering resilience can be seen in the lives of the SAC beneficiaries. All of them except for Respondent MID were subsistence farmers or charcoal producers before adopting solar energy to provide an alternative revenue stream. Changes in their lives reduced pressure on the productivity of their surroundings and contributed to overall better living and environmental conditions. In order to prevent dependency upon agriculture and other ecologically harmful occupations, additional socioeconomic opportunities through nodes of clean technology, like solar PV, are therefore important to explore. This observation highlights the imperative of the principles brought about by socio-ecological inclusivity through off-grid energy.

East Africa has experienced widespread deforestation. Current estimates place this loss at over 28% of natural forest loss over the past 30 years in order to facilitate expansion of farm land (Otieno & Anyah, 2012). As recently as 2009 biomass use in Tanzania was representative of over 88% of total energy consumption (AFDB, 2015). With such a dependency on biomass Tanzania is experiencing an alarming rate of habitat loss leading to increased environmental concerns. A report released by the Food and Agricultural Organization (FAO) states that currently Tanzania's deforestation is taking place at a rate of, "372,000 ha per annum, which results in heavy pressure from agricultural expansion, livestock grazing, wild fires, over-exploitation and unsustainable utilization of wood resources…" (FAO, 2014). According to all of the individuals interviewed during this study solar energy reduced their personal biomass use and harmful agricultural activities. Three individuals switched entirely to alternative forms of cooking.

5.5 Pathways

The following section will discuss the various pathways that the SAC beneficiaries took in their quest to access solar energy as a socioeconomic catalyst. This section will explore the Innovation and Diffusion Theory (IDT), efforts in mitigation and adaptation, the influence community nodes created through their adoption of solar PV.

The SAC beneficiaries present a varied and successful example of how adopting solar PV can bring about positive and enduring change within communities. There is emerging literature that holds potential for further research to the results of this case study and retrospectively aligns with much of the findings. For example, in his Innovation Diffusion Theory (IDT), Rogers (Rogers, 2010) describes the adoption process as a decision for, utilizing an innovation fully as the ideal way forward. This suggests a level of awareness of the potential value and intentionality of use on the part of the decision maker regarding that type of innovation and its potential face value compatibility with the Awareness component of the AMP framework. He also goes on to describe the diffusion of this adoption as the, "process by which alteration occurs in the structure and functions of a social system" (Rogers, 2010:6) which aligns strongly with Motivational and Pathway components of AMP. It is within this diffusion from identifiable nodes that innovation occurs and a particular practice or object that is new becomes first perceived and then adopted as a viable alternative to what they were doing before (Rogers, 2010). In rural communities the social system is responsible for this process and the individuals within that system have great sway in

how this process transitions into a reality. In the case of the SAC beneficiaries the impact that solar energy had not only altered their lives but also positively impacted their wellbeing and decision making.

In order to more clearly comprehend the adoption pathways observed in this case study it is insightful to consider how Rogers IDT model recognizes five innovation attributes that are relevant to this case study. These attributes are as follows, (1) advantage, (2) compatibility, (3) complexity, (4) ability to trial, and (5) observable traits (Rogers, 2010). Rogers suggests the success of these crucial adoption attributes is based upon, "the degree to which an innovation is perceived as better than the idea that precedes it" (Rogers, 2010:15). This needs to take into account the innovation's role in community values, experience, and current requirements of the individuals choosing to adopt (Rogers, 2010). It is important for adopters to be able to test the technology and as a result their experimentation is visible to others around them. This was evident in the interviews conducted with the SAC beneficiaries. They saw the advantage that solar energy could have in their lives, they realized it was compatible with their surroundings, it was a technology with limited complexity, and through Sepon they were able to access it and experiment with it in their immediate vicinity. While the researcher of this case study did not set out to specifically explore 'diffusion' or the broader IDT, during the field work, it has however emerged as an important theme for further research and discovery that could provide a valuable basis for why individuals, such as the SAC beneficiaries, choose adopt external innovations.

The societal and cultural barriers to solar adoption in rural African communities often relate to "social structures, norms, awareness, perception of risk and lifestyle issues" (Amuzu-Sefordzi et al., 2018:141). With the widespread acknowledgement that solar PV can easily penetrate these barriers in a culturally sensitive way, it positions itself to be a major catalyst in enhancing the resiliency of disenfranchised communities (Amuzu-Sefordzi et al., 2018). Once the SAC beneficiaries began taking steps towards energy independence themselves, they contributed to wider acceptance within their communities towards this alternate source of livelihood development. These findings confirm those found elsewhere where continued success factors of enduring entrepreneurs have been linked to three elements, access or availability, capacity, and quality (Harrington et al, 2020). The above were found to be a major factor in the SAC beneficiaries continued use and early adoption of off-grid solar technology.

