

Livelihood Impact of Solar Home Systems: The case of Ruimsig Informal Settlement in Gauteng

Shepherd Nyamhuno

2009063682

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Supervisors:

Dr Wessel Kruger

Dr Anita Venter

Abstract

The study focused on evaluating the impact of a solar home system (SHS) programme on the residents of the Ruimsig informal settlement in the City of Johannesburg. Furthermore, the study compared the SHS to the previous unclean energy sources such as paraffin, candles and firewood. The study used a mixed method approach made up of both quantitative and qualitative data collection methods. Data collection was done through the telephone to avoid human contact to minimise the chances of spreading the COVID-19 virus. A total of 245 participants were selected for the questionnaires and five for the interviews. In addition, three key stakeholders were interviewed. The study demonstrated that the SHS programme created numerous economic opportunities that were previously unavailable (78% concurrence), such as trading of electric appliances and the selling of entertainment gadgets. The respondents reported that they were able to work longer into the night (80%), transact well under the lights and do mobile banking. Moreover, the respondents confirmed that they saved money because there was no need to travel to banks since they could now transact from home and also save money used on fossil fuel and candles (75%) that had been replaced by the SHS. The programme included energy-saving fridges that added a competitive advantage to their businesses and also increased their ability to store business stock in the fridges. Socially, the SHS improved various aspects of the community. The respondents had a wider choice of entertainment (97%), could communicate better (98%), and their children could study longer into the night (99%). Also, the residents indicated that since they had access to SHSs, their sense of security had improved (85%), indoor pollution decreased (76%) along with coughing (94%). Lastly, shack fires have declined (63%); however, not just because of the SHS, but also as a combined effect of shack upgrades to brick houses. SHS were unable to power heating elements, such as stoves and irons, leaving the residents to use continue using non-renewable energy sources that still posed some challenges of smoke and fire dangers.

Key terms: informal settlements, Ruimsig, solar home systems, impact, health, economic, social, environment

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List of Abbreviations

AC	Alternating current
CoJ	City of Johannesburg
DC	Direct current
GHG	Greenhouse gas emissions
Ha	Hectare
kWh	Kilowatt-hour
LED	Light Emitting Diode
m ²	Square kilometre
NUSP	National Upgrading Support Programme
PV	Photovoltaic
SDI	Shack Dwellers International
SHS	Solar home systems
ToC	Theory of change
TV	Television
UISP	Upgrading of Informal Settlement Programme
W	Watt

Chapter 1

Livelihood Impact of Solar Home Systems

1.1 Introduction

South Africa has faced an increasing demand for electricity in recent years (Musango et al., 2011:124; Smit et al., 2019:39). As a growing country, the economy of South Africa demands more access to electricity by both households and businesses, outweighing its supply (Musango et al., 2011:125). The supply-side constraints of electricity have resulted in planned load shedding, with the country losing billions of rands because of the cost of production (Nkosi & Dikgang, 2018:2). There is a need to urgently address the energy poverty in informal settlements to spur economic growth.

Some informal settlements in South Africa still have no access to renewable energy. Many of them rely heavily on coal, paraffin, diesel, and primus stoves for cooking, heating, and lighting (Kimemia & Annegarn, 2011:383; Olaniyan et al., 2018:9). Lack of access to clean energy has resulted in many health, social, and economic ills in these communities (Nassar & Elsayed, 2018:1-2; Van Breda & Swilling, 2019:1-2; Wolpe & Reddy, 2010:3). The use of polluting energy sources poses both environmental hazards and problems of respiratory diseases when inhaled (Mahlakoana, 2010:14; Olaniyan et al., 2018:2). These energy sources have caused environmental pollution and incessant pulmonary diseases, particularly to minors, after smoke inhalation (Mahlakoana, 2010:14-15). Furthermore, studies have shown a relationship between community lighting and crime, with most unlit communities reporting mugging and robberies at night (Brown-Luthango et al., 2017:3; Kruger, 2005:1-2).

This study investigated the role of solar home systems (SHSs) as renewable energy in improving residents' livelihoods in informal settlements. Several pilot projects in South Africa have been financed through SHSs. This study assessed the impact of SHSs on the residents' livelihoods in the informal settlement of Ruimsig. Ruimsig, located in the West Rand, is an in situ informal settlement that spans 5.2 ha and is located in the City of Johannesburg (CoJ) (Bolnick, 2011). The origins of this settlement can be traced to the

late 1980s (Adegun, 2016:66). By the mid-1990s, the informal settlement had close to 50 shacks; it had grown in 2016 to more than 422 shacks, housing over 1 000 households (Adegun, 2016:66; Energy One, 2017:4). Between 2010 and 2013, Ruimsig informal community underwent an in situ improvement process that was part of South Africa's Upgrading of Informal Settlement Programme (Adegun, 2016:66). Despite being a relatively old settlement, established in the 1980s, the Ruimsig informal settlement was not yet connected to the national power grid (Adegun, 2016:66).

Various stakeholders have put forth many efforts to try to electrify informal settlements (Wolpe & Reddy, 2010:4). In the year 2014, Ikhayalami, Energy One and Shack Dwellers International (SDI) partnered to power the Ruimsig community with an off-grid solar energy project and upgrade the shacks to better, more durable houses (Energy One, 2017:4). The solar project was initiated and left to be managed by women who were residents in the community (Energy One, 2017:4). They were also responsible for revenue collection, management and getting technicians to help in times of challenges (Energy One, 2017:5). Ikhayalami created a hub that acted as an information centre for those who wanted the new solar panels, needed repairs or any connection challenges. Figure 1.1 shows some solar panels on the top of shacks and also night lights at a spaza shop.



Figure 1.1 *Solar home systems in Ruimsig informal settlement*

1.2 Problem statement

Every year, the unsafe use of non-renewable energy has been cited as a major cause of shack fires (Pithouse, 2008:64; Kimemia & Van Niekerk, 2017:289). Disasters reverse the gains made in improving the quality of life of residents who have to start afresh to acquire property. Informal settlements around Johannesburg have been protesting yearly over

poor service delivery, including demanding access to electricity (Buhlungu et al., 2007:54; Chikulo, 2016:52; Morudu, 2017:2). Informal settlements are areas where housing structures are illegally erected (Muanda et al., 2020:238). Access to electricity affects the quality of life and may connect the residents to the rest of the world through mobile gadgets, internet access and entertainment.

Several challenges hamper the electrification of informal settlements. Informal settlements are quite unstable settlements with very rapid growths and can disappear in a short time (Huchzermeyer, 2004:337; Kovacic et al., 2016:212; Walls et al., 2017:2). Some informal settlements are built on swamps, marshes and flood-prone areas unsuitable for human settlements (Dalu et al., 2018:4; Douglas et al., 2008:187; Kohli et al., 2012:154). Additionally, some informal settlements are being built on health hazardous terrains, with no roads for vehicles to get in (Mazeka et al., 2019:93; Pelling & Wisner, 2012:34; Walls et al., 2017:2). There are cost and ethical issues around municipalities providing basic services to an illegal settlement, whose residents may relocate even after installing costly permanent infrastructures. There are also infrastructural challenges in the informal settlements for the installation of electricity (Kovacic et al., 2016:221). Due to poverty, cheap materials are used to build informal shelters that may not be compatible with grid connections. Difficulties have been experienced to connect informal settlements to the national grid (Moagi, 2015:93; Selokela & Langerman, 2019:51-52).

Until 2016, the residents of the Ruimsig informal settlement have been using unclean energy sources such as charcoal, firewood, candles, paraffin and *imbawula*. *Imbawula* is a makeshift coal heater with small holes to release heat on the sides (Ndandani, 2020:12). Since Ruimsig residents received SHSs, it remains unclear what impact SHSs had on the residents in informal settlements, compared to the previous energy sources that the residents used.

1.3 Research question

What is the impact of the solar home system on the quality of life of the residents of the Ruimsig informal settlement, compared to the previous energy sources they used?

1.4 Research aim

This study aimed at understanding the extent to which the solar home system project impacted the livelihoods of the residents of the Ruimsig community. The study assessed the differences in quality of life before and after the SHSs to ascertain the full impact on the dwellers of the Ruimsig informal settlement.

1.5 Research objectives

The objectives of this study were the following.

1. To conduct a literature review on the technical aspects of solar systems and specifically the solar home systems.
2. To outline the theoretical framework of the theory of change that underpins the study.
3. To provide methodological underpinnings for the study.
4. To conduct interviews with beneficiaries of the solar home systems in Ruimsig and provide recommendations for future implementation projects.

1.6 Conceptual framework

This study mainly assessed how SHSs had impacted the livelihood of the residents of the Ruimsig informal settlement. Andrade-Pacheco et al. (2019:1) and Niu et al. (2016:550) adduced that electricity affects the day-to-day lives of human beings. The impact of SHSs on the Ruimsig informal settlement can best be investigated by comparing the livelihood circumstances of the residents before and after the implementation of SHSs. The study further assumed that SHSs changed the livelihoods of the residents and that the changes in the livelihood were attributable to SHSs. The changes brought by the SHSs ultimately contributed to the improvement in the quality of life. The conceptual and theoretical framework for this study is the Theory of Change (ToC). This theory allows the reader to see the connections between the intervention and the outcomes or impact. Through it, the reader can see how the study came to specific results. It prevents black-box evaluation in which a study comes up with results and interprets outside the context of the programme (Ramaswamy et al., 2018:16; Stöhr & Adawi, 2018:1-2). The ToC underpins

the theoretical framework of the study by connecting different elements such as the environment, social, health, and economic factors that lead to the anticipated impact.

1.7 Chapter outline

The rest of the chapters are outlined as follows:

Chapter 2: Solar Energy – This part of the research focuses on the solar power in informal settlements, provides technical aspects of solar energy, and explains SHSs and technical aspects of the working of SHSs. Where the study focuses on SHSs and outlines the technical aspects of solar energy in general, this chapter focuses on how solar energy is generated and converted into energy and the various components making up a SHS.

Chapter 3: Theory of Change Framework – This study is informed by the ToC framework. ToC is often used to evaluate the impact of development interventions and explore causal pathways between different elements that could have changed due to the intervention. The intervention, in this case, is to provide an informal settlement with SHSs. The causal pathways could have possible changes related to the environment, social, health and economic factors.

Chapter 4: Research methodology – The methodology of this study is a mixed method sequential exploratory approach based on evaluation research. The research design is a case study and focuses on the case of the Ruimsig informal settlement in Gauteng.

Chapter 5: Research results – The research results section shows the outcome of the data collection, including a detailed outline of the analysis of the data. The chapter amalgamates the questionnaires and the interviews to show the impact of the SHS upon the residents of the Ruimsig informal settlement.

Chapter 6: Discussions and Conclusion – This chapter analyses the results from Chapter 5 and look at what they mean. The chapter also summarises the whole study and conclude on the impact of the SHS to the Ruimsig informal settlement.

1.8 Conclusion

Informal settlements face problems of access to clean and reliable energy. As a result, they resort to unclean energy sources such as charcoal, firewood, candles and paraffin that will expose them to dangers such as shack fires and smoke inhalation. The Ruimsig informal settlement received an SHS programme from Energy One and this study evaluates the extent to which this made any difference. The ToC concept is used to answer the research question.

Chapter 2

Solar Energy

2.1 Introduction

In Chapter 2, the focus shifts to the relevance of solar energy, particularly decentralised energy provision, such as SHSs, for providing energy needs in informal settlements. The chapter first explores the context of energy poverty in informal settlements. The focus then shifts to solar energy and its role as a clean energy source to provide electricity in informal settlements. Much attention is placed on technical aspects. Understanding the technical aspects are imperative for the user to ensure long-term maintenance of solar systems. Lastly, a specific focus is placed on SHSs in South Africa, and the specific SHS that was used in the Ruimsig informal settlement in Gauteng.

2.2 Solar energy

Solar energy is the power that comes from the sun that is converted into thermal or electrical energy (Solar Energy Industries Association, 2019). The sun is a star 110 times bigger than the earth and the largest object in the solar system, and is larger than other stars in our galaxy (Ahsan & Hossan, 2014:8). Solar energy from the sun comes from its core, where the hydrogen converts to helium in a thermonuclear reaction. The light energy travels for 8.5 minutes from the sun to the earth (National Aeronautics and Space Administration, 2018).

The sun delivers its energy in two forms: heat and light. Consequently, there are two types of solar technologies: solar thermal systems that trap heat to warm water or geysers, and solar photovoltaics (PVs) that convert light into electricity (Tan & Seng, 2017:4). This study focused on SHSs that are components of solar PVs. Inganäs and Sundström (2016:15-16) defined PV technology as solar gadgets that convert light energy into electrical energy through semi-conductors. All solar panels are PVs. According to Ahsan and Hossan (2014), solar PVs are either grid-connected or stand-alone systems. Grid-

connected solar PVs are connected to the commercial power infrastructure, while stand-alone solar PVs feed electricity to a facility for immediate use or to a battery for storage.

2.3 Solar energy as renewable energy

Solar energy is renewable energy because it cannot be depleted (Inganäs & Sundström, 2016:16). Long-term sustainable development hinges on renewable energy, which has no risk of decreasing as is the case with non-renewable energy. Around the world there is a growing recognition of solar energy as a better way of supporting the demand for energy (Hayat et al., 2019; Kannan & Vakeesan, 2016). The demand for solar resulted in increased manufacturing and sharp decreases in solar prices (Chandler, 2018; Apostoleris et al., 2019).

There are several benefits of solar energy to countries and communities. The advantages of using renewable energy such as solar energy are that it preserves the environment better than non-renewable alternatives (Ahsan & Hossan, 2014:6). Fossil energies are harmful to the environment because they emit smoke and poisonous gases that have been responsible for the depletion of the ozone layer (MacCarthy et al., 2018:2; Abeydeera et al., 2019:1). The added advantages of solar energy are that it is cheap and more cost-effective than expensive fuels (Buonocore et al., 2019:11; Laslett, 2020:11).

Solar energy represents a vast opportunity of untapped possibilities. Harvey (2010:17) posited that the solar energy intercepted is 11 000 times the total energy demand for the entire planet. The challenge, however, is that the availability of this energy is inconsistent and at times in inconvenient places. The maximum solar radiation anywhere in the world is 2 200 kWh/m² per year, while the northern hemisphere often reaches a peak of 1 600 kWh/m² per year. Solar energy is converted into energy using PV panels that use a variety of solar collectors. As Harvey (2010:9) pointed out, the flux of solar radiation on a plane is called solar irradiation. By 2005, it was estimated that 0.7% of the world's deserts could supply power for the entire planet with an efficiency as small as 10%, which now many PVs have exceeded. However, getting power from the desert is a challenge. It is necessary that some of the energy generated, even when not needed, be converted into some other form of energy and reconverted when the need to use it arises.

There are two types of solar PV systems: utility-scale installations and distributed generation (Asian Development Bank, 2015). The utility-scale installations are large solar systems that usually require a large open land and often generate more than one megawatt of power (Asian Development Bank, 2015:xi). However, the distributed generation are usually mounted on walls and rooftops and generate power during the day and feed into the main grid (Asian Development Bank, 2015:xi). Several components of a solar PV support its functions. PV modules are made up of several linked cells to increase the power supply (Albadi et al., 2014:402).

According to Albadi et al. (2014:402), PV modules fall into two categories: monocrystalline or polycrystalline. Monocrystalline modules consist of one large crystal block of silicon; they convert the sunlight into electricity and are 18% efficient (Albadi et al., 2014:402). Polycrystalline is the most common type of PV module, although less efficient than the former. The efficiency levels of polycrystalline are rated between 13% and 15% (Albadi et al., 2014:402). Furthermore, polycrystalline PVs are also cheaper than monocrystalline PVs (Albadi et al., 2014:402).

In connecting solar PVs, batteries play an integral role in storing power generated during the day when the sun's radiation is converted into energy. Albadi et al. (2014:202) reflected that batteries are either lead-acid or deep-cycle batteries. Lead-acid batteries are most common and cheaper as an immediate investment, but do not last as long as deep-cycle batteries. Deep-cycle batteries are cost-effective in the long term. They can produce high currents of power at a relatively lower price if longevity is kept in mind (Albadi et al., 2014:402). A charge controller is a device placed between the solar and the charger and is responsible for regulating the flow of the current between the two gadgets. The charger controller prevents the overcharging of the battery by regulating the flow of the current into the battery as it gets full (Albadi et al., 2014:403).

Solar energy involves the use of PV technology to generate electricity. PVs is a technology that converts solar radiation to electrical energy (Ahsan et al., 2016:643). Solar energy is growing increasingly popular in countries that have a lot of sunny days in a year (Nirwan & Thakur, 2017:3190). Presently, there are three models through which solar PVs serve communities and businesses, namely solar rooftops, solar fields feeding directly into

communities, and solar fields feeding into the country's main grid to add to the national power supply (Asian Development Bank, 2015: xi).

As illustrated in Figure 3.1, solar panels convert the clean energy into direct currents (DC). DC is a type of energy that flows in one direction, such as a battery, and is mostly not commercially available (Herman, 2012:2-3). An inverter converts the DC power into usable alternating current (AC) power (Herman, 2012:2-3). Alternating currents regularly reverse directions of a power supply (Portela et al., 2008:44-45). An electrical switchboard has two outlets, one that measures supply directly to the household and one that feeds into the main electrical grid.

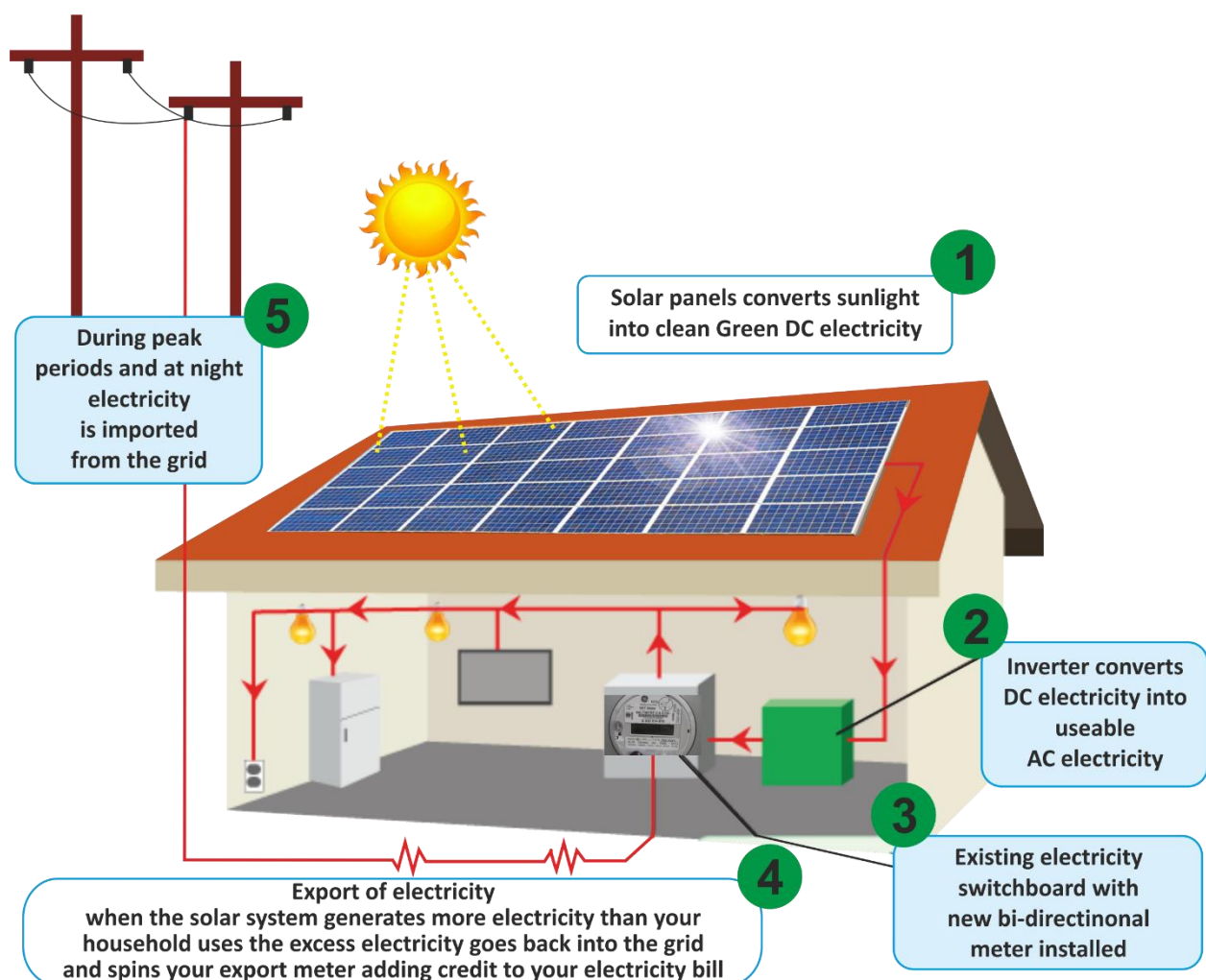


Figure 2.1 Solar power generation

Source: Sunvis Solar (2020)

Solar rooftops are systems of solar installations where solar panels are placed on the roof of a house or a business unit to provide energy to it (Castellanos et al., 2017:2). It would appear from this alone that putting solar panels on top of the housing structure would also depend on how strong the roof is and how heavy the solar panel is. Solar rooftops are ideal with no ground space to mount solar panels (Binkley, 2013:1-2). Kappagantu et al. (2015:492) categorised it into two main forms: with battery and without battery.

Metering is an integral tariffing component in the sustainability of programmes focusing on revenue collection. Kappagantu et al. (2015:492) dichotomises metering configurations into gross and net metering configurations. In this case, the owner of the solar rooftop projects sells power to the national utility provider (Kappagantu, 2015:492). However, with net metering, the owner consumes the electricity on his own, stores surplus supply in batteries and then sell some to the utility (Kappagantu et al., 2015:492). The net meter system measures the power sold to the utility and that which is imported bi-directionally. For the Puducherry rooftop programme, the government uses capital subsidies, generating based incentives and tax credits to incentivise the metering stream (Kappagantu et al., 2015:492)

Rooftop installations can be self-owned or third-party owned, which is essentially a lease. In the self-owned option, net metering, the net power consumed, is put under the owner's account and may be used as a trade-off for imports (Kappagantu et al., 2015:493). Nevertheless, in the third-party owned option, net-metered set up, the lessee will pay monthly rentals to the leaser (Kappagantu et al., 2015:493). The advantage of rooftop installations is that it gives consumers the power to use in the absence of conventional electricity. Additionally, they have the added advantage of being prosumers, power producers and consumers with some possible financial benefits (Kappagantu et al., 2015:493). Lastly, leasing may help offset the upfront installation costs and technology risk.

2.4 Solar energy in South Africa

Solar energy is one of the great natural resources that South Africa has. South Africa has sunshine all year round with an annual 24-hour global solar radiation averaging to about 220 W/m². Moreover, the country experiences over 2 500 hours of sunshine per year

with average solar radiation of between 4.5 and 6.5 kWh/m² per day (South Africa, Department of Mineral Resources and Energy, 2019).

As depicted in Figure 3.2, solar radiation in Johannesburg, where the Ruimsig informal settlement is located, is above 5 kWh/m² per day, making investments in solar energy viable in that part of the county.

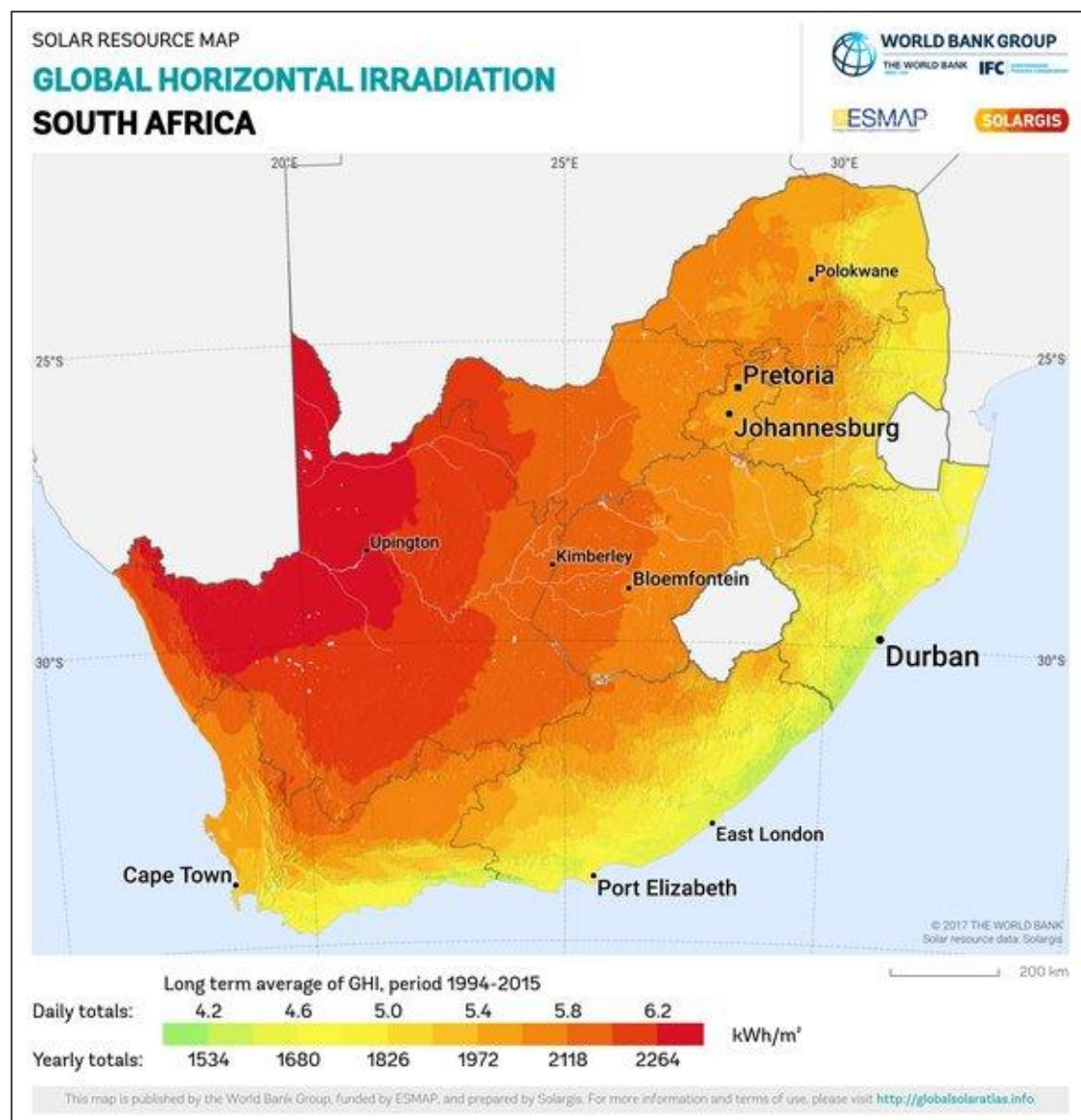


Figure 2.2 Solar radiation for South Africa

Source: Global Solar Atlas 2.0 (2020)

2.5 Solar home systems

SHSs are electrical systems composed of a solar panel, battery and converter to supply households with power (Stojanovski et al., 2017:33; Sunlabob, 2020). Stojanovski et al. (2017:33) further added that SHSs usually charge the batteries during the day and mostly use the batteries at night for lighting, entertainment, charging some cell phones and running energy-efficient fridges. SHSs are mainly used in remote rural and non-electrified areas where it is costly to connect to the national grid (Chahuruva & Dei, 2017:982). The advantage of SHSs is that it needs no construction of infrastructure to support the generation of electricity, such as power plants and electrical power. The abundance of sunshine makes the working of SHSs through PVs much more accessible through the generation of clean energy.

The solar energy is converted into electrical energy and sent down to the controller as shown in Figure 3.3.

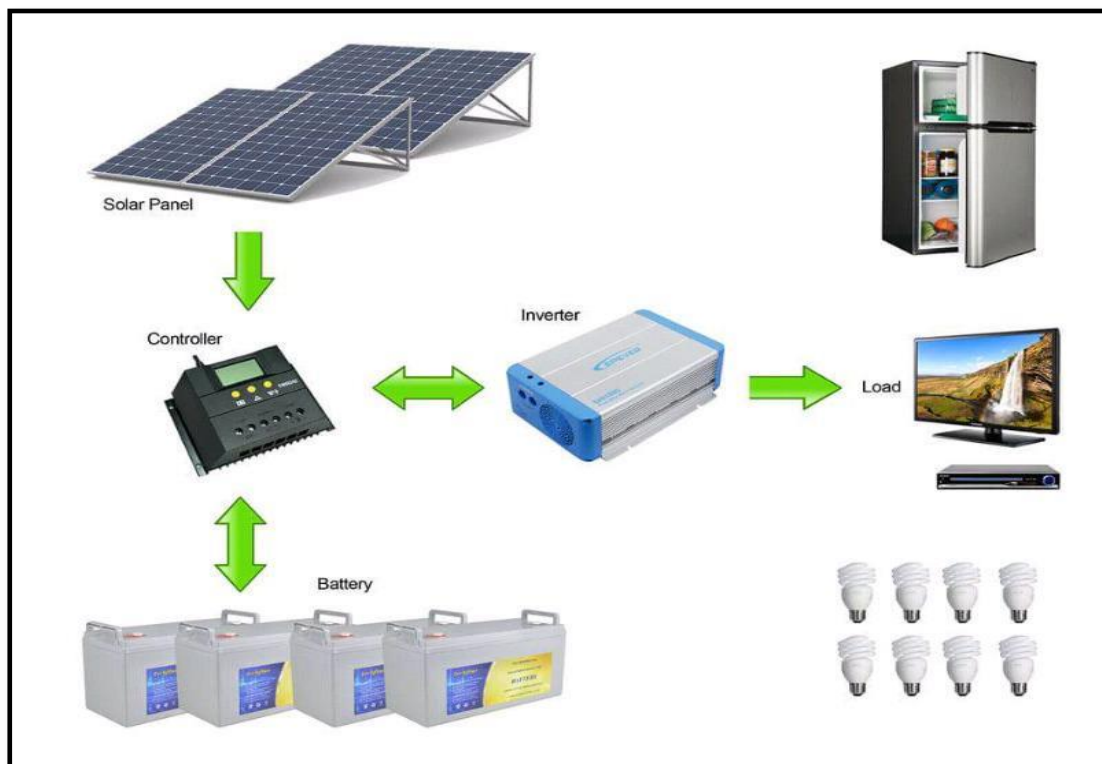


Figure 2.3 *Solar home systems*

Source: GA Solar Shop (2021)

Singh et al. (2017:994) clarified that the controller serves to protect the battery from overcharging. The power is sent from the controller to the inverter to convert DC into AC

(Ahmed et al., 2016:1). Depending on the transformers, circuit controllers, and switches, the AC can be at any voltage and frequency. The inverter converts the DC power into AC power, which is then distributed to various gadgets such as light bulbs, televisions (TVs) and refrigerators for usage (Ahmed et al., 2016:1).

SHSs often use a power storage device or battery so that at night the residents would have power (Energy One, 2016:7). The SHSs from Energy One, used for the case study battery as discussed here, came with the end user devices, such as charging ports and ports to connect TVs and lights. The battery is a high capacity 7,4 Volts 11 ampere-hour Li-ion, battery capable of charging two cell phones at a time and up to eight cell phones per day. The energy management circuit balances the direct solar and the battery charge. The Li-ion lasts for three to five years. A charge controller is also included in the package to reduce the risk of tampering and the need to control it via electronic software. The package comes along with software to assist in the proper usage of the power station. Moreover, the SHS package provides end-user details, a manual for use and fault finding instructions. The software undergoes frequent updates at the hub as part of their after-sales service (Energy One, 2016:7).

The Energy One solar system is made to integrate a Light Emitting Diode (LED) 15-inch TV for the residents' entertainment. Under normal solar radiation conditions, the TV can work 10 hours during the day and four hours during the night. Moreover, the Energy One solar system has integrated MP3 and MP4 players to provide music and other digital and electronic media entrainment. The solar system tested different lights and lamps, and it appeared that the LED lamps seemed to be working optimally with the system (Energy One, 2016:7).

The project itself has been going through several changes (Energy One, 2016:8). The prices of solar PV dropped due to market dynamics on an international level. The solar panels were initially the 15-Watt peak, but were upgraded to 25-Watt peak when the market prices dropped and this upgrade was thus done for free. The larger solar PV was more efficient because with lesser solar radiation it could serve more gadgets than the smaller one. A R350,00 down payment was made before the installation when customers signed up for the Energy One solar system. The down payment included R120 for the first month of the operation of the system. After that, the customer could choose favourable

prepayment options ranging from R7 per day, R35 per week and R120 per month (Energy One, 2016:8).

2.6 Conclusion

An SHS is an emerging power generation technology that is not only sustainable but cheap and reliable. Moreover, the recent drop in solar PVs added to the need to expand access to SHSs as a poverty alleviation strategy. South Africa enjoys a vast amount of sun and, therefore, solar energy generation has the potential to turn things around for South Africa. SHSs also represent a business opportunity because they can be added to the national power grid and then billed to the utility power supply company or a connected community. The advantage of SHSs is that it is now coming with a battery that enables storage of power during peak hours and usage into the late hours of the night.

The next chapter focuses on technical aspects related to solar energy, particularly SHS benefits as cost-effective decentralised solutions in informal settlements to improve the livelihoods of their residents. Chapter 3 also explains the technical aspects of SHSs used in the case study of Ruimsig used in this research.

Chapter 3

Theory of Change

3.1 Introduction

The theoretical framework looks at ToC that supports the impact of SHSs on energy-poor communities. ToC is a scientific approach used by development practitioners to evaluate complex interventions by ascertaining causal links between inputs and outcomes (Arensman et al., 2018:221). ToC also explores the underlying assumptions and how they bring about changes in the programme. ToC allows to track the pathway of changes to explain how changes take place. ToC also seeks to understand how and why a programme has worked or not (Breuer et al., 2015:1).

All over the world, housing remains a critical issue that affects the social, physical and mental well-being of human life (Ayedun & Oluwatobi, 2011:1-2). About 880 million people are without shelter globally (Zaman et al., 2018:1-2). In Africa, almost 50% of urban dwellers stay in informal settlements due to failure by the governments to address housing issues (Friesen et al., 2019:99). South Africa's problems with accommodation predate democracy and are a product of the old political system of apartheid that disadvantaged communities of colour (Schoeman, 2018:29). Access to electricity is associated with socio-economic and health status and is an important economic and environmental development indicator (Bhattacharyya, 2006:3388).

ToC has a set of assumptions of what processes an intervention programme is likely to go through as well as the impact of interventions. This case study discusses the implications of the theoretical framework to the study as a whole. Finally, the study outlines how various elements of the ToC will influence data collection methods. The next section is about ToC broken down into environmental impact of access to SHSs, followed by health and safety, economic and social impact. Lastly, the potential impact of the SHS is discussed.

3.2 Energy poverty in informal settlements

Andrade-Pacheco et al. (2019:1) asserted that access to electricity improves a person's lifestyle and helps to reduce poverty. Electricity access goes beyond just improving lives but also reduces inequalities within societies. There is an opportunity cost of time spent looking for firewood, which could be spent on other viable economic activities. Moreover, the residents save costs because cleaner energy access is cheaper than kerosene, leaving households economically better off than before.

Residents of informal settlements have problems accessing heating facilities in winter and using safe heating devices. A lack of insulated walls further amplifies the heating problem and does not prevent heat loss due to lack of insulation (Arnold et al., 2009:5). More often, poorly built shacks lose heat through holes and other open spaces due to poor construction. The only available types of insulation are cardboard, newspapers and metal scraps, which are not sufficient to prevent heat loss. Thus, energy efficiency is challenging to achieve when living in a shack; hence, shack dwellers buy heating fuel during winter because their infrastructure is not compatible with heat retention. As in the Joe Slovo case study, upgrading an informal settlement optimises heat efficiency technologies (Sustainable Energy Africa, 2014:3). In terms of heating, informal settlements often resort to using *imbawula*, by burning wood chips inside a recycled metal container. According to Kehrer et al. (2008:140), almost 16% of informal settlements admitted to using *imbawula* for heating in winter, which may cause shack fires if not properly handled.

Residents resort to kerosene and firewood when they do not have electricity as a heating source. Kerosene and firewood pollute, expose households to respiratory diseases, and cause shack fires that have resulted in the loss of both property and lives. The use of charcoal, wood and cow dung for lighting, heating and cooking often results in internal pollution and airborne infections (Smith et al., 2000:518). As a result, many people are predisposed to respiratory problems, particularly children, and premature deaths are often the result (Perez-Padilla et al., 2010:1079-1080). Research shows that children living in houses where paraffin stoves are used often have respiratory problems (Hill, 1997:22; Vanker & Gie, 2018:71-72). The kinds of fuel used in informal settlements are

an environmental concern and a public health matter. In theory, electricity access results in improved health status of community residents and perhaps a longer lifespan.

Most of the informal settlements are not lit in the evenings and are conducive places for crime (Deryol & Payne, 2018:52-55, Palmary, 2001:12; Singh, 2012:46). Opportunistic criminals take advantage of poor lighting and visibility, and as a result, muggings and physical or sexual attacks are more common in unlit areas than lit areas in informal settlements (Meth, 2017:416). Previous studies have shown that improved street lighting reduces crime rates (Pease, 1999:71-72; Xu et al., 2018:5). Problems faced by informal settlements are also a socio-economic construct. The availability of electricity and water improves the shack dwellers' socio-economic status by ensuring community safety (Deryol & Payne, 2018:52-55; Lloyd et al., 2004:18).

Women are disproportionately affected by energy poverty more than their male counterparts. Women have to fetch firewood and cook in many societies while providing unpaid household duties (Sustainable Energy Africa, 2017:18). Energy poverty is therefore more severe for women than for men, because low incomes leave them with no better option for quality energy choices. Poverty in women transcends economy spheres and lead to health issues. Failure to access clean energy will expose them to ill-health through indoor gas pollution, leading to more financial losses as they seek treatment for their households, thereby incurring opportunity cost to generate an income.

The following section focuses on the technical aspects related to solar energy and reasons why SHSs can be a suitable solution to start addressing energy poverty in the context of informal settlements.

3.3 Theory of change

ToC evaluations became prominent in the 1980s and 1990s (Chen, 1990; Coryn et al., 2010). However, Weiss and Connell (1995) popularised the concept of ToC in 1995. Before that, Weiss (1972) had intimated that credible evaluations needed to have sound theories supporting them. There has since been a general increase in ToC usage in development programmes and the design of programme monitoring and evaluation systems (Arensman et al., 2018; Belcher et al., 2017; Mayne, 2017).

Weiss (1997) defined ToC as an approach to understand why, and how, a programme has worked in a specific context. ToC is a methodological approach used to assess the linkages between inputs, outputs, activities and outcomes in complex development programmes (Arensman et al., 2018:2). Belcher et al. (2017:1) further added that ToC is a comprehensive description and illustration of causal relationships between the intervention and the impact. Furthermore, ToC clearly shows the conditions that must prevail for the impact to be achieved. ToC also allows the testing of several theories (Belcher et al., 2017:2).

A typical ToC structure is depicted in Figure 2.1.

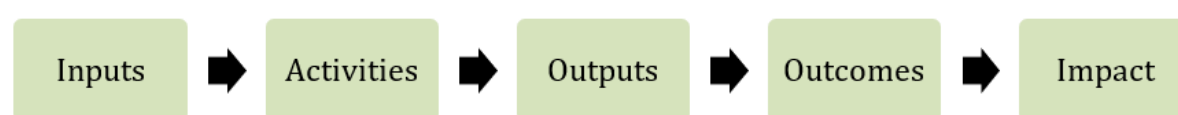


Figure 3.1 *The traditional theory of change*

Source: Author (2021)

Inputs are the resources that are invested in the programme as part of the interventions (Harries et al., 2014:4). The inputs will then be employed, and this employment is the activity (Harries et al., 2014:4). Outputs are the direct products of the activities (Hayes et al., 2011:9). Outcomes are the short-term and intermediate benefits of the intervention (Hayes et al., 2011:9). Impact refers to the overall causal effect of the programme (Mishra & Das, 2017:2). Dhillon and Vaca (2018:67) concurred that impact represents the bigger picture and the ultimate of what the intervention contributes to. This study looked at the impact of SHSs on the livelihood of the residents of the Ruimsig informal settlement.

An SHS is a renewable energy source. The residents of the Ruimsig informal settlement were the beneficiaries of the SHS programme through the corporate body of Energy One (2017). Subsequently, the programme expected that SHSs would bring several changes to the lives of the residents. Broadly, the programme interventions were envisaged to have environmental, social, health and economic benefits.

Figure 2.2 shows a suggested ToC for an SHS intervention.