It is important during the adoption process to explore the role grassroots actors have in the diffusion of new technology. An example of this can be seen through a program established by the charity, The Smart Villages Initiative, the goal of this program is to ensure that SDG 7 is met through promoting rural electrification (van Gevelt et al., 2018). A key aspect of the initiative is to ensure that promotion of off-grid electrification must be, "founded on a more integrated approach to rural energy access in which increased emphasis is placed on the use of renewable energy and modern information communication technologies (ICT) to enable productive enterprises and the provision of key services" (van Gevelt et al., 2018:139). Throughout the Smart Villages process it was found that community members adoption was a key element of successful transformation. Often external actors were unable to respond to or identify localized challenges. They also tended to introduce solutions that were not relevant in a given situation (van Gevelt et al., 2018). They concluded that there needs to be a more holistic approach when addressing energy access problems. This process involves the integration of agriculture, provision of services, energy solutions, and private enterprise (van Gevelt et al., 2018). In the case of Tanzania, it can be argued that there is opportunity to avoid large investments in grid infrastructures, and their associated lock-ins, as evident in the challenges currently faced by South Africa (Jaglin & Dubresson, 2016) or California (Forrest et al., 2018). Through the adoption of technology provided by companies like Sepon there are endless options for implementing new innovations and technological solutions. This approach is in stark contrast to developed countries where past restrictions often dictate operational approaches in the present (van Gevelt et al., 2018). This sort of approach gives these solar entrepreneurs the ability to jump ahead of individuals in more developed countries by leveraging current technology into actionable solutions (van Gevelt et al., 2018).

5.6 Adaptation and Mitigation Co-Benefits

According to the UNEP climate change mitigation "refers to efforts to reduce or prevent emissions of greenhouse gases" (UNEP, 2019). Mitigation efforts can have come from a variety of sources but often tend to utilize new technology or renewable energy. Changes within traditional 'best practices' are also an important aspect of any climate-based mitigation methods (UNEP, 2019). Such efforts can be as simple as improving cooking methods and reducing dependency on biomass. The above reduction methods help to contribute towards lower greenhouse gas emissions and form an important step in the creation of a society that is resilient to the destructive elements of climate

change (UNEP, 2019). These elements of mitigation were evident in the changes made in the livelihoods and lifestyles of the SAC candidates. If the SAC program, and others like it, can be replicated at scale, considering the percentage population of Tanzanians dependant on biomass, these off-grid energy nodes have substantial potential to reduce current rates of anthropocentric carbon dioxide emissions and other suspended particulate matter into the atmosphere. Examples of mitigation include less deforestation, varied occupational pursuits with a transition away from agricultural dependency, and environmentally sound energy production.

Adaptation can be defined as an, "adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities" (England et al., 2018:2060). Initially global policy was focused on lowering greenhouse gas emissions and preventative measures to reduce anthropogenic climate forcing on a global level, yet more recently there has been a shift into how adaptation can have a more localized response (Mercer, 2010). For the purposes of this research when adaptation is considered it simply means that people have taken specific steps to adapt to climate change effects. Various studies around the world state that off-grid solar energy is a form of climate adaptation, for example Fang and Wei (date and pg. here) state that the, "exploitation and utilization of renewable energy, especially solar energy, is a clear domain for climate change adaptation" (Fang & Wei, 2013). Another journal article states that decentralized and properly implemented off-grid energy projects are an ideal adaptation response to the threat of climate change in the developing world (Venema & Cissé, 2004).

While the above might be correct in some parts of the world it did not hold true for this case study. Based on the ethnographic foundation of the interviews and how the beneficiaries articulated the motivations they had for adopting solar they did so out of a motivation to improve their lives. They did not choose renewable energy adaptation in response to perceived climate risk but according with their needs and desire to improve their livelihood options through energy access. In order to do so they had to navigate unstable governance, energy access, lack of awareness, and limited socioeconomic or livelihood diversification options. Therefore, while adoption of solar power in other contexts may be framed according to or seen to be motivated by particular adaptation adoption rationales, this was not the case for the SAC candidates. Although there seems to be an assumption in development and sustainability discourses that the transition to renewable energy is or should be climate adaptive, the results of this research show that the actions of SAC

beneficiaries, when understood from their AMP view point, provide substantive mitigation outcomes while adaptation outcomes can rather be understood as co-benefits in their embrace of renewable energy.