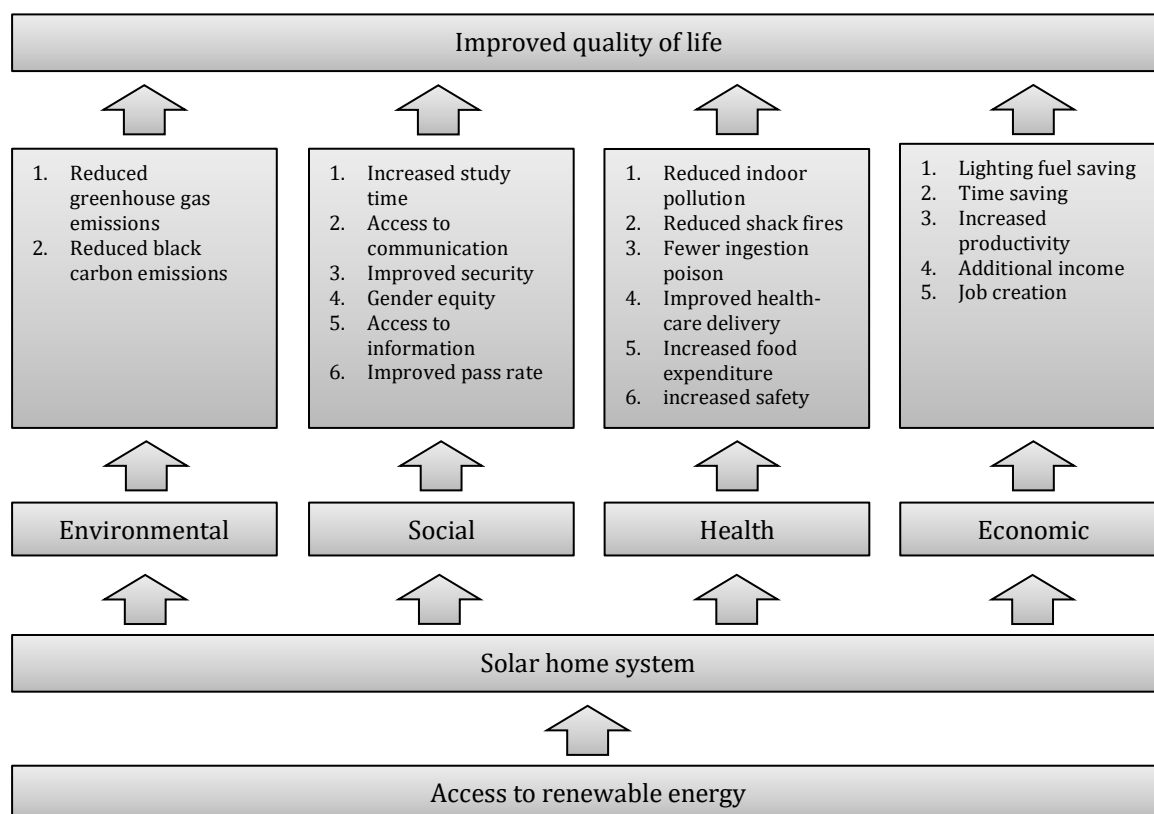


Figure 3.2 Theory of change

Source: Adapted from Karber (2018:17)

3.3.1 Environment

Informal settlements in South Africa suffer from energy poverty (Sustainable Energy Africa, 2017:5). Jessel et al. (2019) defined energy poverty as low or lack of access to modern sources of energy. Energy poverty has left residents with no option but to use open fires and other unclean sources of energy, leading to indoor pollution and other health hazards (Bouzarovski, 2018:11). Sources of power for those stricken with energy poverty range from kerosene, candles, wood, liquefied petroleum gas, coal and cow dung (Conway et al., 2019:2; Makonese et al., 2016:1). As suggested in the definition of energy poverty, conversely, it goes without saying that SHS is a poverty improvement strategy.

The combustion of non-renewable energy is likely to increase the chances of emissions of very poisonous gases such as nitrogen oxide, carbon monoxide, and formaldehyde, which pollute the environment (McCarron, 2018:171). Greenhouse gas emissions (GHG) are responsible for several environmental problems today. GHG retains infrared radiation, which results in an increase in temperatures on planet earth, leading to global warming, which largely contributes to other environmental challenges (Mohammed et al., 2019:1).

Global warming has resulted in climate change, which is evident in increased flooding, droughts and heatwaves (MacMillan & Turrentine, 2021). MacMillan and Turrentine (2021) defined global warming to be a result of carbon dioxide and other polluting gases that collect in the atmosphere and absorb sunlight and solar radiation from the earth. These gases trap heat and cause the earth to be warmer, ultimately resulting in a warmer planet. The issue of global warming has become a topical issue in many forums, and more, one that negatively affects development in the global South (Sanson & Burke, 2020). The United Nations Framework Convention on Climate Change came up with a plan to combat the interference of human beings with the climate, further underlining the importance of climate change.

The use of non-renewable energy sources increases the air pollution in the environment around the informal settlements. The high unemployment rate in informal settlements increases the risks of inhaling the gases for those residing in these settlements most of their time (West et al., 2020:2).

Replacing non-renewable energy with SHSs reduces carbon emissions and inadvertently reduces pollution and exposure to respiratory disease. In places where SHSs have been implemented, there have been reductions in local air pollution (Kabir et al., 2017:8). In addition, Masson et al. (2014:8) discovered that solar energy reduced both global warming and urban heat islands. As an alternative to unclean energy sources, SHSs are a cleaner source of energy, which has replaced pollutants.

3.3.2 Health and safety

The cooking done in-house using unclean energy sources such as firewood and kerosene is likely to cause indoor air pollution, leading to respiratory diseases. Indoor pollution is worse in informal settlements due to the combination of burning fossil fuels on appliances and having poorly ventilated houses, which means that the poisonous gases are retained in the house long after use (West et al., 2020:2). This is opposed to cooking on an electric stove that is connected to the grid because it ultimately relies largely on coal-powered electricity. Moreover, the unemployment levels imply that most are exposed to indoor pollution for longer due to the time spent in closed polluted environments. Increased exposure to gases will inevitably result in respiratory disease (McCarron, 2018:173). These diseases include chest infections, irritations in the eyes,

nose and throat, lung damage and cancers. For those with chronic problems such as asthma, the attacks are likely to be more frequent due to exposure to pollution. Not only is pollution responsible for morbidity, but mortality too. Lelieveld et al. (2019:1591) argued that particulate matter is responsible for the death of 8.79 million people every year. Malley et al. (2017) added that 3.4 million premature births were a result of indoor pollutions.

Zhang et al. (2020:11) demonstrated that clean cooking and lighting from SHSs improved health in the local communities. When the community replaces pollutants for cleaner and safer ones, they reap the benefit of a cleaner environment. Zhang et al. (2020:11) furthermore realised that when this happens, the community reaps lesser disability-adjusted life years, a measure of improved quality of life in health terms.

Shack fires are a problem in South Africa, especially in informal settlements. Shack fires destroy an average of 23 shacks daily (South African Institute of Race Relations, 2016). Of all the shack fire cases reported, the Western Cape province accounts for just over 50% of those, while Gauteng follows second with almost 25%. Patrick Kulati, managing director of the Paraffin Safety Association of South Africa (n.d.:2) reported that paraffin used to be known for poisoning, but is now also known for igniting fires and causing burns. The newspaper headings below reveal that shack fires have become a common feature in South African news bulletins:

- *“Baby among 3 killed in Joburg shack fire”* (News24, 2017).
- *“10 die in raging shack fires in Cape”* (Payi, 2017).
- *“Four children, three adults burn to death in Cape Town shack fires”* (The Citizen, 2017).
- *“Shack fire leaves hundreds destitute in Durban”* (Wicks, 2017).

Most of the informal settlements are not lit in the evenings, and as a result, mugging has become common (Singh, 2012:46). Opportunistic criminals take advantage of poor lighting and visibility, and as a result, physical and sexual attacks are more common in unlit areas, particularly in informal settlements (Meth, 2017:416). Recent studies have shown that improved street lighting reduces crime rates (Pease, 1999:71-72). Informal settlements are conducive places for crime, and therefore, the issue of electrifying the

informal settlements goes as far as deterring crime (Palmary, 2001:12). Kimemia and Van Niekerk (2017:289) added that families using non-renewable energy sources were more prone to burns.

SHSs has improved the safety of the community by reducing the number of shack fires. Shack fires are mainly caused by unsafe use of or accidents caused by candles, kerosene fuels and paraffin stoves (Kimemia & Van Niekerk, 2017:289). As a solution to these safety and security challenges, clean energy significantly reduces the number of shack fires (Kimemia & Van Niekerk, 2017:289). Solar energy proved to improve community safety (South Africa, Department of Mineral Resources and Energy, 2019). Azimoh et al. (2015:354-364) studied the social impact of SHSs in seven villages in South Africa. They used semi-structured interviews to collect data from 88 households. The study confirmed that SHSs improved lighting and increased the household's security from attacks by thieves. The residents responded that SHSs had done away with the need for candles, thereby reducing the risk of houses being burnt down by fires. The study hours for the students increased, and so was the access to information and entertainment (Azimoh et al., 2015:358).

3.3.3 Economic

Energy access is a critical determinant of economic growth (Mulugetta et al., 2019). Stern et al. (2019:1) added a positive correlation between economic growth and access to electricity. Access to electrical energy spurs economic opportunities and allows for small businesses to operate. The World Bank (2018) further concurred that access to electricity is at the centre of all economic development. Several economic activities are dependent on access to electricity, and therefore it is logical that improved access to dependable electricity improves economic growth.

Due to energy poverty, informal settlements have often been reliant on kerosene, which is often expensive. Energy poverty is defined as a lack of reliable clean energy (Wolpe, 2010:1). Empirical evidence shows that clean energy is very cost-effective because solar energy is free, once installation and technology costs are paid (Hossain et al., 2019:11-12). However, SHS technology is expensive and payback time is very extensive. The use of SHSs in place of non-renewable energy sources saves household costs and leaves households with more disposable income for other essentials (Kabir et al., 2017:8).

SHSs will also improve economic opportunities for the users (Kabir et al., 2017:8). Several businesses exist because of access to power, electrical energy and proper lighting (Gulaliyev et al., 2020:10). In a study in Bangladesh, women started sewing projects using electrical access as a springboard to starting businesses (Kabir et al., 2017:8). In addition, several shop owners were able to open for longer hours into the night due to improved lighting. In the same study, small business owners who did not have an SHS reported losing customers to those who had proper lighting. Electrical access has opened opportunities for new businesses and increased the trading opportunities within the informal settlement.

SHSs are likely to improve access to information through the internet (Kabir et al., 2017:7). Access to information will increase trading diversification and promote business efficiencies. Access to information enables the reduction of information irregularities and market inefficiencies, thereby increasing business opportunities. Other added benefits of access to clean electricity are creating more job opportunities, benefits for students who can study for longer, and improved quality of medical care (Hancock, 2015:2-3). Appies (2016:43) noted that access to clean energy reduces the time spent by women looking for firewood and gives them equal economic opportunities than men. It also offers women better access to education through access to lighting. Access to electricity reduces poverty by providing women access to study and opportunities to do business, even long into the night.

When informal settlements have access to electricity, several other advantages are realised. Informal settlements are usually unsafe, especially at night. Access to electricity reduce burglaries and criminal activities that take advantage of poor lighting and stealing economic assets from its owners (Appies, 2016:44). Access to electricity increases trade, even in informal settings, because shop owners can operate for longer hours into the night, thereby trading more efficiently. Clean energy technologies have given many households connection to refrigerators, which reduced wastage of food through rotting.

3.3.4 Social

The social fabric of human lives is affected by SHSs. Kabir et al. (2017:7) found that the social capital of the informal settlement residents improved. Most men started spending more time with their families due to having lighting at home. Several people reported that

their access to SHS improved their awareness of the current affairs in the country. General living conditions are more likely to improve as households connect TVs and radios and charge their phones to communicate (Appies, 2016:44). SHSs enable the ability to use smartphones and consequently social media, allowing connecting with friends and relatives from far and near through the internet (Kabir et al., 2017:7).

Moreover, SHSs can improve student life by increasing the length of the student's study hours (Kabir et al., 2017:7). In other studies, students' pass rates increased due to SHSs (Azimoh et al., 2015:358). There is, therefore, a plausible connection between access to SHS and educational improvement. SHSs also ensure social equity in society across all genders. Women will start competing for equal opportunities with men, when they no longer need to go looking for firewood and other energy sources (Kabir et al., 2017:7-8).

3.3.5 Synopsis of the potential impact

SHSs may potentially bring changes to the livelihood of residents. Reduction in GHG emissions results in a cleaner environment. In addition, SHSs can bring social cohesion through entertainment and improve social capital through increased interaction of families under SHS lights. In theory, SHSs avail more economic opportunities, increase trading times, create job opportunities for residents, and more importantly, will remove polluting by non-renewable fuels that cause health problems.

Without a doubt, SHSs have a potential to improve the livelihood of the residents through increased social convenience, additional income, cleaner environments and improved health outcomes. Several conveniences and comforts are brought forth by SHSs that may improve the quality of life. Women will not worry about firewood or children playing in the dark or risk of fires. SHSs bring the comfort of using modern appliances and connect them to the rest of the world. Communities become safer from crimes and dangerous animals and shack fires that have often destroy the properties of communities in South Africa.

3.4 Conclusion

This section concludes that in theory, SHSs improve the lives of residents. When the community gets solar access, several positives are expected in their livelihood. When a community moves from using non-renewable energy to renewable energy, a wholesome change for the betterment of lives happens to everyone. This study used ToC as a theoretical underpinning of the study. The ToC assumes that the interventions will bring a set of short-term changes and then a long-term overall goal, which is the impact that SHSs have on the livelihood of the residents.

In summary, access to SHS affects social, economic, health and environmental factors. Economically, it can be theorised that SHSs result in time-saving, increased productivity and additional income and job creation. In terms of the environment, SHSs reduce shack fires and also carbon emissions. Certain social aspects may potentially change, such as increased study time, improved access to communication, improved security, gender equality, improved access to information, and improved educational pass rates. There are also anticipated health benefits such as reduced indoor pollution, decreased shack fires, improved health outcomes and increased food expenditure.

The research methodology is discussed in Chapter 4, with specific focus on data collection methods, sampling, data analysis and ethical matters.

Chapter 4

Research Methodology

4.1 Introduction

Chapter 4 outlines the methods used to operationalise the case study in the Ruimsig informal settlement. The chapter focuses on the evaluation concept since it relates to concepts embedded in the ToC. Thereafter, the focus shifts to the research design, describing the population used in the study and sample sizes considered for data collection. The chapter further considers the sampling techniques and rationale for the methods chosen.

4.2 Evaluation field

The evaluation field is a growing field of a body of knowledge. Evaluation refers to collecting large numbers of data to pass judgement on the relative worthiness or merit of a programme (Alkin & King, 2017). Fynn et al. (2020:2) also alluded that evaluation is concerned with the creation of an evidence base to justify and inform policy decisions. Gargani and Miller (2016) added that an evaluation aided learning programme leads to programme improvement and the enhancement of social welfare. An evaluation is also concerned about the effectiveness of social interventions as well as any other programme (Wanzer, 2020). According to Rossi et al. (2003), evaluations done systematically by means of social research methods can help to better understand the successes or failures of interventions in social programmes.

Evaluation started off in the 1930s as several social scientists tried to assess the impact of social programmes (Freeman & Rossi, 1981:350). After the Second World War, the government of the United States of America wanted to monitor the morale of its soldiers and evaluate its policies to manage the welfare of its employees (Rossi et al., 2003:8). In the 1960s, the term *evaluation research* was invented to name the appraisal of the US programmes (Pawson & Tilley, 1997:2). In the same year, books and articles increased dramatically on the subject such that by early 1970s, evaluation research had become

trade for some who had ventured into this speciality until it became a fully-fledged field in the mid-1970s (Rossi et al., 2003:9). Presently, evaluation is funded by policymakers who want to use evidence to make key policy decisions.

4.3 Research approach and design

A research approach refers how the research should be conducted (Creswell, 2014:295). Research approaches are usually quantitative, qualitative or a mixture of methods (Creswell, 2014:14). Research designs follow the research approach and provide a clear and systematic delineation of methodological, systematic data collection, measurement, and analysis (Akhtar, 2016:69). The research for this dissertation followed a mixed methods research approach and used a case study design to operationalise the study. A research design refers to a technique used to select, collect and analyse information in a study (Abutabenjeh & Jaradat, 2018:5). Qualitative, quantitative, and mixed methods are the most often used research approaches (Shorten & Smith, 2017).

Quantitative methodologies are measured through methods such as surveys (Apuke, 2017; Creswell, 2014:14). On the contrary, the qualitative methods use words, objects and images collected from interviews, observations and discussions (Apuke, 2017). Qualitative methods are often used to substantiate perceptions and experiences beyond pure numbers (Hammarberg et al., 2016). This study used a mixed methods approach made up of both quantitative research methods and qualitative methods. Mixed methods have the advantage of combining the best of both quantitative and qualitative methods and removing a single method's biases (Shorten & Smith, 2017:75). Mixed methods allow the comparison of both the quantitative and qualitative methods in research (Wisdom, 2013:2-3). Mixed methods also provide a scope for triangulation of results to see if the findings of the other support one methodology. Findings from the mixed methods approach are comprehensive and give power to the numbers by explaining the lived experiences of the participants (Wisdom, 2013:2-3). Data interpretation is more meaningful when mixed methods are applied (Hughes, 2016:2).

4.3.1 Sequential exploratory mixed method approach

This study used an explanatory sequential design, a mixed method approach that uses quantitative and qualitative methods in consecutive phases (Wipulanusat et al.,

2020:485). When quantitative and qualitative methods are used in the same study, they must be done concurrently or sequentially. Whereas, in concurrent data collection, the data collection of both methods happens simultaneously; in a sequential explanatory approach, priority is given to the quantitative phase and thereafter the qualitative approach (Wipulanusat et al., 2020:486). The sequence in Figure 4.1 describes the order of getting both quantitative and qualitative data.



Figure 4.1 *Sequential explanatory approach*

Source: Author (2021)

For this study, quantitative data was obtained through questionnaires and then analysed for common trends, preferences, and experiences using SHSs (Berman, 2017:7). Semi-structured qualitative questions followed the quantitative data to better understand the trends from the closed-ended questions (Wipulanusat et al., 2020:487). The research used a case study design and explored the case of the Ruimsig informal settlement to evaluate the impact of SHSs on the livelihoods of beneficiaries making use of the system.

4.4 Case study of Ruimsig informal settlement

According to Adegun (2016:66), Ruimsig is an informal settlement on the western side of the CoJ and spans over 5.2 ha. The informal settlement lies in the middle of the upper-class residential area of Ruimsig. In the 1980s, the place now occupied by the informal settlement was a farm that was sold to a new owner in 1986 (South African SDI Alliance, 2013). The owner charged rent to some farmworkers who were a small community in the mid-1980s. In 1998, the CoJ bought the farm. The farm was then rezoned from a peri-urban agricultural zone to a residential area. Thereafter, the construction of new residential houses around the area started attracting jobseekers who settled in the area. After continual growth, the CoJ built about 100 toilets and two water tanks in 2006.

The Ruimsig informal settlement is divided into four sections: Shebeen, on the north-western side, Spaza in the north, Church in the east and Wetlands in the south (Adegun, 2016:71). As part of the National Upgrading Support Programme (NUSP), a programme run by the national Department of Human Settlements, Ruimsig was made a beneficiary of the NUSP (South African SDI Alliance, 2013). In 2011, a coalition of the University of Johannesburg, iKhayalami, and SALAVIP coalesced around upgrading the in situ settlement. Phase 1 had 38 shacks in Wetlands, which were upgraded to better shelters. In the second phase, 96 shelters in Church and Spaza were upgraded. The settlement grew rapidly, and presently, the CoJ estimated that the Ruimsig informal settlement consists of approximately 2 100 people that are not connected to the centralised power grid (Sonwabile, 2015) (see Figure 4.2) .

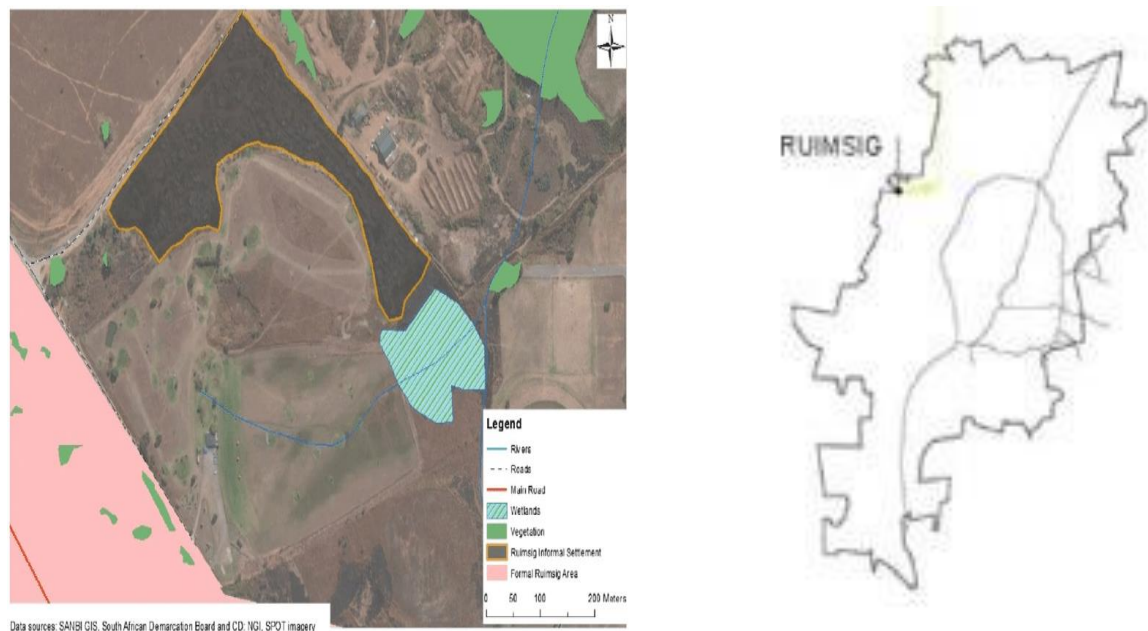


Figure 4.2 *Ruimsig informal settlement map*

4.4.1 Demographics of Ruimsig

The Ruimsig informal settlement comprises of black South Africans and some foreigners from neighbouring countries as well as from the Democratic Republic of the Congo, Nigeria, and Somalia. Most of the small businesses in the Ruimsig informal settlement are owned by foreigners. Residents tend to work in menial jobs as domestic workers, gardeners and childminders around the nearby areas. The foreigners in the community had been targets of xenophobic attacks in the past (Sonwabile, 2015).

No precise data about the population of the Ruimsig informal settlement is available in the literature. Still, a community survey about informal settlements in Johannesburg done in 2001 provided some demographic profiles of the Ruimsig informal settlement. About a quarter (24%) of the informal settlement residents were single, while 34% of the households living in shacks had a household greater or equal to four people (Housing Development Agency, 2012:19). The average household in 2001 had 3.1 people, and 28% of the shacks were overcrowded. Approximately half (48%) of the households had at least one child (Housing Development Agency, 2012:31). Recent statistics of the area were hard to find, and it can be assumed that the overcrowding has escalated since the community survey done more than a decade ago. Recent estimates are that approximately 2 100 people reside in the Ruimsig informal settlement, of which 705 households make use of an SHS.

According to the Housing Development Agency (2012:31), informal settlements had an unemployment rate of close to 37%. Of those employed, 32% were employed in the formal sector, while 68% were in the informal sector. Eighteen percent (18%) were employed as domestic workers. In terms of education, 6% had no schooling, while 15% had matric only and 2% had a tertiary qualification. A follow-up survey done in 2007 showed that 22% of the residents owned a shack, while 14% rented and 64% occupied rent-free accommodation (Housing Development Agency, 2012).

As illustrated in Figure 4.2, 43% had access to electricity, while 55% used fossil fuels (Housing Development Agency, 2012). Most of the residents had access to piped water in their communities and 37% had flush toilets. Most of the informal settlements (63%) were serviced by the municipality with refuse collection.

ACCESS TO SERVICES: HOUSEHOLD LIVES IN SHACK NOT IN BACKYARD THE CITY OF JOHANNESBURG

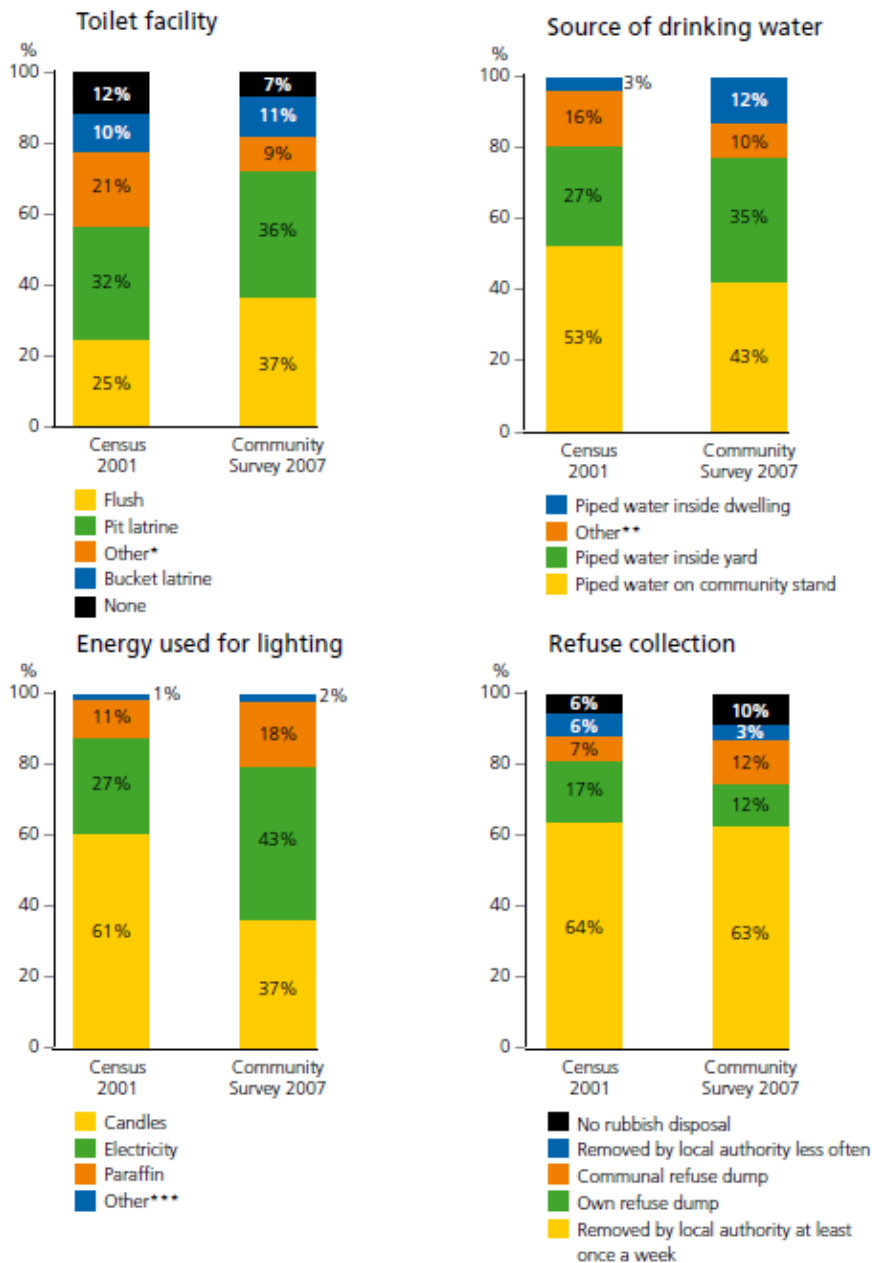


Figure 4.3 City of Johannesburg service delivery statistics
City of Johannesburg (2020)

4.5 Sampling

Sampling refers to the process of selecting a group of people from a population to take part in research (Bryman, 2012:715). The census population of an area is sometimes large. It is impossible to collect data from the entire population but cost-effective to

collect data from a random sample, smaller than the population, but big enough to generalise results to the more significant population in an area (Baran, 2016:109; Enticott et al., 2017:2). A generalisable sample retains all the characteristics of the population.

There are two main types of sampling, namely probability and non-probability sampling methods. Whereas probability sampling draws samples from the population using random selection, non-probability sampling involves some arbitrary selection of elements into the sample for which inclusion of probabilities are unknown (Wiśniowski et al., 2020:121).

This study used a systematic probability sampling method. A systematic probability sample selects participants from a larger population according to a random starting point, but with a fixed, periodic interval. The periodic interval is also called the sampling interval and is calculated by dividing the population size by the desired sample size (Babbie, 2012:147).

The study population in the Ruimsig informal settlement has approximately 2 100 people and 705 households who each received an SHS. The Raosoft sample size collector (2004) was used to calculate the sample size based on the 705 households who made use of an SHS. The Raosoft sample size calculator calculated that 245 participants would be sufficient for the study to generalise the results to the greater population of the Ruimsig informal settlement. To get to 245 participants, every 2.9th person was calculated as follows:

$$\begin{aligned} \text{Participants} &= \frac{\text{Total households}}{\text{sample size}} \\ \text{Participants} &= \frac{705}{245} \\ &= 2,9^{\text{th}} \end{aligned}$$

The formula was applied to a Microsoft Excel spreadsheet of the beneficiary list to choose the research participants. A 95% confidence interval was used, with a 705 sample size and a 50% response distribution as inputs for the sample size calculator.

4.6 Questionnaire

This study used a questionnaire with both closed and open-ended questions to explain the experiences of the Ruimsig informal settlement community in using SHSs. The ToC informed the design of the questionnaire. ToC constructs were used to evaluate the changes encountered with elements of SHSs related to economic, environmental, health and social dimensions.

The list of beneficiaries was collected from the Energy One programme and telephonic interviews was conducted to save time and money. Interviews were conducted in English and isiZulu, the commonly spoken languages in Ruimsig, Gauteng. A total of 245 questionnaires were completed and the data were recorded in the Statistical Package for Social Sciences (SPSS) and Excel to be analysed. The questionnaire contained a Likert scale test as shown in Table 4.1.

Table 4.1 *Likert scale test*

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

Source: Author (2021)

The close-ended questionnaire had categories according to the ToC and measured impact using a five-point Likert scale. Semi-structured questions followed the Likert scale opinions, and respondents had an opportunity to explain why they agreed or not on the statements made in the questionnaire.

4.7 Triangulation interviews

Interviews are a qualitative data collection tool to explore and allow insights into experiences and perceptions (McGrath et al., 2019). Semi-structured interviews explored the lived experiences of the residents of Ruimsig and their perceptions. Semi-structured interviews allow flexibility to explore emerging themes and concepts to produce a quality report (DeJonckheere & Vaughn, 2019). A further five semi-structured interviews were held with household owners to understand the residents' experiences on using SHSs. The participants were selected through random sampling from the list of 705 beneficiaries. Every 141st person on the list was selected for the interviews. For the stakeholder interviews, three participants were also chosen through random sampling from a pool of

stakeholders. The in-depth interview questions were formulated from the ToC theory. Participants that were not part of the questionnaire were chosen to ensure a complete triangulation of data, using different data collection methods. The interviews were recorded and then later transcribed and analysed.

4.8 Data collection

The data was collected in March 2021, during the second wave of the COVID-19 pandemic. To prevent the spread of COVID-19 during the data collection process, I had to avoid any close contact with the respondents. In some instances, I communicated with the respondents through social media platforms such as WhatsApp. I had to send study documents and information letters through WhatsApp and emails. I sometimes had to try several times to get a convenient time to speak to the residents. An advantage was that the community leader had informed the residents of the study, which made the data collection process easier.

I recorded the data collection interviews and transcribed them later on. There were a few difficulties in calling some clients because of network challenges and load shedding. I had to use different means to obtain the data, ranging from telephonic interviews and triangulation interviews to a respondent that sent a long audio message with all his responses, after I had guided him through the process. Some respondents had to chat to me through WhatsApp to confirm their availability. Most of the respondents were available after working hours and also during the weekend. Some respondents, especially the unemployed or self-employed, were available during the day.

To ensure quality control, I sent randomly selected audio messages and transcripts to my supervisors to double check whether the inputs of the recordings were done correctly. Based on my supervisors' recommendations, I made corrections and improvements until the quality of capturing of the recordings was up to standard. The recorded audio messages were stored on a password-protected hard drive. The qualitative data was rich, and it was not possible to capture the essence of all the advantages of SHSs in one dissertation. Therefore, in line with the ethics application, the raw data will be made available for further analysis by either researchers or students. Furthermore, I hired a language editor to ensure that all the transcriptions were accurate.

4.9 Data analysis

I captured the questionnaire responses on SPSS and ran some frequency tables to be able to see the responses in a summarised format. Evaluation is not only concerned with assessing the impact but also understanding the context in which it happened. To do that, I had to run some cross-tabulations to understand if there were different responses by age and by gender. Although no large statistically significant differences were noticeable in age and gender with the Likert scale questions, the open questions showed many gender differences in why males and females agreed or did not agree on certain statements. In terms of age, the youths and elderly were also differently motivated to choose an option on the Likert scale. Chapter 5 explores the differences in the qualitative answers in further detail.

The data analysis shows the importance of mixed methods to fully comprehend the impact of SHSs according to a ToC theoretical framework. To understand the experiences of the residents of SHSs, I did a thematic analysis of common themes and texts across the 245 questionnaires as well as the five triangulation interviews on the impact of SHSs on respondents' livelihoods (Fernandez, 2018).

After analysing the quantitative data, I grouped the responses by the ToC categories of impact (social, economic, health and environment), and then analysed the data by themes. I looked at commonalities and outliers (or peripheral matters) that were not commonly mentioned through the process of coding. In essence, I fused the qualitative data, picking the most impactful statements from the respondents, quoting them verbatim in order to highlight the voice of the beneficiary.

4.10 Ethical considerations

Ethical clearance is an important section of any data collection because there are chances that some data collection may cause physical or emotional harm (Wagner et al., 2012:62). As such, the researcher must go through ethical clearance to ensure that no oversight was done by researchers, lest there be a raft of litigation after the research. Additionally, ethics ensure that the research reports on accurate data with no false fabrications and skewed results (Wagner et al., 2012:62). Ethical clearance was obtained before collecting the data, and the clearance letter is attached in Appendix 1. As part of the application

process, I did due diligence to ensure that the data collection instrument would not result in harm to the participants. I ensured that the informed consent was truthful, accurate, ensured privacy and confidentiality, and confirmed informed consent. The data was collected, transcribed and stored on password-protected devices. Lastly, personally identifiable information was removed from the dissertation to protect the privacy of the data.

Written permission was received to do the study from the Energy One company and also the community ward councillor, which made it easy to access local leaders for the informal settlement. Energy One provided me with a list of beneficiaries but had engaged with the community before sharing their information with me. This was done to prevent any violation of the Protection of Personal Information Act (also known as the POPI Act or POPIA) that came into effect on 1 July 2021, long after the data had been collected. The ward councillor also assisted through telephonic means to prepare residents in the Ruimsig informal settlement of the envisaged research. I did not obtain written consent because I was trying to ensure that I do not expose the respondents to COVID-19. Verbal consent was recorded.

4.11 Limitations

There were certainly some limitations to this study. The Energy One project from which the data was collected was the sole provider of SHSs in the Ruimsig informal settlement. The country has several services such as projects with different service providers and as such responses and experiences are based on this case study alone. Caution needs to be exercised when generalising the results of this study beyond the Ruimsig informal settlement because the services received, reflect on only one service provider. The COVID-19 lockdown restrictions affected some of the things that I initially planned to do. I would have preferred in-person interactions with the people of Ruimsig, rather than conducting research through telephonic means. I missed out on possibly collecting the data in person where I could have had opportunities to be in many yards and houses to do observations on the environment, and also read non-verbal communication which would have added to the quality of the study.

4.12 Conclusion

In this chapter, the data collection tools and methods have been discussed. In addition, sampling, ethical considerations and data analysis were also outlined. The chapter justified the choice of different methods and also outlined the demography of the population under study. The study committed to using an online sampling size tool, Raosoft, to calculate the optimal sample size required for the study. A mixed methods research that comprised of qualitative and quantitative methods was used in the study, using a sequential approach. SPSS was used to analyse data. Data was collected virtually in accordance with COVID-19 prevention measures. Lastly, I sought ethical clearance before embarking on data collection to ascertain that all processes followed ensure participant safety.

Chapter 5

Results and Interpretation

5.1 Introduction

This chapter outlines the research results of the questionnaires, the interviews of the residents and community leaders. The results combine mixed methods (quantitative and qualitative methods and observations) to answer the research questions. The results are summarised and excerpts or quotes from the respondents are provided to ascertain the extent to which SHSs impacted the livelihoods of the residents of Ruimsig. The final chapter discusses the results and explores the outcomes concerning ToC.

5.2 Demographic profile of the respondents

A total of 245 beneficiaries were interviewed. All the interviews were conducted through the telephone to prevent the spread of COVID-19. As illustrated in Figure 5.1, the average age of 106 (43%) respondents was less than 35 years of age, while 57% of the respondents were 35 years and above. All the respondents were blacks.

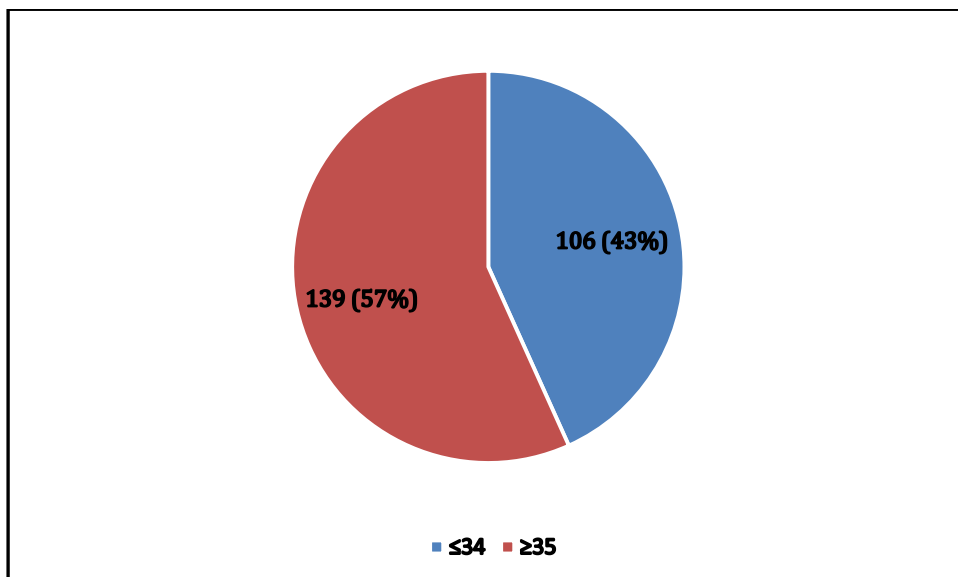


Figure 5.1 Age distribution frequency

Source: Own compilation (2021)

In terms of distribution by gender, 159 respondents (65%) were females and 86 (35%) were males. Most of the SHS users started using an SHS in 2016 at the inception of the programme. Approximately half (49%) of the SHS respondents started using the system at the onset of the programme, followed by 20% in 2017, 13% in 2018, 11% in 2019 and 7% in 2020.

Figure 5.2 shows the year the respondents started using SHSs.

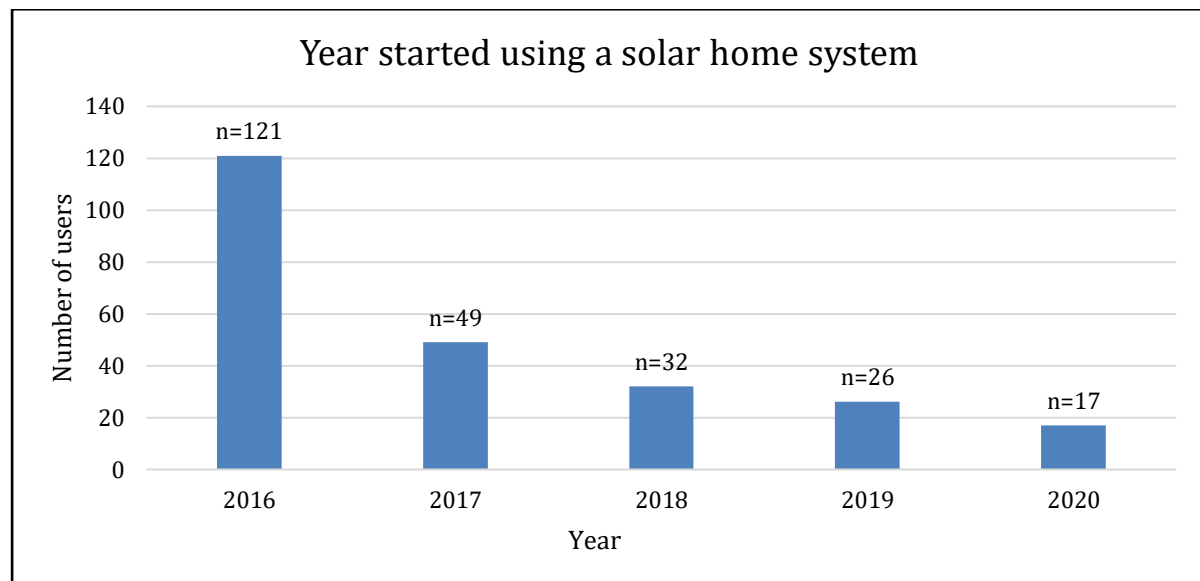


Figure 5.2 *Year started using solar home systems*

Source: Own compilation (2021)

5.3 Devices connected

The SHS was mainly used to connect and charge electronic devices. Figure 5.3 indicates the devices that respondents connected to their SHSs.

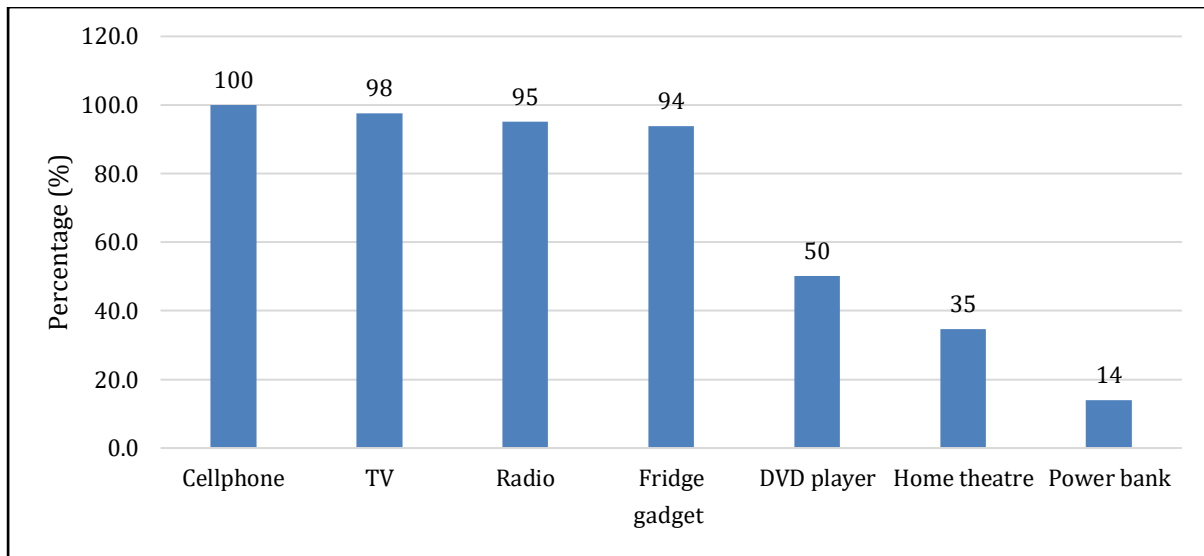


Figure 5.3 *Devices connected*

Source: Own compilation (2021)

Figure 5.3 shows that 245 (100%) of the respondents used an SHS to connect cell phones. Secondly, an SHS was used to connect TVs (98%), and 95% used an SHS for radio connections. Over and above the communication devices, 94% used the SHS to power their fridges, and 50% connected DVD players. Finally, 35% had home theatres, while 14% had power banks connected to the SHS.