What has been of interest throughout this case study is how nodes of energy access create diffusion gradiences which enhance the potential for adoption. When considering how private individuals, acting in their own capacity, are seeking to secure essential public goods, especially when the state is failing to provide these goods to them, across the world, developed countries with centralized distribution networks are failing because of climate shocks. An example of this can be seen in Hurricane Marias devastating impact in disrupting Puerto Rico's main grid power supply and the Cape Town drought's (2015-2018) impact on the City of Cape Town's water reticulation network. According to Simpson (Simpson, 2019:226), "Hurricane María decimated Puerto Rico's grid and disrupted the power utility's ability to produce and deliver electricity. More than a year later, the island is still not prepared for another hurricane". In cases like this there have been many calls for a drive towards renewable energy as a more sustainable alternative, yet these sorts of initiatives are, "viewed as a threat to the central utility and have resulted in push-back by established interests which risk losing their governing reach" (Simpson, 2019:226). This sort of transition holds difficulties in nations where the state provides services for a fee. In the case of Tanzania, the state has failed to provide these services and, in some instances, has not even attempted to do so. Rather than see this as a negative aspect it can instead be viewed as an opportunity to establish a robust and climate change resilient off-grid nation. Climate change may severely disrupt conventional centralised grids, like water or energy, as seen in the example of Puerto Rico (Simpson, 2019). The emerging developments observed in Tanzania hold potential for a 'leap-frogging' of such centralised networks to off-grid nodal benefits through their adoption of solar energy.

5.7 Design principles for inclusive off-grid energy access

Based on the case study and lessons learned, design principles are proposed as a means of learning from one case study, reflecting on those lessons in light of more fundamental principles (such as an inclusive economy and a strong sustainability) and then applying those lessons learnt to the next iteration of interventions. The following field observations of nodes of off-grid energy access underpin environmental principles of sustainable resource management and socio-ecological

balance, social principles of equality and participation, and economic principles of access and stability (Liu & Simpson, 2019:35).

Potential design principles for energy interventions in Africa need to therefore consider:

1. Decisions are made leading up to and during the adoption process need to consider long term impacts, including environmental, on the surrounding society together with both intended and unintended consequences (Liu & Simpson, 2019).
2. Appropriate technologies that provide incremental economic improvements can decrease pressure on the local ecosystem.
3. Increased education and socioeconomic stability can bring about a downward trend in local and communal inequality.
4. Both beneficiaries and others in their location benefit from improved connectivity and ease of living (Liu & Simpson, 2019).
5. Off-grid and green energy can play a role in a low carbon energy transition away from biomass.
6. Technology diffusion throughout a community can usher in a slow transformation towards economic stability throughout the community and contribute towards more general economic resilience towards shocks and stresses (Liu & Simpson, 2019:35).

5.8 Discussion Conclusion

The above section also integrated the AMP framework with the observable nodes providing an innovative analysis of off-grid renewable energy in Tanzania. As stated previously to the researcher's knowledge this sort of consilience has not been undertaken previously. The integration of the AMP model alongside nodes of change shows how off-grid renewables affect adopter's lives and enabled beneficiaries to increase their personal and financial security.

The above discussion section highlighted the most prominent aspects of the findings and has shown how Solar PV systems are facilitating young Tanzanian small business owner's participation in off-grid renewable energy access. Research focused on the current Tanzanian development trajectory and wider literature regarding the effects of off-grid renewable energy access has in developing countries. This was done by exploring the various 'nodes' of change observed through the provision of off-grid energy and revealed the range of effects, both intended

and unintended, of energy independence. The main nodes that were highlighted included, improved social capital, economic development, financing, improved knowledge, reliability of energy, flexible operations, and escape from multidimensional poverty (security, healthcare, education, and financial security).

Throughout this research, it was of interest that these nodes of energy access had a wide range of environmental benefits, both intended and unintended. Early adaptors in Tanzanian rural communities have shown that through the SAC model there can be affordable and replicable energy transitions available to all segments of a society, regardless of income bracket. Such adoption of off-grid renewable energy has enabled the beneficiaries to become self-financed and able to control more of their own security and individual prosperity.

6 Conclusion

This research set out to explore individual's rationales for adopting off-grid energy (adoption rationales) and personal effects of access to household-level renewable energy for youth (ages 18-35) in Tanzania in eastern Africa. As seen in the above sections, this research engaged on a deeply personal level with some of the beneficiaries of a locally run business that set up a unique program referred to as Solar as Capital (SAC). The research was guided by in depth interviews and supplemented by field visits and examined how off-grid energy systems impacted the lives of these beneficiaries. The SAC model proved to be a great example for this research and would be a good basis for additional exploration into how private sector innovations can impact rural communities.

The link between and compounding effects of energy access and socioeconomic poverty has been well established in the literature and is strongly affirmed by this research. Considering adoption rationales provides highly instructive framework to understanding how solar energy use can be encouraged in rural Tanzanian communities. In terms of awareness, this research indicates that word of mouth is a crucial component to scaling solar energy solutions. Rural communities need to see with their own eyes what is possible. Because of the deep-seated mistrust of large government and NGO projects, organic, grassroots delivery over time is likely to be much more effective than a large regional roll-out all at once. Additionally, it is important to understand motivation as a key element to adopting new technological systems or innovative product designs.