5.4 Social impact of solar home systems

The questionnaire used a Likert scale to measure the impact of SHSs on the respondents. The respondents had to reflect on several questions to indicate whether they strongly agreed, agreed, were neutral of opinion, disagreed, and disagreed strongly on various impacts of SHSs on their livelihoods. Using a Likert scale measurement is in line with the ToC that hypothesised that SHSs improved the lives of the informal settlement residents.

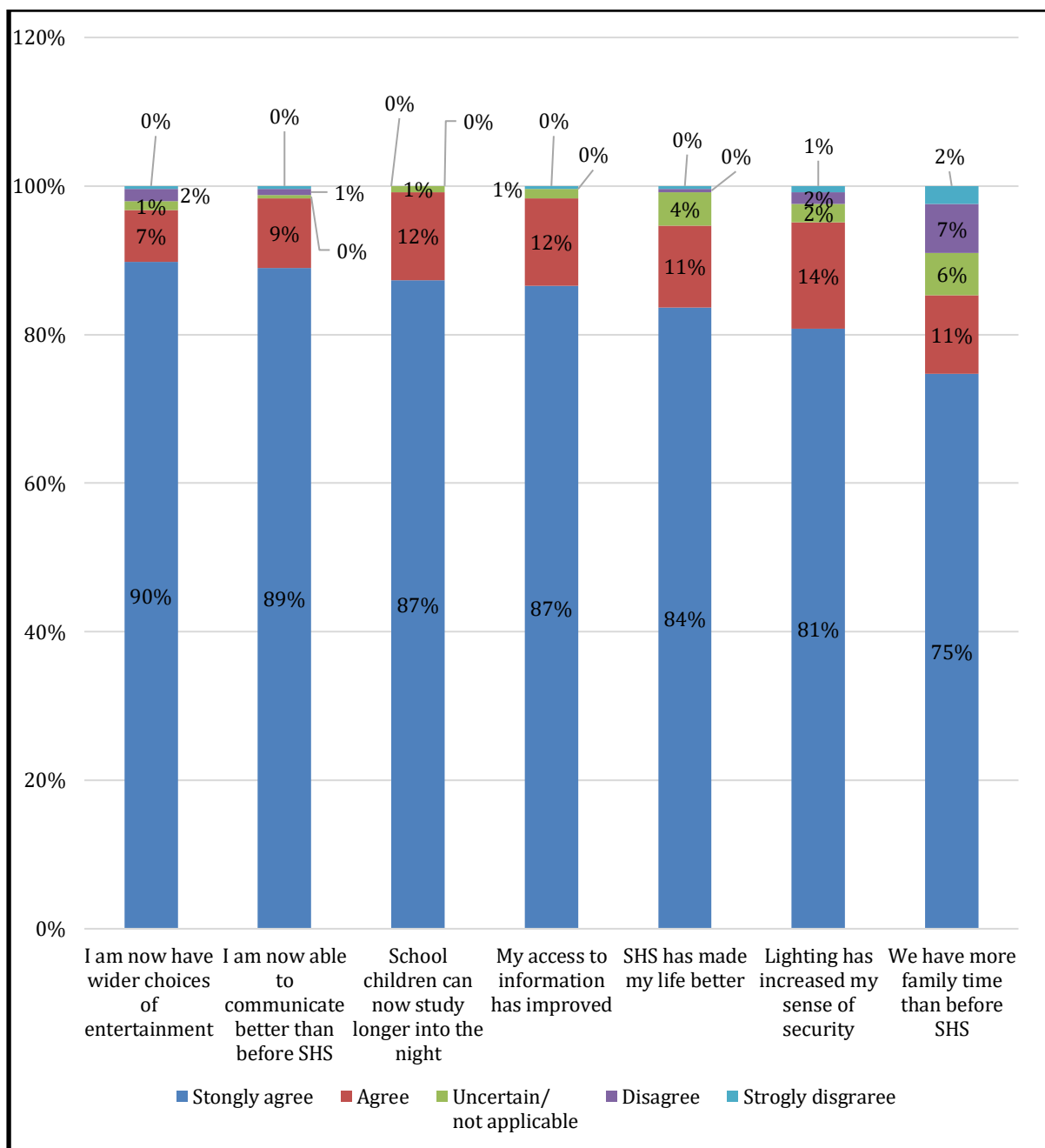


Figure 5.4 Impact of solar home systems on respondents' livelihoods

Source: Own compilation (2021)

As illustrated in Figure 5.4, there is a general view that most respondents agreed on the positive impact of SHSs. The areas in which the SHSs impacted the respondents most strongly were respondents who had a wider choice of entertainment, they can communicate better through electronic devices than before using the SHS, and additional study hours and access to information has improved. The majority of the respondents (95%) agreed that the SHS made their lives better if the “strongly agreed” and “agreed” answers were combined. The two aspects that rated the lowest, yet positive, impact was

that lighting increased the respondents' sense of security and improved family time. The following section will look at each of the questions and combine that with the open-ended responses.

5.4.1 Value of entertainment

In the social category, the question of whether the respondents agreed or disagreed that they had a wider choice of entertainment, had the highest responses. The SHSs generally improved access to broaden their entertainment choices such as radio and TV. The residents could use other gadgets, such as home theatres, to play digital audio data (MP3s) and music from compact discs (CDs) and memory sticks. As shown in Figure 5.3, more than 90% of the respondents had entertainment gadgets, mostly TV and radio. A total of 220 (90%) of the respondents strongly agreed to the improvements of life through entertainment. When asked what impact the TV had on their lives, two respondents argued as follows:

With the coming of the SHSs, we were able to have a satellite dish at our shack over and above the radio, and free to air TV channels. I could watch the church channels on TV, charge the MP3 player and listen to the radio.

My kids control and run my TV and I allow it to be so because I live for them. I think they are happy and know most of the TV programmes. I think my family is happier now with the TV than before.

With access to charging cell phones came other options. The phone is also being used to access radio stations. Also, people are using discs and memory stick options to broaden their choices of entertainment:

I can now play online radio stations [on the] internet. Well, the internet uses a lot of electricity on the phone but with the SHS, I can afford to listen as much as I want ... As for me, I don't like DSTV so much because it's very repetitive but I watch movies from discs and DVD players. I got a colleague of mine who saves them on my memory stick.

The entertainment devices kept children inside the house, which contributes to safety. Some parents felt safer in having their children indoors, because they considered outside as an unsafe environment, especially in terms of sexual assaults:

I am not a TV person as such but my kids love it. They spend more time in the house because of the TV. Previously, I would struggle to get hold of my child but now when there is a TV my children are always around or in the

house watching cartoon networks. I can easily ask for their hands in doing household chores ... The TV helps to keep children off the streets. There is a lot that happens here such as drugs and stealing property. The TV keeps the children in the house. Sexual assaults are common here.

Respondents cited that TVs were very informative, especially during the COVID-19 pandemic. The TVs and radios also provided helpful information from the presidential bi-weekly updates. Others could worship at home by attending TV programmes during the lockdown period:

We love to sit as a family and watch TV while talking in general. We cannot go to church because of COVID-19 but we can watch church online on Sunday with my children.

The TVs were not just sources of entertainment but also for education. The respondents cited that exposure to TV programmes improved children's English language literacy and also helped the matriculants with regular Mathematics and Science programmes. Others also added that their maturing children were taught the dangers of sex and drugs:

My son in matric can watch an educational programme on Maths and Science. I think he is now able to benefit from educational materials like that and I hopefully think he will pass ... There are some helpful TV programmes too that keep the children off dangerous things like unprotected sex and drugs.

Some residents answered that TV was essential to fight off depression at the time of COVID-19 that was killing people around them:

TV and radios bring us information and news. We cannot live without knowing what is happening, like COVID-19. The updates on the TV help us. Also, it's very depressing during the time of COVID-19 not to know what is going on. The TV helps us fight depression and gloom.

Although there were numerous positive comments about TVs, some negatives were cited about TVs, such as their effect on behaviour. Some TV programmes potentially teach violence and other bad behaviour and can be addictive, leading to it that the children might not want to read:

It's good and bad. TVs have some programmes that need very careful control lest they teach your children immoral behaviour and may also cost the children time to read. Now I have to look at curbing what they watch, but for us as adults, this is a good thing.

5.4.2 Improved communication and access to information

SHSs can improve the ability to communicate. It enables cell phone charging and inadvertently communication with the outside world. Additionally, access to radio and TV will ensure that everyone knows what is transpiring in the outside world. As shown in Figure 5.4 those who responded with “strongly agreed” (89%), combined with those who responded “agreed”, gave a cumulative score of 98%. Many respondents indicated that they were encouraged to buy a smartphone which enabled them to use social media and access several apps, including entertainment because of the SHS access. This was mainly because they were now able to sustain the power needs of smartphones:

I used to keep those smaller phones that keep power for days because of the situation here. Then in 2016, I moved to a smartphone that could be sustained by the SHS ... I never used to own a phone, reason being it was pointless simply because we had no charging places. It was worse because I am always here. If I didn't have a phone even you [researcher] wouldn't be calling me.

The access to charging has enabled the residents to use their phones for doing business through communicating with their clients. It further helped those who were looking for jobs to be reachable, as well as for others to be in contact with their employers:

My phone is always charged now my clients who need me for my hairstyle services can book me well in advance. I can plan my week very well. I used to use my phone sparingly before the SHS, to use it for business only. But now I can fidget with the phone a lot because there is power ... I can check with the suppliers what they have on the day before going there using 2 taxis. I can choose not to waste time and money. I can save a bit of money with improved communication.

The residents are now able to use their phones for social media pleasure, which they could not do previously due to limitations in charging their batteries. With improved technology, some can enjoy the full benefits of social media when they have both lights and power. The charging has resulted in parents' increased sense of ease, with them being able to check up on their children while at work. Also, social relationships have improved because of being able to charge their cell phones:

I now do videos with my children back home (in Limpopo) through WhatsApp video calls. When you have a solar lamp, you can be seen by the person on the other side ... I come home late and I need to be able to check

on my kids and to do this I need my children to have a phone. So I feel safer now because I can check on my children when they come back from school or when they are on holiday and I am at work. It is a good feeling to be reachable always. My partner used to struggle as to why I was reachable and it was pretty hard to always explain why your phone was off but now it's better. I don't have a battery excuse unless we don't have sun for several days.

Phones have brought added convenience of transacting online banking while people are at home, as opposed to spending time and money to do so. This saves money and also increases time for running a profitable business:

Our lives are much better because we can do business, even do online banking, send money home. Before this, I used to go to town to do this but now I can do it at home ... I can enjoy the use of the smartphone to do some transactions without having to travel. I can do some banking or order some groceries for my mother in Zimbabwe using some apps like Mukuru and Grocery Remit app. This is enabled by having the power to run a phone.

The Ruimsig community also took advantage of SHSs to start an online market where people sell what they have through WhatsApp. The online platform was also used for community announcements:

The charging ability has been quite a good thing because we are now closer to each other as a community. Most people now have WhatsApp and their many groups for markets, second-hand goods, veggies, transport, security and announcements.

Lastly, phones play other roles such as torches to enhance safety and is also used for entertainment (games). The multiple uses of phones increase the impact of SHSs:

I use the phone as a torch too. Apart from calling, I use the phones to check on the pots and around the house or take the child to the toilet ... I also play games on the phone to while up my time. I can do this backing on the phone's ability to be charged again and again. I am addicted to the Candy Crush Saga game since buying this phone ... Yeah, as a single person I get to use my phone a lot. I used to get very lonely but now I can be in the chatrooms and doing video calls. I am a lot less lonely than I was before I had my solar home system package.

Some parents have been grateful to have the gadgets during the lockdown period where their children had some online studying and doing research that needed tablets. This added convenience that improved the studies of the child:

The charging of the phones has given us many benefits. For me, my child can also charge the tablet for his school lessons. The tablets have been helpful during this lockdown to do school online. I am so grateful for that ... For besides being reachable, my child can also use his school tablet and do some researches for his school. It was hard to have a child at school and not have internet.

5.4.3 Increased studying time

Most respondents agreed that SHSs allowed the school children to study late into the night. Although some respondents did not have any current school-going children, there was greater concurrence on the impact of SHSs. A total of 99.2% of the respondents agreed that SHSs had made it convenient for the school children to study longer into the night:

My son did very well in matric in 2017 and I don't think he could have passed the way he did if we didn't have the solar connections. Even the way he used to read, changed for the better when we started using the solar. He read longer and more into the night.

Asked why SHSs were better, one former student said:

With the kerosene lamps, they cause the eyes to itch and they are very prohibitive to long usage. You are sneezing and scratching your eyes frequently. I used to have red eyes while using paraffin lamps.

Children that did not have solar lanterns joined their neighbours in using solar lamps to do their homework:

My neighbour's children would come and join my children in the evening to do their homework because they didn't have lights like ours ... It's a good feeling when you can sit daily at the table and go through your kids' books for homework and help them through the books. I feel that I can help through school daily. Before, I used weekends for that because I cannot work clearly under the candles. The children have been able to read and write faster, I think. I can also take care of household chores better with lights than without. Before, I used to wait for daylight to do a few things.

SHSs improve students' educational outcomes because the SHS lights support night studies. It was indicated that the SHS systems are superior to the old lights and also effective. Moreover, they are friendly to students because they do not irritate eyes, unlike the paraffin lights.

5.4.4 Lighting has increased my sense of security

Concerning security, 81% of the respondents strongly agreed that lighting increased their sense of security. Together with those who agreed, a total of 95% of the respondents agreed that lighting was good for their safety. One thing that was reported throughout was that lights deter crime because they make it easy for criminals to be seen. However, not the lights alone increased safety but the consequences of detection, such as mob justice. It seems those caught have paid the ultimate price of death:

The ability to see everything gives confidence in security. Usually with clear visibility comes the sense that no one or nothing is hiding in the dark. The criminals here fear to be seen because if you are caught there is mob justice. I think being seen and being caught is the last thing that one hopes for here because if caught, you can get killed in mob justice.

Security also had several other aspects apart from crime. The respondents mentioned several times that the place had snakes and reptiles that sometimes crawled into their houses. Clear lights helped to make the place safer as the residents could more clearly see their place of residence:

Our informal settlements are surrounded by heaps of rubbish and uncollected garbage with a lot of rats and with rats come the snakes too. The SHS helps to see clearly what is in your house and I think that way they make me feel safe.

Several respondents indicated that lights made them feel safe when they walked, they would not step on top of objects which could injure them:

The place has a lot of ongoing construction for new shacks and also there is a problem of metal objects lying around here and the ground has not been cleared from that debris. I need the lights to be able to see all this ... It also makes a huge difference to have seen where you are walking not to step on sharp objectives. It makes the environment safer.

With safety came increased convenience for the children to play outside. Some respondents alluded that they now allow children more time to play as a result of this safety:

We should have the solar lights now. It's easier to see the children crawl and run around the yard safely.

It is also important to note that safety is not just in individual lights but because of communal effects of having neighbours with lights too that makes the place clearer:

When you can see all-around you think you are safer. Personally, I feel that better because there are lights even by the neighbours.

However, in terms of crime reduction, some respondents objected that crime remained, especially because of the high unemployment rate:

I really don't think the lights can change much about the criminal life here. There are no jobs around here and crime is very common. They get in to steal phones and anything that they can find.

5.4.5 Family time and solar home systems

The respondents agreed that SHSs increased family coherence and family time. A total of 75% of the respondents agreed that family time had increased due to SHSs. A small proportion of the respondents (7%) disagreed with the idea that SHSs improved family time. There were ideas that some men might want to spend time with other men at night clubs, implying that even the entertainment at home was not enough to keep some men from spending time at nightclubs. A total of 85% suggested that families with an SHS had increased family time:

We have much more social time as a family because the lights are bright and do allow the family to sit long. Besides, the children can also study at night ... My husband loves soccer and he used to go to the shebeen to watch soccer and come late but now he can watch soccer from home.

However, a few viewed this differently. They still felt that there was a need to have the companionship of other men:

I still need time to spend time with some men and talk politics and current affairs which we can't do at home. So, I still need time with other men and of course, have some drinks. There is no way I can have drinks in my house.

5.4.6 Solar home systems have made respondents' lives better

On average, 84% of the respondents strongly agreed that SHSs bettered the people's lives, while an additional 11% agreed. In all, 94.7% agreed to the positive impact of an SHS. Better night lighting enabled households to do many things that could not be done under paraffin lamps. The respondents highlighted that SHSs were much clearer and cleaner. The respondents indicated that things such as cooking, cleaning, serving food, putting children to sleep, and social evening seasons were better by better lighting:

My life and that of my family has been impacted positively by the SHS. Firstly, you can do a lot of personal work at night because of the lights. I can take a bath at night because I used to be very scared and felt very tired to go to the bathroom at night because of the poor lights. However, the lights have made it more convenient to do some things which were previously not doable ...

In general, SHSs brought increased convenience so that residents can do several activities. The SHS lights encouraged the doing of more activities, which the residents had found to be prohibitive previously:

Taking a bath is very difficult in informal settlements because it's dangerous and also unsafe. For me, I use to feel lazy because the dim lights seemed not to support this activity. With lights, I can now do baths at night.

5.5 Economic impact of solar home systems

The SHSs had a positive economic impact on the respondents' lives, especially in increasing activities in the informal sector and communicating with clients (see Figure 5.5).

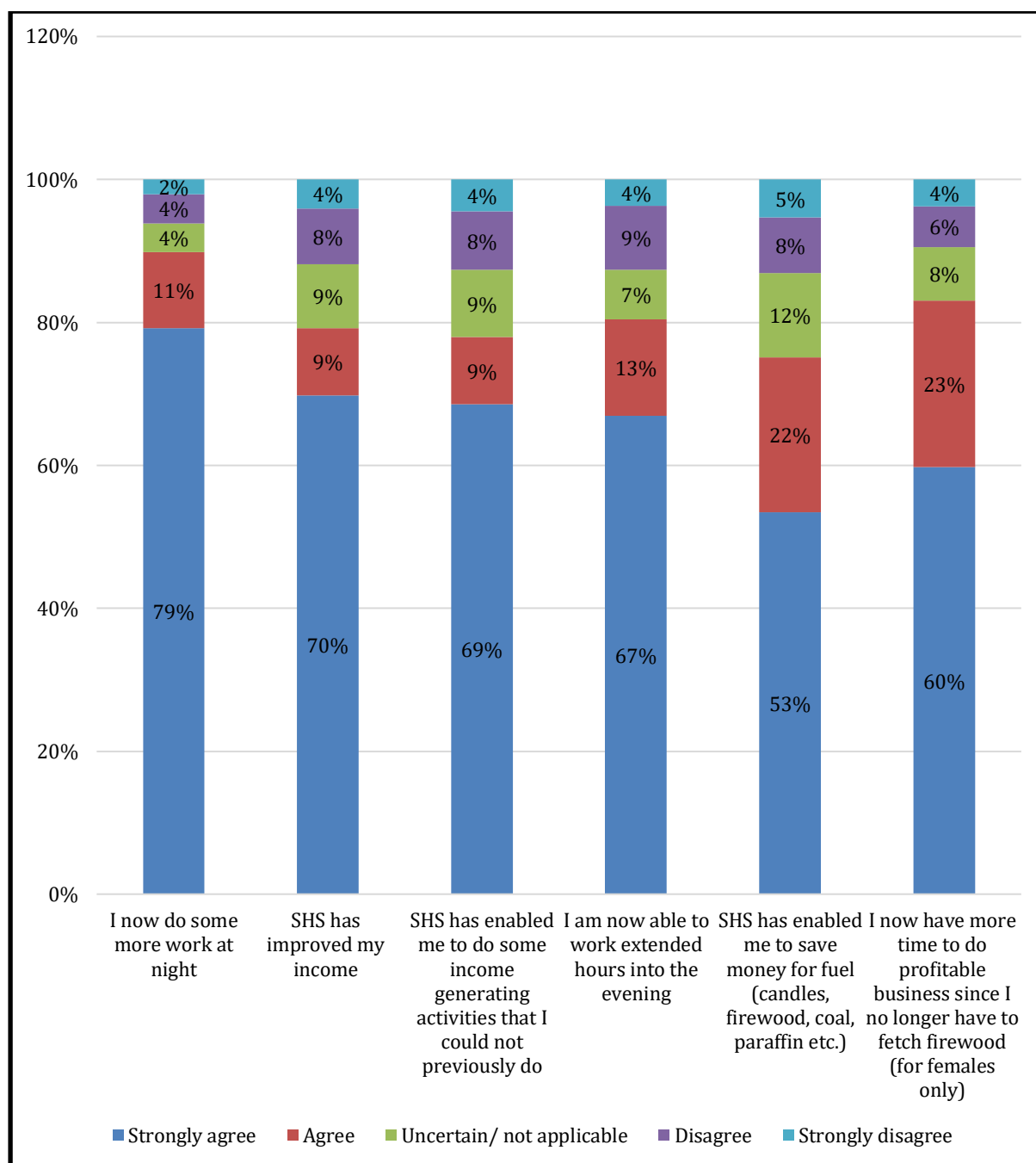


Figure 5.5 Composite scores for the economic impact of solar home systems

Source: Own compilation (2021)

The economic impact was less than the social impact, yet positive in terms of improving respondents' livelihoods. The greatest impact was that respondents could work at night, improve their income, and start generating an income based on having an SHS. Many respondents lived on informal trades such as beauty salons, selling vegetables, beers, shebeens, second-hand clothes, goods market, and electronic devices, to complement the SHSs. SHSs opened many opportunities that were not there, such as selling gadgets and

entertainment systems such as DVDs and memory sticks. SHSs had a lesser impact on saving money for fuel or collecting wood for heat and cooking for the female respondents.

5.5.1 Working at night

The SHSs enabled the residents to do extra work into the night because of the convenience of lighting. The small-scale business enterprises got a lifeline through the SHSs. Of the total respondents, 79.2% responded that they strongly agreed or 10.6% agreed to the positive impact of SHSs by working at night. This question had the highest number of people answering “strongly agreed” in the economic section of the questionnaire. The respondents could do more activities at night, including work that helped them to generate an income. Small-scale business enterprises got a lifeline through SHSs:

I run a shebeen even though I know it's not allowed. But people pass by here at night from work and have a few drinks. The lights are a great component to this additional hour at night.

I was able to do hairstyling after work to supplement my income. The lights of the solar lamps enabled me to work at night in my shack. I was able to book my clients and do some hair plaiting and earn more cash.

I couldn't do hairstyling at night before SHS. The candles were so inconvenient for night work because the delicate work of hairstyling needs proper lighting. So, I used to use daylight but SHS opened more opportunities to work at night.

A respondent who had a tuck shop also revealed that SHSs increased the number of trading hours because they felt safer to trade at night. Before the SHS, the trader said that he would close earlier to avoid falling victim to petty theft and making mistakes in transacting with money at night. He also showed that SHS lighting is deterrent to petty crime like theft, and thieves take advantage of poor lighting to steal:

Now I can open until about 9 pm. I put the solar light outside and I can see who is coming and when there are lights, even criminals or suspicious-looking people, I close at once. I also see that that there is a decrease in petty crime but it's still there though.

Lastly, others saw brand new business opportunities to embark on:

I bought a machine that could dispense airtime and I could charge it through the SHS. I could be able to do more income as a result of the SHS.

This section showed that a close relationship exists between lighting and working additional lights in the evening. The lighting added advantages to trade at night.

5.5.2 Solar home systems improved income and extended working hours

A total of 171 respondents agreed that SHSs had at some point helped to improve their income. The qualitative results showed that some respondents indicated that having an SHS enabled them to generate an income from time to time. It has frequently emerged that those who had informal trade businesses which thrived during weekends and Fridays, especially at the end of the month:

Yeah, the business is much better on weekends, especially Friday nights at month-end ... most evenings are busy and I can make R5 000 in a good month.

It also emerged that some who were employed during the week ran informal businesses in the evening. The SHSs have been enablers for this business opportunity, by putting tables outside their shacks and sell goods under the floodlights. Some also carried these businesses into the weekend whenever they were off business. Thus, the SHSs not only provided sole business traders but also helped those working to supplement their incomes:

I am a domestic worker in Krugersdorp but on weekends I sew clothes and do mending work. I use Friday nights and weekends to do more things. I have my side business to help me increase my income ... Yes, I get plus or minutes R1 000 with my weekend business per month.

The SHSs have also brought in added advantages. The energy-saving fridges have brought in a competitive advantage to businesses. The fridges were also used for business, thus increasing stocking levels and offering quality services such as cold beers:

The lights are good. I also stock some beers in the fridge. For me, it's a combination of lights and a fridge that has given me a great deal of business.

Lastly, it seemed that some had small profits margins because everyone wanted to be selling something, and in the end, it was not sustainable. Several respondents mentioned having done something before and left it for full employment:

I have been able to supplement my income. Although not much but it has helped a little bit. I have been able to get around more than R500 per month.

In times of a high unemployment rate, it is logical that people would do anything to get sustenance. For some residents, selling is a transient phase while waiting for something that is well paying:

Although not much, it has helped a little bit. I have been able to get around more than R500 per month ... I used to have a small income though, but it was enough to live. though it was very small so I had to look for another job, but yes it was a job for me. But now I do hairstyle at night once in a while, I see customers from my old job that followed me. Per month I can add around R1 000 at most ... I used to sell sweets, chocolates and biscuits to supplement my income and it used to work well.

SHSs generally helped respondents to earn a living. A total of 168 (68.6%) respondents strongly agreed that they had experienced an increased income because of having SHS lights. SHSs did improve not only their income but also opened trading opportunities for some residents. The increase in people using entertainment gadgets has opened an upmarket for some to sell pirated discs for entertainment:

The lights have so many advantages for us here ... am selling some movie discs and opening at night is helpful because sometimes people realise at night that there is nothing to entertain them.

Some have started using advanced machines to sell airtime. This also tied in with the fact that so many now have phones (smartphones). It makes sense that the demand for airtime and data has risen, creating the market for selling data and airtime:

What I can say is that I am able to sell airtime using the dispensing machine. That machine needs a connection.

More than half (60.8%) of the respondents strongly agreed that they could work longer into the night. Given the unemployment levels in the area, it made sense that a few people would strongly agree. Lights are attractive in a place without much taking place. One business owner highlighted that sometimes people would come and just sit with them and entertain patrons at the shebeen:

Lights attract people at night and so I sell some beers at my tavern. It serves me well to have lights. At weekends we close midnight and sometimes morning when there is no curfew. I must admit that the

business has gone well because of the lights. Because some people who have nothing to do, come to spend time with us.

Interestingly, the customers also indicated that they used the lights to go out and buy. So, the SHS worked both ways:

I can go after work and look for things to buy at the market. I arrive late but with the lights, we can buy until late at night.

Some businesses seemed to thrive well at night, such as taverns and also the purchasing of relish:

I sell chickens and with lights, it has made my work better because many people come back late from work. During the week, the markets become lively at night when people return from work ... Yeah, at night that's when most business transactions take place. I am making a living by selling chickens and this has added income. People can choose from the live chickens that they need using the lights put around the cages. I charge my lights during the day and put them around the cages until 8 pm.

Lights also enable traders to transact their monies well, especially the change, and see their customers well. This borders around security as it was said several times that the place was not always safe:

Yeah, I can say that I can see my change very well at night and see my customers at night too.

Lastly, it came out that the lights helped the customers to choose the product they wanted to purchase:

I sell live chicken around my shack. The lights make it easier for my customers to select the chickens that they want. The lights also make it easier to sell up to 9 pm.

5.5.3 Solar home systems versus non-renewables (candles, firewood, coal, paraffin)

SHSs affected the economic welfare of the residents in several ways. First, from the responses it was clear that an SHS was a free energy source that saved the residents more money than they usually spent on fossil fuels and lighting. Consequently, 131 (53.5%) respondents strongly agreed. The concurrence here was not as high, as the qualitative data showed that people still cooked with paraffin and coal:

Yeah, for me I am not happy with cooking for now because these solar home systems cannot help us cook. We still use paraffin and coal for cooking.

From a question on how much these usually roughly cost, many respondents mentioned that it was between R120 and R5 000, which considering the economic status of the residents, was a considerable amount:

My family have a three-bedroomed shack, so we need lights for all those rooms. I can say we use around R350 every month. We need these lights for bathing and walking outside the house. However, because of the SHS lights we no longer need to have many candles in the house.

It was also unequivocal that to have sufficient lights, a family needed probably more than one light to be reasonably well-lit, which contributed to more costs under the old energy sources. SHSs are more effective when compared to the previous use of lighting:

The lamps were not as luminous as the lanterns that we have. I needed two candles at least to be able to see where I sleep and where I cook but now one solar lamp is enough.

Despite the once-off costs for purchasing SHS equipment, solar energy remains a cheap energy source because it is free. The once-off cost gives rise to future savings for energy costs, while alleviating energy poverty.

5.5.4 The gender dimension to economic opportunities

Of the 159 women interviewed, 95 revealed that they had more time to do business. Fetching firewood was predominately a woman's responsibility. What has also come through is that SHSs cannot do power cooking and ironing; hence, cooking and heating are still done with paraffin, coal and firewood. Some women admitted that they lost time looking for firewood:

I don't think the solar lamps have given us an advantage over men because we still have to get some firewood ... I think the man is better than women until now because at times we have to look for firewood around some areas here to cook for the family ... I have no other use for solar lamps. However, in terms of equality with men, I feel that the responsibility to look for fuels is primarily the role of a woman. Those with money can buy coal or firewood. I sometimes team up with some women to look for firewood, usually on Sundays. We miss opportunities because we go for hours in the forests to look for firewood.

Some highlighted that they do not have to hunt for firewood but can buy from around the area:

I don't use solar for anything else. I don't think that the solar home systems have improved anything because we still need to look for firewood. However, we do not always have to go and hunt for them but can buy them from those who sell them.

Some women also highlighted that although it is sold, the firewood was quite expensive so they reported looking for it themselves:

For me, I can say that looking for firewood is a great burden for us women here. The firewood that is sold here is very expensive and for me, I prefer to hunt for them nearby. This takes a lot of my productive time, sometimes I wish this SHS can have stoves and we can cook and equally compete for opportunities even with those who don't hunt for firewood.

It appears that those who do not have to fetch firewood have less trading hours:

Men do not go to look for firewood but women do. I think even as we compete with other women who buy paraffin and use primus stoves, men have a better advantage because they can open early or can be at the vegetable market stalls longer. After all, I have to fetch firewood.

5.6 Impact of solar health systems on health and environment

The SHSs had a positive impact on the respondents' health and environment as shown in Figure 5.6.

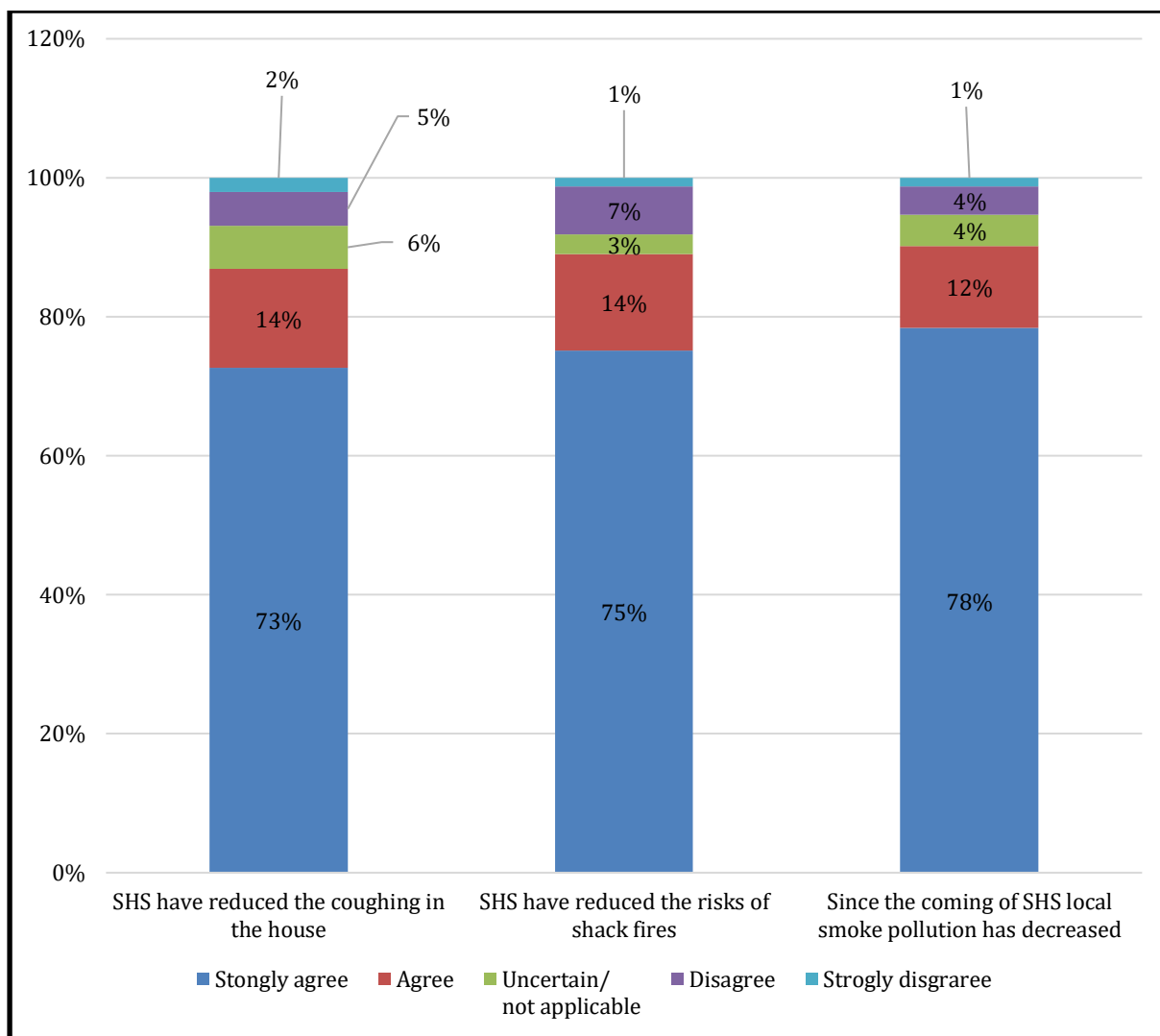


Figure 5.6 Health and environmental impact of solar health systems

Source: Own compilation (2021)

Most respondents strongly agreed or agreed that SHSs reduced the risk of shack fires, decreased local smoke pollution and reduced coughing in the house.

5.6.1 Reduced shack fires and pollution

SHSs resulted in less shack fires. The respondents indicated that candles and lamps were the major causes of shack fires. Therefore, removing these sources of energy reduced the level of risk categories. A total of 190 respondents strongly agreed that SHSs improved community safety:

Most fires are caused by the candles and paraffin and therefore removing these resulted in a reduction of shack fires. Most of the time the fires are a result of children being left alone with these lights. It's worse when there is an accelerant.

The response above showed the hazards that the old fuel sources had towards shack fires. SHSs have now become an effective technology to reduce the dangers of shack fires, thereby improving the safety of the residents of informal settlements:

I can now leave my children alone and bath without worrying about fires. This place has had a lot of fires. I lost my entire property in 2013 and we used to have a lot of shack fires before.

Shack fires have declined since the coming of the solar lights. We used to have our hands full with incidences of fires. I wish the lamps (SHS) had come earlier and prevented a loss of human lives and property.

An interview with a community leader showed another reason why shack fires had declined. Many of the shacks in Ruimsig were upgraded to brick houses, which contributed to the decline in shack fires:

Of course, the houses are being upgraded through some other NGO so that eventually don't have the shacks at all here. That has also contributed to the drops that we have in shack fires incidences. We had to space out the houses and now we have some space to breathe a bit and so fires cannot move from house to house that easily. But of course, this is a going project and yes, we have had some fires until now, but less often though.

The respondents, however, did admit that in winter they did not have safe heating elements that were less risky. Seasonal factors influence the fire incidences that are added by a lack of appropriate energy to warm residences:

To some extent, I can yes but it's not just the paraffin lamps that cause that; there is imbawula (heater) and primus stoves too that can cause fires. Here in Joburg it's cold in winter and sometimes fires start with these coals inside the houses. But I must admit that fewer shack fires have been reported over the last few years.

The respondents were not in agreement on whether smoke pollution has decreased significantly or not. SHSs were not enough to significantly reduce the local pollution because of firewood and coal still being used for cooking. This part of the research reflected the inadequacies of the SHSs in that they were unable to provide enough power for cooking:

The smoke was significantly still there due to coal and firewood for cooking. Remember, the solar was not powerful enough to power the electric stove ... so yeah, people still needed their firewood for cooking.

However, some felt that they had observed some differences, mainly when no cooking was done, like a light night where only kerosene lamps and candles were lit. It was then that one could make observable differences:

Personally, I felt that it had gone down because the smoke from the lamps and the candles were too much, especially light night after cooking.

One stakeholder also mentioned an additional impact which was the reduction in the burns reported among the children and infants:

It's not just shack fires that have gone down but also burns reported to us as community leaders. These cases are still there but less common than before. The candle drops on the kid's skin was a terrible thing for us.

5.6.2 Solar health systems have reduced coughing in the house

The majority of the respondents said that SHSs reduced coughing in the house. When asked about coughing in the house, 85% of the respondents strongly agreed that indoor pollution was lesser than before. The respondents expressed that before SHSs, the residents needed to bring the paraffin lamps closer to see clearly, thereby inhaling a lot of smoke. The replacement of candles and paraffin lamps by SHSs reduced indoor pollution. It became clear in the study that for students to see clearly, they had to be closer to the lamps and candles, thereby increasing the amount of smoke inhaled:

What can I say about this? Yeah, whenever you are reading, especially children, they had to place the lamps close to them to be able to read clearly, thereby inhaling plenty of smoke. Before these solar lights we now have, my son used to struggle a lot with asthma attacks but when we changed that for the solar lamps, the attacks are lesser and lesser.

Equally important, the coughing and sneezing declined as a direct result of replacing the polluting lights:

I used to sneeze a lot and cough a lot before the SHS. I think the smoke that we inhaled was a lot dangerous when I look back. Even my kids when they were young, used to have so many coughs and I visited the clinic a lot. They used to have black nostrils because of the dark smoke that they inhaled.

The reductions in smoke emissions did not only improve the health of residents, but also made the houses cleaner. Smoke also caused problems with causing dirt on several surfaces within a home, including surfaces and windows. The SHSs thereby lessened the need for frequent cleaning:

SHSs are smarter and cleaner than lamps. Even windows and all surfaces used to be black with smoke but now the internal surfaces are cleaner, so lesser smoke inside the houses. I needed to clean several times but now less often.

However, it must be said that several respondents indicated that while there was a decline in indoor pollution, outdoors was a different matter. The cooking that was normally done outside the house was still polluting the area.

5.7 Observational data

As shown in Figure 5.7, the informal settlement has a lot of sewage water flowing through it and many wires and debris lying around, made of sharp stone and some bricks. This ties in well with what the respondents said about the increased safety when it was well lit.



Figure 5.7 Wires, debris and sewage water flowing through the yards

Source: Author's own (2021)

When I visited the area, I saw plenty of vegetable and meat markets, selling of second-hand clothes, car washes, barber and hair salons, and tuck shops. From what I observed, it seemed they adjusted the SHSs to suit their various needs by using electric cables. Some with an SHS were now adding multiple lights to further brighten their places.

I observed that the toilets were outside the shacks, which made sense to add that people felt more secure. Some of the respondents answered that they used cell phone lights and portable (rechargeable) fluorescent lights. The lights were not just for indoor use but also for outside use. This shows the versatility and adoptive practices of the informal settlements in making things a sustainable livelihood.

The owner of the barbershop that I visited highlighted that because of the size of the barbershop or hair salon, they had to add various lights which were not of the original package because hair plaiting needs closer lights. I observed that some shacks operating as hairstylists did not have white interior surfaces, which necessitated having several lights. Aptly so, the owners of the adapted workable arrangements maximised the benefits of solar lighting. Another barber owner was charging fees for charging cell phones for those that did not have an SHS.

The observations above helped to add the qualitative aspects that were missed in the telephonic data collection process. The following figures (Figure 5.8, Figure 5.9, Figure 5.10, and Figure 5.11) show some of the characteristics of the Ruimsig informal settlement as well as SHSs connection aspects.



Figure 5.8 *Car wash business*

Source: Author's own (2021)



Figure 5.9 *Vegetable and meat market*

Source: Author's own (2021)



Figure 5.10 *Spaza Shop showing the bulb connection*

Source: Author's own (2021)



Figure 5.11 Barbershop with additional cell phone charging services

Source: Author's own (2021)

5.8 Reliability

As shown in Table 5.1, the reliability was 0.819. This range shows that the data collected through questionnaires was credible because the respondents were reliable and consistent in answering their questions. This finding is important to adding the integrity of the research results.

Table 5.1 Reliability test score

Reliability statistics		
Cronbach's Alpha	Cronbach's Alpha based on standardised items	Number of items
0.819	0.821	245

Source: Author's SPSS output (2021)

5.9 Conclusion

In summary, the results showed that most of the respondents agreed that SHSs made a difference in their lives. SHSs improved the social aspects of human lives, including improved communications, increased social coherence, and an increased feeling of security. Moreover, because of the SHSs, children were able to study longer into the night, and improved their access to information. The SHSs improved economic opportunities through opening up businesses, increased business hours and created more employment opportunities. Access to SHSs enabled the respondents to save money because there was no longer a need to buy unclean energy sources to light up their homes. This was also applicable to the health outcomes. The use of SHSs reduced pollution levels and, subsequently, respiratory diseases. Also, the SHSs reduced shack fire incidences and also the cases of child burns. The last chapter provides a discussion on the results and how it relates to the ToC.

Chapter 6

Discussions and Conclusion

6.1 Introduction

Chapter 6 discusses the results in line with the ToC theoretical framework. The main conclusions are related to social, economic and environmental dimensions of the SHSs. Recommendations for further research are discussed before the research closes on conclusions and main lessons gleaned from the study.

6.2 Social dimension

From the results sections, it was evident that SHSs have changed the livelihoods of the residents of the Ruimsig informal settlement. They could start charging their phones and could surf the internet for news, thereby increasing information access. Additionally, they could use their smartphones whenever they wanted to, particularly on social media platforms. Before getting the SHSs, they would use their phones sparingly to ensure they lasted longer at night or over the weekend. The SHSs allowed the residents to use their phones as much as they wanted. SHSs has contributed to social cohesion because some men were now spending more time at home than before. The phones have also resulted in the residents becoming closer to their own families and loved ones through telephonic contacts.