Through the adoption of solar energy, the Solar as Capital beneficiaries saw many changes in their livelihoods. They became less dependent on biomass for cooking which had positive health implications for their whole families, improved security, financial gains and pursuit of additional external investments, along with creating nodes that benefited both the community and surrounding environment. Through unique strategies available to youth that are being provided by companies like Sepon there is a chance for individuals in off-grid and rural contexts to take development into their own hands. The above research has shown that a business as usual approach to industrialization of developing nations can be driven by grass roots actors such as the Solar As Capital beneficiaries and does not need to be conducted as western nations traditionally pursued economic development. This is a chance for nations like Tanzania to forge their own destiny and leapfrog past decades of harmful industrial practices while also ensuring that their citizens are able to gain meaningful occupations and living standards.

This research has indicated that for the consumer in rural Tanzania, the first bar of success is low – early adopters want to create businesses around charging phones and solar lights. Just through moderate increases in their income means that they can move away from biomass cooking. People want to have lights in their house for security and for education. This has critical implications for system design – people want an easy to use, low-capacity system that can charge batteries and power lighting. In terms of the pathways individuals take, it is important to build on the idea the initial marker for success for rural consumers is relatively low, solar businesses and policy makers must focus on solutions that do not rely on complex banking or financing to get started. The entrepreneurs in this study demonstrated ability to take basic systems and adapt them over time to suit their needs and market demand within their local community.

Understanding how people seek to improve or secure their lives through establishing more secure 'nodes', provides a foundation for how the impact of off-grid solar PV systems extends to so many aspects (nodes) of life which remain poorly understood, ungoverned and therefore unsecured for the rural poor of Africa. Understanding how practices of adoption diffuse through a community and affect scalability (Diffusion Theory) is an important aspect of any new embrace of external technological adoption. There is room for future research to provide more robust consilience between the theoretical notions applied and extended here, but this thesis has created a preliminary foundation for additional pursuit in linking the above theoretical concepts empirically.

This research has shown there are many challenges that nations like Tanzania face while in the pursuit of pathways towards resilient economic development. While realizing that Tanzania faces many challenges, they also have the benefit of a large and youthful population base. Instead of relying on a business as usual approach and investing in agricultural development or expansion of existing energy grids, which are both expensive and fraught with challenges brought on by climate change, they can instead encourage uptake of innovative practices such as the model introduced by Sepon. The role that the individual Solar As Capital beneficiaries had was important in its contribution to both reducing energy access and created alternative socioeconomic pursuits. The case study has demonstrated a valuable example of how the implementation of such measures can be transformative in these societies. These findings have highlighted that interventions for energy access in Africa can learn from principles that underpin the success factors of this case study. They include environmental principles of sustainable resource management and socio-ecological

balance, social principles of equality and participation, and economic principles of access and stability (Liu & Simpson, 2019:35).

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8 Appendices

Appendix 1: The table below shows the justification for the selection rationale.

Location	Rural/Urban	# SAC Clients
Dar es Salaam	Urban	142
Bagamoyo	Urban	18
Dodoma	Urban	2
Coast	Rural	26
Morogoro	Rural	5
Zanzibar	Rural	3
Singida	Rural	2
Mwanza	Rural	3
Mtwara	Rural	1
Tanga	Rural	2
Grand Total		204
Total Urban		162
Total Rural		42

Appendix 2: Interview Schedule

The below interview will be transcribed via hardcopy and audio recording upon written consent of the interviewee. Once the interview is concluded, both the lead researcher and the research assistant will create a cohesive summary of the interview onto a soft copy. The hard copy will then be disposed of and audio recordings will be deleted after interviewer is satisfied the content has been appropriately transcribed. Each individual soft copy of the interview will be password protected and for additional security stored in a private and password protected storage drive with names anonymized. The interviewer confirms that if the interviewee at any point wants to stop the interview this can be done through verbal confirmation during the process and all records will be immediately deleted.

Questions below are structured according to AMP Category

Awareness

Technology

- What sort of equipment do you have?
- How does the technology work?
- What education do you have, certificates? Technical or electrical trainings?

Energy

- What energy requirements do you currently have?
- Other than solar what additional energy options do you have access too?

Motivation

Business

- What is your current business (how does the tech above enable you to do this)?
- What business strategies do you employ, what are operations like?
- What sort of customer base do you have and what do you charge per service?

Pathways

Empowerment

- What sort of employment opportunities are available to youth in the community?
- How has this business changed your life?
- What enabled you to access this technology and what might inhibit others?
- Closing statement? (Advice for entrepreneurs and policy makers?)