Cell phones performed additional secondary tasks. The respondents agreed that cell phones were used for lights or as torches for going to the bathroom. They also added that phones were part of entertainment through playing games. This was said in light of the informal settlement not having much to entertain the residents. When contrasted to the ToC, it showed that TVs and radios attributed to entertainment, while the SHS lantern lights contributed to safety. However, it was learned from this study that torch lights from cell phones contributed to safety.

Furthermore, the SHSs helped to keep the children at home. Children staying at home also saved parents from paying someone to look after their children while they are away. As

opposed to the ToC, the casual pathway of security had been slightly altered. TVs coupled with solar lights, were also thought to increase children's social skills by inviting their friends over at night. TVs and radios are now being used to keep school children in the house after school, thereby increasing their security. This prevents them from unnecessarily toiling around unaccompanied, which has been cited as a danger because of the previous cases of sexual assault reported. Also, TVs were thought to avert children from social ills such as drugs and unprotected sex. Some felt that the TV helped them fight depression during the COVID-19 lockdown. However, some parents also cited that there was a need to control access to TVs because children could end up watching programmes that were not appropriate for their age. The respondents also mentioned that the children were also no longer reading because of the TV. While the TV was suitable for the children, there was a need to control the programmes to minimise damage caused by the devices. Some respondents mentioned that the TVs helped them to attend church services at home by watching church programmes on TV at a time when public religious gatherings were banned.

The SHSs improved the feeling of security of the residents. The lights at night enhanced their feelings of safety. The residents responded that they could now afford to freely walk at night without fear of trampling on wires and objects. Moreover, the residents no longer feared snakes because the places are now well lit. It has become more accessible for the residents to use the outside bathroom because of the lighting systems. The lights also increased safety in the houses as the places are now well lit.

The respondents agreed that lights were deterrent to crime. Thieves were scared to be seen and be dealt with. However, another deterrent was the severity of the punishment meted out when one was caught. This also could have made detection through lights something to fear. The fear of mob justice could have contributed to a decline in the crime rate. Instead of attributing crime reduction to improved night visibility, it was safer to attribute crime reduction to the aforementioned combination of factors.

The children were able to study well at night and do homework because of the improved lighting that came through SHSs. With the SHSs, they were able to increase the number of hours that children and students could study in the evening. The children could also play outside in the lights, which gave parents more freedom to allow their children to play.

The parents also highlighted that their children were passing school better due to the SHS. However, passing might not just be the effect of reading, but the result of the additional help of TV in Mathematics and Science programmes. Having a TV in the house helped to improve English literacy for most school-going children.

Contrary to the ToC, the SHSs did not necessarily free up the time for women because it did not help much with cooking or replacing the cooking fuels. The SHSs did not come with a stove for cooking because it could not power many electrical appliances. The SHSs did not improve gender equity as the women still had to forage for firewood. Some women alluded that fetching firewood took most of their time and that when they were able to have an SHS, it freed up some time that could be used for economic opportunities. However, this did not solve the sociocultural issues of imbalances. Nevertheless, the responses alluded that women still had fewer opportunities compared to their male counterparts. Yet, most respondents acceded that firewood and paraffin were still sold there, probably helping those women who could afford firewood for themselves.

Whenever the respondents had access to their phones, it increased communication with the outside communities, including their relatives and friends. They could optimally use social media platforms and market their products very well. The SHSs improved social coherence through improving family connections. The respondents indicated that they could afford to have TVs and radios in their homes and could watch the news and current affairs. The respondents could access information on new markets to sell their products and use gadgets to trade their commodities and labour.

Some respondents also pointed out that some men were now spending more time at home with their families where previously they would watch football at the shebeens. SHSs improved family cohesion as many fathers started spending more time at home with their families, unlike before. During the interview, it was deliberated that a dark unlit family set-up was not attractive for some men who preferred to watch soccer in clubs and shebeens. As a result of the SHS, family time was improved as fathers could help raise their children at home.

The respondents confirmed that not only having an SHS helped, but having lighting improved their livelihoods tremendously. Lighting contributed to a safer community. The respondents implied that one household having one SHS was not enough, but many lights

around the area gave rise to a safer community. So, it seemed that collectively having various SHSs improved the community by making the area brighter than if it was only a few SHS lights.

While some cited lighting as contributing to safety, some respondents said that SHSs attracted thieves, thereby compromising the security of the residents. Additionally, the informal settlements had no hard infrastructure to deal with petty thefts taking place. The materials used to build shacks made them so cold in winter, leaving the residents with no option but to use coal heaters, risking pollution and shack fires in the process. Also, the informal settlement shacks did not have adequately painted walls that improve the lighting in the houses.

6.3 Economic aspects

There is evidence that SHSs helped the residents to work later into the night, which they could not previously do before the SHS. Two tuck shop owners or spaza shop owners alluded that they could enjoy trading longer into the night under the floodlights of the SHS. The lighting gave the traders an increased sense of security and could well transact under the solar lanterns, which could not be done without them. Some respondents who were hairstylists showed that they could work additional hours under the solar lamps. It was also mentioned that the SHS helped customers to choose their products quite well.

With increased communication comes the opening up of markets and economic opportunities. Several respondents showed that they could sell their products on social media platforms due to having access to electricity. These included selling or marketing their second-hand clothes on the informal settlement's WhatsApp groups. Moreover, they could discuss what other products they had, before boarding public transport to buy from their suppliers on the phone. SHSs availed online business opportunities which were previously limited without access to an SHS. Several women selling vegetables concurred that they could team up and send one person to order vegetables instead of travelling together, which was facilitated by electricity access. Economically, people could save themselves from unnecessary travelling to town and transact on their phones. Also, people can save money from buying fuels to light up their houses.

The Energy One programme availed some employment opportunities for residents to serve the SHSs. They employed local staff and employed women as part of their women empowerment programme, thereby increasing gender equity. The responses also revealed that the SHSs opened up and freed up some time for women to focus on other economic activities. In general, some women said that they did not save any time or money through SHSs because the SHSs did not provide power for cooking and ironing. However, because firewood was sold there, some would not save money. Conversely, some respondents indicated that they could not afford to buy firewood and, as a result, still had to collect firewood. Women relying on getting firewood for themselves admitted that it sets them back against competitiveness as others gain ground while they are looking for firewood.

Some respondents alluded that they could do extra income-generating activities at night, such as tailoring and hair saloons that needed access to electricity. Some even concurred that they started businesses due to the access to electricity. Several opportunities were availed around supporting SHSs, such as selling DVDs, light bulbs and cables. Others found opportunities in charging cell phones at a fee for those who did not have an SHS. However, others felt a loss because they used to sell candles and paraffin lights which have now been redundant due to solar technology.

SHSs are a cost-effective way to save household income. Although there is capital required to buy the SHS, several respondents showed that buying paraffin and candles were something of the past because they now had an SHS. These respondents only used non-renewable energy in the time of emergencies such as when the systems were down. If cooking could have been done by using the SHS, there would be more savings from fuel costs and time because the residents were still looking for alternative sources of fuel for cooking. Considering that the residents of the informal settlement are low-income earners, SHSs are a cost-saving intervention that leaves many residents with more disposable income for household use in other areas. Access to cell phones also saved residents travelling costs and time as they could also do transactions from home by using their phones.

Lastly, the energy-saving fridges that were added were not just being used for household preservation of goods. They are now transcending households to businesses. Some

residents have started using the fridges to stock business goods such as beer and meat for selling. This shows that SHSs not only opened opportunities but also created an enabling environment for businesses.

6.4 Environmental and health dimension

There was agreement that SHSs come with lanterns and take away candles and paraffin lamps to reduce the amount of household air pollution. Consequently, environmental air pollution is reduced when the residents introduce cleaner lights. Most paraffin lamps emit smoke that is choking and causing several respiratory diseases. Therefore, the SHSs have contributed to the reduction in carbon emissions as well as respiratory diseases. There was accord in respondents alluding to a decrease in morbidity that was induced by indoor pollution of smoke emanating from the lamps and candles.

There was a generally agreed fact that SHSs made the informal settlement cleaner. The residents also agreed that SHSs reduced clinic visits because the children were no longer coughing as much as before. Inadvertently, less morbidity comes with lesser costs as parents have to pay to take their sick children to the clinic. This is not just a health outcome but also an economic outcome because some cost savings are involved that come with fewer hospital or clinic visits.

The respondents agreed that SHSs were safer to use in place of paraffin lamps and candles, which could lead to shack fires. There was consensus in deciding that parents were feeling safer to leave their children playing outside for a few minutes since using SHSs. The community leader also agreed that the SHSs had resulted in the decline in child burns and shack fires that had previously claimed several lives and property. The spilling of kerosene lamps would result in the fuel acting as an accelerant to the fire. The way the shacks were structured, if one shack catches fire, several others catch fire with kerosene lamps, accelerating the fires across the shacks. Stakeholder interviews indicated that several houses had been upgraded to brick houses, thereby stopping the spread of fires. Although respondents alluded that fires had been there but had been quickly dealt with, it ties in with the fact that brick houses in between will prevent fires from spreading.

It has also been debated that SHSs needed proper care, which was lacking in most residents and it was mentioned that at times the services for the systems were not so

good. The SHSs could well be complemented with power-saving stoves, which most residents referred to as shortfalls of the current programme. Some still cooked with primus stoves because the SHS does not come with cooking facilities.

6.5 Conclusion

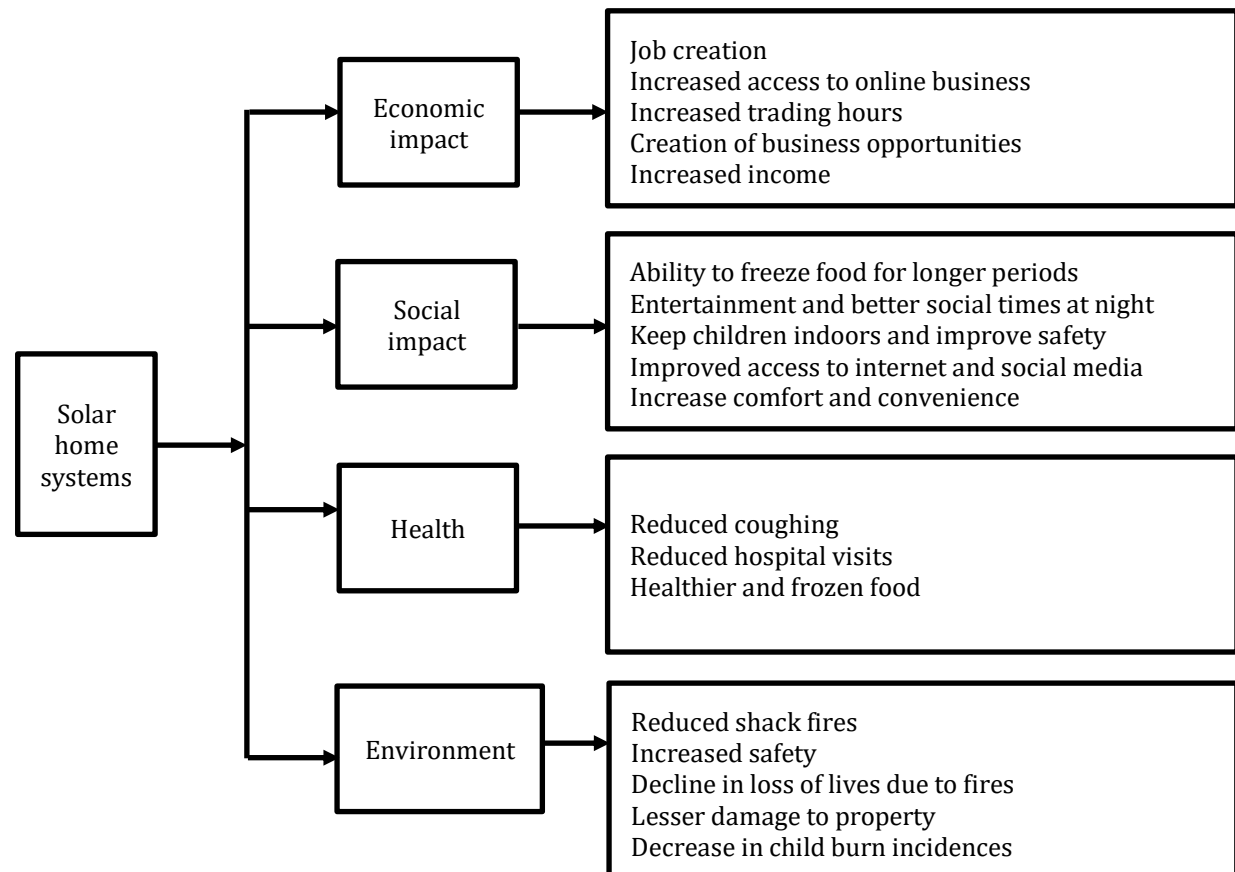


Figure 6.1 *Ruimsig informal settlement theory of change*

Source: Author's own (2021)

From the results showed in Figure 6.1 above, it is clear that the SHSs have improved the livelihoods of the residents of the Ruimsig informal settlement. The study showed that the SHSs improved the social aspects of human livelihoods. Access to SHSs improved access to communication and resulted in increased usage of cell phone devices, resulting in improved social cohesion. The residents reported an improved sense of security due to lighting. The SHSs increased the economic opportunities for the residents. Several respondents reiterated that they could do more part-time jobs, which they could not previously do with the previous unclean energy. Also important, the SHSs reduced the

number of shack fires by replacing the energy sources used to cause the fires. Lastly, the SHSs reduced the levels of pollution by replacing the kerosene lamps.

Economically, the SHSs added not only hours of trade, but also availed previously unavailable opportunities during the pre-SHS era. The SHS programme benefited new opportunities for small informal traders such as airtime, entertainment (selling of DVDs and memory sticks) and electrical appliances that support the SHSs. Likewise, SHSs also added trading hours for some traders (such as shops), and others could start working at night, which they could not previously do, such as plaiting of hair.

There has been a social impact of SHSs on so many levels. Convenience has been added, such as the ability to bath at night and children reading well into the night. Likewise, people now can have radio and TV and get themselves entertained during lockdown periods because of COVID-19. The SHSs have also helped development because most people admitted that they now have phones due to the SHS. Many can now do cell phone banking from home instead of going to town, thereby saving time and money. Lastly, many admitted that they felt safer with the lights because they could see their surroundings better than before.

Health outcomes improved because of SHSs. Several respondents concurred that since the coming of SHSs, coughing and respiratory diseases had declined but were, however, not gone. Indoor winter heating elements through coal still posed a security threat of shack fires. The cooking done outside the house still used coal, firewood, and paraffin, which was still a concern. Shack fire incidences have decreased, partly because of SHSs and the upgrades from shacks to brick-walled structures in some sections of the informal settlements. There were, however, opportunities for improvement for the residents. Cooking remained a challenge for the residents because the residents had to use primus stoves, coal and firewood. This remained a source of pollution for outside cooking. SHSs do not have the capacity to power cooking stoves.

This study was, however, not exhaustive as to the opportunities of SHSs. There are opportunities for the SHS to come with energy-saving cooking stoves that are light on energy.

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Appendix 1

Letter of Ethical Clearance



GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

03-Feb-2021

Dear Mr Shepherd Nyamhuno

Application Approved

Research Project Title:

Livelihood impact of Solar Home Systems: The case of Ruimsig informal settlement in Gauteng

Ethical Clearance number:

UFS-HSD2020/1899

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. Furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis

Chairperson: General/Human Research Ethics Committee

Adri Du Plessis

205 Nelson Mandela
Drive
Park West
Bloemfontein 9301
South Africa

P.O. Box 339
Bloemfontein 9300
Tel: +27 (0)51 401
9337
duplessisA@ufs.ac.za
www.ufs.ac.za



Appendix 2

Letter of Permission



Mogale City
Local Municipality

OFFICE OF THE SPEAKER (OOTS)

04/01/2021

To: The University Free State Centre For Development Studies

In my capacity as the Councillor for Ward 28 Mogale City Local Municipality, I hereby grant permission to Shepherd Nyamhuno (student number 2009063682) to conduct research in the Ruimsig informal settlement (Pikoko) on the impact of Solar Home Systems (SHS). Members of the community who have benefited from the program have been informed of this study and that their contacts will be shared with Shepherd who will reach out to them telephonically.

We hope the research will assist in the future development of informal settlements.

May Shepherd enjoy his visit to our shores.

Kind regards

Yours Sincerely,

CLLR JEAN KOTZE WARD 28
081 287 0450
kotzejean10@gmail.com

Appendix 3

Consent Form – Beneficiaries



VERBAL CONSENT FORM/SCRIPT

DATE

11.01.2021

TITLE OF THE RESEARCH PROJECT

Livelihood impact of Solar Home Systems: The case of Ruimsig informal settlement in Gauteng

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Shepherd Nyamhuno

2009063682

078 422 9666

[Click here to enter text.](#)

FACULTY AND DEPARTMENT:

Faculty of Commerce & Management
Centre for Development Support Department

STUDYLEADER(S) NAME AND CONTACT NUMBER:

Supervisor: Wessel Kruger
083 378 8494

WHAT IS THE AIM / PURPOSE OF THE STUDY?

To investigate the impact of SHS on the livelihoods of the Ruimsig informal settlements

WHO IS DOING THE RESEARCH?

I am Shepherd Nyamhuno, I work as an Evaluation Specialist for an NGO that is into capacitating independent power generating to increase power output and other off grid initiatives

HAS THE STUDY RECEIVED ETHICAL APPROVAL? No

Approval number: N/A

WHY ARE YOU INVITED TO TAKE PART IN THIS RESEARCH PROJECT? No

The participant was chosen because he/she was a beneficiary from the solar home systems program. The participants details were obtained from Energy One who are running the program. We did a random sampling and ended up choosing you as a respondent. I expect a total of 248 participants in



WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

The participant will have to answer as precisely as possible the questions that will be asked in this exercise. The study is a questionnaire administered and the interview through the telephone as precautionary measures for Covid 19 prevention. The questionnaire will ask questions around the experience of using the solar home systems while interviews will ask around broader issues how stakeholders viewed the program. The questionnaire and the interviews are both expected to last for about an hour.

CAN THE PARTICIPANT WITHDRAW FROM THE STUDY?

Participation in this study is purely voluntary and there is no penalty or loss of benefit for non-participation. Being in this study is voluntary exercise and you are under no obligation to consent to participation. If you decide to take part, you will be given this information sheet to keep and be asked to verbally consent. You are free to withdraw at any time and without giving a reason. It will not be possible to withdraw once they have submitted the questionnaire. Furthermore, the questionnaires do not have personally identifiable information making withdrawal unnecessary.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

Participation in this study may contribute to the future improvements of the solar home system program. The subject's participation in the study will be kept confidential, but responses will be summarized in the research report.

WHAT IS THE ANTICIPATED INCONVENIENCE OF TAKING PART IN THIS STUDY?

Participation in this research will require time of the participants. The research will explore the participants' experience in using the SHS and also the stakeholders view of the program. The researcher will remove all personally identifiable information to protect the identity of the respondents.

WILL WHAT I SAY BE KEPT CONFIDENTIAL?

This research will not record the names of the participants anywhere. Your answers will be given a fictitious code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. The researcher will do the transcribing and the coding thereby minimizing the risk of breach of confidentiality. Although anonymity is guaranteed, the data may be used for other purposes, e.g. research report, journal articles, conference presentation, etc. Furthermore, the academic supervisor will have access to data in order to guide the student in the research writing. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report). It is your right to refuse to take part even if your parents/guardians have agreed to your participation. You can stop being in the study at any time without getting in trouble.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Soft copies of your answers will be stored by the researcher for a period of five years in a google drive

Ethics Review and approval if applicable. In order to destroy the information, the files and the backup files will be deleted. The research may cost time for some respondents to be able to participate. The researcher will attempt as much as possible to do the questionnaire/interview during the weekend or after working hours in order accommodate the busy schedule of the participant.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There is no incentive or payment for participating in the researcher. Participating in this study is entirely voluntary. The researcher is aware that this data collection will require the participant to spare some time. The researcher will ensure that the questionnaire/interview is completed/conducted during the convenient hours of the day or weekend. As part of giving back to the community for participating in this study, a copy of the results will be shared to the community through their leaders.

HOW WILL THE PARTICIPANT BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

If you would like to be informed of the final research findings, please contact Shepherd Nyamhuno on 078 422 9666 or snyamhuno@gmail.com. The findings are accessible for 1 year. Should you have concerns about the way in which the research has been conducted, you may contact Kruger Wessel, on 083 378 8394 or email wesselkruger8@gmail.com.

DO YOU CONSENT TO TAKE PART IN THIS STUDY?

Thank you for taking time to read this information sheet and for participating in this study.



DATE _____

11.01.2021

TITLE OF THE RESEARCH PROJECT

Livelihood impact of Solar Home Systems: The case of Ruimsig informal settlement in Gauteng

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Shepherd Nyamhuno

2009063682

078 422 9666

Click here to enter text.

FACULTY AND DEPARTMENT:

Faculty of Commerce & Management

Centre for Development Support Department

STUDYLEADER(S) NAME AND CONTACT NUMBER:

Supervisor: Wessel Kruger

083 378 8494

WHAT IS THE AIM / PURPOSE OF THE STUDY?

To investigate the impact of SHS on the livelihoods of the Ruimsig informal settlements

WHO IS DOING THE RESEARCH?

I am Shepherd Nyamhuno, I work as an Evaluation Specialist for an NGO that is into capacitating independent power generating to increase power output and other off grid initiatives

HAS THE STUDY RECEIVED ETHICAL APPROVAL? Yes

Approval number: N/A

WHY ARE YOU INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

The participant was chosen because he or she is a stakeholder of the solar home systems program (SHS) program that is run by Energy One. It was plausible that the stakeholder was in a position to respond to the research questions that will be addressed by this research and was an interested party due to the position he or she holds.

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?



The participant will have to answer as precisely as possible the questions that will be asked in this exercise. The interview questions will ask around broader issues of how as stakeholders, they viewed the program and how they think it contributed to the development of the community. The interview is expected to last for about 1 hour 30 minutes.

CAN THE PARTICIPANT WITHDRAW FROM THE STUDY?

Participation in this study is purely voluntary and there is no penalty or loss of benefit for non-participation. Being in this study is a voluntary exercise and you are under no obligation to consent to participation. If you decide to take part, you will be given this information sheet to keep and be asked to verbally consent. You are free to withdraw at any time and without giving a reason. It will not be possible to withdraw once you have participated in the interview.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

Participation in this study may contribute to the future improvements of the solar home system program.

WHAT IS THE ANTICIPATED INCONVENIENCE OF TAKING PART IN THIS STUDY?

Participation in this research will require the time of the participant. The research will explore the stakeholder's view of the program. The MDS student will remove all personally identifiable information to protect the identity of the respondents.

WILL WHAT I SAY BE KEPT CONFIDENTIAL?

This research will not record the names of the participants anywhere. Your answers will be given a fictitious code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. The MDS student will do the transcribing and the coding thereby minimizing the risk of breach of confidentiality. Although anonymity is guaranteed, the data may be used for other purposes, e.g. research report, journal articles, conference presentation, etc. Furthermore, the academic supervisor will have access to data in order to guide the student in the research writing. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report. You can stop being in the study at any time without getting in trouble.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Soft copies of your answers will be stored by the MDS student for five years in a google drive for future research or academic purposes. Moreover, the electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. To destroy the information, the files and the backup files will be deleted. The research may cost time for some respondents to be able to participate. The MDS student will attempt as much as possible to interview during the weekend or after working hours to accommodate the busy schedule of the participant.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There is no incentive or payment for participating in the research. Participating in this study is entirely voluntary. The student is aware that this data collection will require the participant to spare some time. The MDS student will ensure that the interview is completed/conducted during the convenient hours of the day or weekend. As part of giving back to the community for participating in this study, a copy of the results will be shared to the community through their leaders.

HOW WILL THE PARTICIPANT BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

If you would like to be informed of the final research findings, please contact Shepherd Nyamhuno on 078 422 9666 or snyamhuno@gmail.com. The findings are accessible for 1 year. Should you have concerns about how the research has been conducted, you may contact Kruger Wessel, on 083 378 8394 or email wesselkruger8@gmail.com.

DO YOU CONSENT TO TAKE PART IN THIS STUDY?

Thank you for taking the time to read this information sheet and for participating in this study.

Appendix 5

Consent Form – Zulu



IFOMU LOKUVUMA NGOMLOMO

USUKU

11.01.2021

ISHLOKO SOMSEBENZI WOKUHLOLA

Umthelela wokuziphilisa weSolar Home Systems: Ucwango lwamacala emijondolo yaseRuimsig eGauteng

IGAMA NOXHUMANA NABO BOMFUNDI:

Shepherd Nyamhuno

2009063682

078 422 9666

[Click here to enter text.](#)

FACULTY AND DEPARTMENT:

Faculty of Commerce & Management
Centre for Development Support Department

IGAMA NOXHUMANA NABO BAKATHISHA:

Wessel Kruger
083 378 8494

YINI INHLOSO YOKUTADISHA KWAKHO?

Ukuphenya umthelela we-SHS ezimpilweni zemijondolo yaseRuimsig
WHO IS DOING THE RESEARCH?

Igama lami nginguShepherd Nyamhuno futhi ngisebenza ngamandla elanga

NGABE ISIKOLE SIVUMELE UKUTHI LOLU CWANINGO LUQHUBEKE? YEBO

Inombolo yomvumo: N/A

KUNGANI UMENYWA UKUBA UZIBANDELELE KULE UCWANINGO?

Umbambiqhaza wakhethwa ngoba wayengumhlomuli ohlelweni lwamasistimu asekhaya elanga. Imininingwane yabahlanganyeli itholwe ku-Energy One eqhuba uhleloSenze isampula engahleliwe futhi sagcina sikukhethe njengomphendulayo. Ngilindele isibalo sababambe iqhaza abangama-248 kulolu cwango.

YINI IMVELO YOKUBAMBA IQHAZA KULESI SIFUNDO?

Umbambiqhaza kuzofanele aphenzule ngokunembile ngangokunokwenzeka imibuzo ezobuzwa.



Izingxoxo zizobuza ngezinkinga ezibanzi ukuthi ababambiqhaza balubuke kanjani lolu hlelo. Uhlu lwemibuzo nezingxoxo kulindeleke ukuthi zithathe cishe ihora lonke.

INGABE OBABAMBAQHAZA ANGAKWAZI UKUMHUMA ESIFUNDWENI?

Ukubamba iqhaza kulolu cwaningo kungokuzithandela futhi akukho sijezi noma ukulahleka kwenzuzo ngokungabambi iqhaza. Ukuba kulolu cwaningo kungokuzivocavoca ngokuzithandela futhi awunaso isibopho sokuvuma ukuhlalanyela. Uma uthatha isinqumo sokubamba iqhaza, uzonikezwa leli phepha lemininingwane ukuthi uligcine bese ucelwa ukuthi usayine ifomu lokuvuma elibhaliwe. Ukhululekile ukuhoxa noma nini futhi ngaphandle kokubeka isizathu. Ngeke kube khona ukuhoxa uma sebethumele uhlu lwemibuzo. Ngaphezu kwalokho, uhlu lwemibuzo alunalo ulwazi olukhomba umuntu uqobo olwenza ukuhoxiswa kungadingeki.

ZIYINI IZINZUZO ZOKUTHOLA UKUTHATHA INGXYENYE KULESI SIFUNDO?

Ukubamba iqhaza kulolu cwaningo kungaba nomthelela ekuthuthukisweni kwesikhathi esizayo kohlelo lwesistimu yasekhaya yelanga. Ukubamba iqhaza kwesihloko ocwaningweni kuzogcinwa kuyimfihlo, kepha imininingwane ngaye izonikezwa umxhasi wocwaningo.

YINI UKUNGAVUMELEKI OKUTHIZIWE KOKUTHATHA INGXYENYE KULESI SIFUNDO?

Ukubamba iqhaza kulolu cwaningo kuzodinga isikhathi sabahlanganyeli. Ucwanoinguzohlola isipiliyoni sababambiqhaza ekusebenziseni i-SHS kanye nombono wababambiqhaza bohlelo. Umcwaninguzosusa yonke imininingwane ekhomba yena uqobo ukuvikela ubunikazi babaphenduli.

INGABE ENGIKUSHOYO NGIZOKUGCINA NGIYIMFIHLO?

Lolu cwaningo ngeke luqophe amagama abahlanganyeli noma yikuphi. Izimpendulo zakho kuzonikezwa inombolo yekhodi yamanga noma igama elingumbombayi futhi uzobhekiswa ngale ndlela kudatha, kunoma yikuphi ukushicilelwa, noma ezinye izindlela zokubika zocwaningo ezifana nezinqubo zenkomfa. Yize ukungaziwa kuqinisekisiwe, idatha ingasetshenziselwa ezinye izinhloso, isb. umbiko wocwaningo, izindatshana zephephabhuku, isethulo senkomfa. Umbiko wesifundo ungaletshwa ukuze ushicilelwe, kepha abahlanganyeli ngazinye ngeke babonakale kulowo mbiko. Ngaphezu kwalokho, umphathi wezemfundo uzokwazi ukufinyelela kwimininingwane ukuze aqondise umfundi ekubhalweni kocwaningo. Kuyilungelo lakho ukwenqaba ukubamba iqhaza noma ngabe abazali / ababheki bakho bevumile ukuthi ubambe iqhaza. Ungayeka ukuba sesifundweni nganoma yisiphi isikhathi ngaphandle kokungena enkingeni.

ULWAZI LUZOGCINYLWA KANJANI FUTHI LULAHLEKELWE EKUGCINENI?

Amakhophi athambile wezimpendulo zakho azogcinwa ngumcwaninguzisikhathi esiyiminyaka emihlanu ku-google drive yocwaningo lwesikhathi esizayo noma izinhloso zezifundo; ngaphezu kwalokho, imininingwane ye-elektroniki izogcinwa kwikhompyutha evikelwe nge-password. Ukusetshenziswa kwesikhathi esizayo kwedatha egcinwe kuzoba kuncike ekubuyezweni nasekuziphatheni okuqhubekayo kokuziphatha kocwaningo. Ukuze uchithe imininingwane, amafayela nama-fayela wesipele azosuswa. Ucwanoinguzungadla isikhathi sokuthi abanye abaphenduli bakwazi ukubamba iqhaza. Umcwaninguzozama ngangokunokwenzeka ukwenza uhlu

INGABE NGIYOKUTHOLA UKUKHOKHWA NOMA IZIMANGALISO ZOKUBAMBA IQHAZA KULESI SIFUNDO?

Asikho isisusa noma inkokhelo ngokubamba iqhaza kumcwaningi. Ukubamba iqhaza kulolu cwaningo kungokuzithandela ngokuphelele. Umcwaningi uyazi ukuthi lokhu kuqoqwa kwedatha kuzodinga ukuthi umbambiqhaza achithe isikhathi esithile. Umcwaningi uzoqinisekisa ukuthi uhlu lwemibuzo / ingxoxo iyagcwaliswa / yenziwa ngesikhathi esivumelana nosuku noma ngempelasonto. Njengengxenye yokubuyisela emphakathini ngokubamba iqhaza kulolu cwaningo, ikhophi lemiphumela lizokwabiwa emphakathini ngabaholi bawo.

NGABE OBABAMBAQHAZA BAZOKWAZISWA KANJANI NGOKUTHOLA / IMIPHUMELA YESIFUNDO?

Uma ungathanda ukwaziswa ngemiphumela yocwaningo lokucina, sicela uxhumane noShepherd Nyamhuno ku-078 422 9666 noma snyamhuno@gmail.com. Okutholwayo kufinyeleleka unyaka ongu-1. Uma kungenzeka ube nokukhathazeka ngendlela olwenziwe ngayo ucwaningo, ungaxhumana noKruger Wessel, ku-083 378 8394 noma uthumele i-imeyili ku-wesselkruger8@gmail.com.

NGABE UYAVUMELA UKUBA NENGXENYE KULOLU CWANINGO?

Siyabonga ngokuthatha isikhathi sakho ufunde leli phepha lemininingwane futhi ubambe iqhaza kulolu cwaningo.

Appendix 6

Information Sheet – Beneficiaries



INFORMATION LETTER

11.01.2020

Dear prospective participant,

My name is Shepherd Nyamhuno and I am a University of Free State (UFS) student studying towards Masters in Development Studies. I am hereby inviting you to take part interviews for my research on Evaluating the solar home system project for Ruimsig informal settlement. The interview will take 1 hour, 30 minutes at most.

Purpose of the study:

The study will find out from the residents of the informal settlements their experiences in using clean energy such as solar energy. The study intends to find how the residents use clean energy and if the current programs are helping the residents with better livelihood, through providing lighting, heating, cooking and powering electronic gadgets such as phones, and computers.

The researcher would like to establish how the residents feel towards Solar Home Systems (SHS) and if they think this program is good or bad and if they want it to be continued. Furthermore, the researcher would like to know if this program has made any difference in the lives of the residents of Ruimsig informal settlements.

The researcher will conduct his data collection through telephonic interviews and will seek verbal consenting through the telephone and the call will be recorded with the permission of the participant.

For more information about this research please contact the following:

Academic Supervisor	Researcher
Name: Kruger Wessel	Name: Shepherd Nyamhuno,
Phone: 27 83 378 8394	Student #: 2009063682
Email: wesselkruger8@gmail.com	Phone: 078 422 9666
	Email: snymhuno@gmail.com

Thank you,

Shepherd Nyamhuno



Appendix 7

Information sheet – Stakeholders



INFORMATION LETTER

11.01.2020

Dear prospective participant,

My name is Shepherd Nyamhuno and I am a University of Free State (UFS) student studying towards Masters in Development Studies. I am hereby inviting you to take part interviews for my research on Evaluating the solar home system project for Ruimsig informal settlement. The interview will take 1 hour, 30 minutes at most.

Purpose of the study:

The study will find out from the residents of the informal settlements their experiences in using clean energy such as solar energy. The study intends to find how the residents use clean energy and if the current programs are helping the residents with better livelihood, through providing lighting, heating, cooking and powering electronic gadgets such as phones, and computers.

The researcher would like to establish how the stakeholders feel towards Solar Home Systems (SHS). Additionally it wants to know if they think this program is good or bad and if they want it to be continued. Furthermore, the researcher would like to know if this program has made any difference in the lives of the residents of Ruimsig informal settlements in social, economic, health and environmental terms.

The researcher will conduct his data collection through telephonic interviews and will seek verbal consenting through the telephone and the call will be recorded with the permission of the participant.

For more information about this research please contact the following;

Academic Supervisor	Researcher
Name: Kruger Wessel	Name: Shepherd Nyamhuno,
Phone: 27 83 378 8394	Student #: 2009063682
Email: wesselkruger8@gmail.com	Phone: 078 422 9666
	Email: snyamhuno@gmail.com

Thank you,

Shepherd Nyamhuno



Appendix 8

Information Sheet – Zulu



INCWADI YOLWAZI

11.01.2021

Usuku oluhle,

Igama lami ngu Shepherd Nyamhuno ngingumfundi e-University of Free State (UFS) ngifunda maqondano neMasters in Development Studies. Ngikumema manje ukuthi ubambe iqhaza ezingxoxweni zocwaningo lwami lwe-SHS. Inhlolokhono izothatha ihora eli-1, imizuzu engama-30.

Inhloso yocwaningo:

Ucwaningo luzothola kubahlali basemijondolo ulwazi lwabo ngokusebenzisa amandla ahlanzekile njengamandla elanga. Ucwaningo luhlose ukuthola ukuthi abahlali bawasebenzisa kanjani amandla ahlanzekile nokuthi ngabe izinhlelo ezikhona manje zisiza abahlali ngokuphila okungecono, ngokubanikeza izibani, ukufudumeza, ukupheka nokufaka amandla izinto zobuchwepheshe ezifana nezingcingo, namakhompyutha.

Ngaphezu kwalokho, umcwaningi angathanda ukuthola ukuthi abahlali bazizwa kanjani ngeSolar Home Systems (SHS). Umcwaningi angathanda ukuthola ukuthi abahlali bacabanga ukuthi lolu hlelo luhle noma lubi nokuthi bafuna luqhubeke yini. Ekugcineni, umcwaningi angathanda ukwazi ukuthi ngabe lolu hlelo lwenze umehluko ezimpilweni zabahlali baseRuimsig emijondolo.

Umcwaningi uzoqhuba ukuqoqwa kwakhe kwemininingwane ngezingxoxo zocingo futhi uzofuna ukuvuma ngomlomo ngocingo futhi ucingo luzoqoshwa ngemvume yalowo obambe iqhaza.

Ngeminye imininingwane ngalolu cwaningo sicela uxhumane nabalandelayo;
;

Uthisha Igama: Kruger Wessel Ucingo: 27 83 378 8394 Imeyili: wesselkruger8@gmail.com	Umfundi Igama: Shepherd Nyamhuno, Inombolo yomfundi:2009063682 Ucingo: 078 422 9666 Imeyili: snymhuno@gmail.com
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Ngiyabonga,

Shepherd Nyamhuno



Appendix 9

Interview Questions – Stakeholders



PRE-LIMINARY SEMI-STRUCTURED INTERVIEW FOR STAKEHOLDERS

1. How are you involved in the running of Ruimsig informal settlement?
2. What changes do you think have been made by the Solar Home Systems (SHS) programs to the social livelihood of the residents?
3. What economic changes have been brought by the SHS?
4. How does having SHS affect the environment?
5. What are the health effects of replacing the old unclean energy with SHS?
6. What are the other benefits of SHS over the old unclean energy sources?



Appendix 10

Questionnaires – Beneficiaries



QUESTIONNAIRES

A. Demographic information

- Age_____
- Sex: Male ☐ Female ☐ Transgender ☐ Prefer not to say ☐
- Race: Black ☐ White ☐ Colored ☐ Asian ☐ Other/Unspecified ☐
- Do you have a SHS? Yes ☐ No ☐
- Which gadgets have you connected to your SHS? Cellphone ☐ TV ☐ Radio ☐ Fridge ☐ Other Specify.....
- In what year did you start using the SHS?.....

B. SOCIAL	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
1. Lighting has increased my sense of security	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. My access to information has improved	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I am now able to communicate better than before SHS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I now have wider choices of entertainment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. School children can now study longer into the night	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. We have more family time than before SHS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. SHS has made my life better	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- How does having lights improve your life?
- How has the ability to connect to TVs and radios changed your life?
- How has your family and children's safety affected by SHS?



4. How is the ability to charge your phones helping your life to improve?
5. What else have you been able to use the SHS for?

C. ECONOMIC	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
1. I am able to do some more work at night	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. SHS has enabled me to save money for fuel (candles, firewood, coal, paraffin etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I now have more time to do profitable business since I no longer have to fetch firewood (for females only)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I am now able to work extended hours into the evening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. SHS has improved my income	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. SHS has enabled me to do some income generating activities that I could not previously do	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Has the SHS opened any economic opportunities for you? If so, what have you been able to do with additional lights especially at night?
2. What has been the impact of SHS upon your income?
3. What else has night lighting helped you to do?

D. HEALTH & ENVIRONMENT	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree

1. SHS have reduced the coughing in the house	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. SHS have reduced the risks of shack fires	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Since the coming of SHS, local smoke pollution has decreased	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Have the SHS in any way reduced smoke inhalation?
2. Have the SHS reduced the shack fires?

Appendix 11

Questionnaires – Zulu



UHLU LWEMIBUZO

A. Imininingwane yabantu

1. Ubudala_____
2. Ubulili: Owesilisa ☐ Owesifazane ☐ i-Transgender ☐ Ukhetha ukungasho ☐
3. Ngokobuhlangankiea : Mnyama ☐ Mhlophe ☐ Colored ☐ Asian ☐ Okunye/Akucazwanga ☐
4. Ungabe unayo iSHS? Yebo ☐ Cha ☐
5. Unayo imishini exhunye kumakhalekhukhwini ☐ Umabona kude ☐ Umsakazo ☐ Isiqandisi ☐ Okunye Casisa.....
6. Uqale ngamuphi unyaka ukusebenzisa iSHS?.....

B. KOMPHEKATHI		ngivuma kakhulu	ngiyavuma	angiqiniseki	angivumelani	Angivumelani neze
1.	Ukukhanyisa kukhulise umuzwa wami wokuphepha	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	Ukufinyelela kwami olwazini sekuthuthukile	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	Manje sengikwazi ukuxhumana kangcono kunakuqala	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	Manje senginokukhetha okubanzi kwezokuzijabulisa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	Izingane zesikole manje zingafunda isikhathi eside kuze kube sebusuku	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	Siba nesikhathi esithe xaxa somndeni ngemuva kokuthola i-SHS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	I-SHS yenze impilo yami yaba ngcono	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Ukuba namalambu kuyithuthukisa kanjani impilo yakho?



2. Ikhono lokuxhuma kumabona kude nakwimisakazo liyishintshe kanjani impilo yakho?
3. I-SHS ikuthinte kanjani ukuphepha komndeni wakho nezingane?
4. Ngabe ikhono lokushaja amafoni akho lisiza kanjani impilo yakho ithuthuke?
5. Yini enye okwazile ukuyisebenzisela i-SHS?

C. KWEZOMNOTHO		ngivuma kakhulu	ngiyavuma	angiqiniseki	angivumelani	Angivumelani neze
1.	Ngiyakwazi ukwenza omunye umsebenzi ebusuku	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	I-SHS ingivumele ukuthi ngonge imali yephethiloli (amakhandlela, izinkuni zokubasa, amalahle, upharafini etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	Manje senginesikhathi esiningi sokwenza ibhizinisi elinenzuzo ngoba akusadingeki ukuthi ngiyolanda izinkuni (kwabesifazane kuphela)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	Manje sengikwazi ukusebenza amahora anwetshiwe kuze kuhlwe	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	I-SHS ithuthukise umholo wami	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	I-SHS ingivumele ukuba ngenze imisebenzi engenisa imali ebengingakwazi ukuyenza phambilini	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Ngabe i-SHS isivulele noma imaphi amathuba ezomnotho?Uma kunjalo ukwazile ukwenzani ngamalambu angeziwe ebusuku?
2. Uye waba yini umthelela we-SHS emholweni wakho?
3. Ukukhanyiswa ebusuku kukusize ngani?

	ngivuma kakhulu	ngiyavuma	angiqiniseki	angivumelani	Angivumelani neze
D. IMPILO KANYE NENDAWO EZUNGEZILE					
1. I-SHS iyehlisile ukukhwehlela endlini	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. I-SHS inciphise ubungozi bokusha kwemijondolo	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I-SHS inciphise ukungcoliswa kwentuthu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Ngabe i-SHS ngandlela thile inciphise ukuhogela intuthu?
2. Ngabe i-SHS iyinciphisile imililo yomjondolo?