THE IMPACT OF ELECTRIFICATION ON RURAL WOMEN'S PARTICIPATION IN AGRICULTURE AND THEIR WELFARE

BY

DIONNE FARAI MAKUWAZA

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DEDICATION

To dad…ours was a short journey with many lessons learnt. Thank you.

DECLARATION - PLAGIARISM

I, Dionne Farai Makuwaza, declare that;

1. The work contained in this thesis is my original research investigations and findings.
2. Information other than my own was re-written and acknowledge as being sourced from other researchers. Where information was directly extracted from the source, quotation marks were used and referenced. A list of references was appended.
3. The work contained in this thesis has not been previously submitted for any degree or examination at any other university.

Signed: [redacted] Date: 26 August 2021

As the candidate's supervisor, I, Maxwell Mudhara, agree to the submission of this thesis;

Signed: [redacted] Date: 12/02/2022

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ABSTRACT

South Africa's National Development Plan highlights support to smallholder farmers and rural electrification as strategic interventions aimed at fostering economic growth. The government has assigned significant financial investments toward smallholder support programmes and multi-billion rand projects have spent on electrification on the premise that electrification will alleviate poverty. Development strategies that lack empirical research to guide policy can result resource misallocation, and adverse consequences for intended beneficiaries and growth sectors. Electrification is a time-saving technologies that can free up farmers' time, especially women's, enabling them to increase their participation in agriculture. There are very few studies that analyse the impact of electrification on agriculture in South Africa. The few studies from South Africa and other countries show mixed results on the effect of rural electrification on time allocated to agriculture by women and the impact on their welfare.

This study analysed the relationship between access to electricity and smallholder farmers' participation in agriculture using data from a sample of 243 households in Ward 14 in Msinga Local Municipality of KwaZulu-Natal Province of South Africa. The data from the sample was also used to analyse the impact of electrification on female-headed household's income. The relationship between access to electricity and smallholder farmers' participation in agriculture was assessed using descriptive analysis, Categorical Principal Component Analysis and Principal Component Regression. The study results show a negative relationship between participation in agriculture and access to electricity, high household income per capita, household head employment in fulltime off-farm employment, household ownership of television, and radio ownership. Households that spend more time collecting firewood and cooking allocate more time to agriculture despite the time demands of their home-based chores. Young and elderly smallholder farmers participate more in agriculture compared to middle-aged smallholder farmers. Entrepreneurial smallholder farmers with small plots participate less in agriculture compared to non-entrepreneurial smallholder farmers.

Ordinary Least Squares regression was used to analyse the impact of electricity and other household attributes on households' welfare. The econometric results show that female-headed households have higher income per capita than male-headed households. The results suggest that the income advantage is from smaller family sizes and access to electricity. The study also found that access to electricity, age, education, time spent in off-farm employment, and occupation of household head impact household income. The results suggest that most households are engaging in subsistence farming out of necessity. Therefore, policies that seek to improve agricultural participation and productivity in rural areas must focus on creating awareness amongst households on the benefits of farming as a business. Trends in the sample that contradict findings at the municipal level also show that agricultural programmes and assessments need to consider micro-data for more effective implementation and evaluation. The pivotal role of women in the study area emphasises the importance of a gender-sensitive approach in rural development policies and strategies.

LIST OF ACRONYMS

CAADP	Comprehensive Africa Agriculture Development Program
CATPCA	Categorical Principal Component Analysis
CGIAR	Consultative Group for International Agricultural Research
DOE	Department of Energy
DME	Department of Minerals and Energy
FAO	Food and Agriculture Organization
HDI	Human Development Index
HHH	Household Head
ICT	Information and Communications Technology
INEP	Integrated National Electrification Programme
MDG	Millennium Development Goals
MMIDP	Msinga Municipality Integrated Development Plan
MRFCJ	The Mary Robinson Foundation – Climate Justice
NDP	National Development Plan
NPC	National Planning Commission
OLS	Ordinary Least Squares
PCA	Principal Components Analysis
PCR	Principal Component Regression
RE	Rural Electrification
SDG	Sustainable Development Goals

SLF	Sustainable Livelihood Framework
STATSA	Statistics South Africa
TV	Television
USAID	United States Agency for International Development

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CHAPTER ONE: INTRODUCTION

1.1 Background

In September 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development. Member states adopted the 17 Sustainable Development Goals (SDGs), committing to end poverty, protecting the natural environment and ensuring peace and prosperity for all (van Noordwijk et al., 2018). South Africa's implementation of SDGs is within the context of its local National Development Plan (NDP), which was finalised four years prior to the adoption of the SDGs (Haywood et al., 2019). The NDP aims to eliminate poverty and reduce inequality in South Africa by 2030 (National Planning Commission (NPC) 2011). The historical growth process of most rich economies and the recent experience of fast-growing developing Asian economies suggests that a considerable increase in labour productivity in agriculture and overall agricultural production are two of the five essential characteristics closely tied to developing countries' success. Since the 18th century, there are virtually no examples of mass poverty reduction that did not start with sharp rises in employment and self-employment income emanating from higher productivity in small family farms (Lipton, 2005, Collier and Dercon, 2014). Studies (Kydd et al., 2004, Pinstrup-Andersen and Shimokawa, 2006, Oyakhilomen and Zibah, 2014, Awokuse and Xie, 2015) have emphasised agricultural development as the starting point of economic growth and poverty alleviation in development economics. However, despite the focus on agriculture, there is a contrast between the level of support and outcomes. Radical improvement is needed in the performance of agriculture in Africa (Collier and Dercon, 2014).

Most small farms in Africa are increasingly becoming unviable as sustainable economic and social units. Empirical evidence from East and Southern Africa shows that land/labour ratios are declining (Jayne et al., 2010, Jayne et al., 2016, Bryceson, 2019). High inequalities exist in landholding distribution within the smallholder sectors, thus posing land constraints that hamper productive farm technologies' sustainable use (Jayne et al., 2003, Sitko and Chamberlin, 2015). In addition, rapid urbanisation is moving labour out of rural areas (Mlambo, 2018). Unless governments' policies to agriculture change radically, there may be increasingly frequent and severe economic and social crises in Sub-Saharan Africa (Jayne *et al*., 2010).

African countries will need to accelerate infrastructure development to achieve real progress in economic development and poverty alleviation. Such progress must include, amongst other factors, progress in countries' vital economic sectors and energy technology. There is evidence that a country's infrastructure level is associated with its agricultural productivity level (Antle, 1983, Jayne et al., 2010, Onwuemele, 2011, Donaldson, 2018, Sennuga et al., 2020). This evidence necessitates the need to research how agricultural performance is affected by the critical infrastructural developments in a developing economy. Lack of access to energy impedes development at local and national levels, affecting agriculture and other productive activities. The lack of rural infrastructure is a crucial challenge for increasing agricultural productivity amongst smallholder farmers in Africa (Venot et al., 2017). Recent literature indicates the significant role of rural infrastructure in improving agricultural productivity in developing countries (Chinnasamy et al., 2015, Dogan et al., 2016, Shamdasani, 2021). However, many rural households still lack access to some of these critical infrastructures (Llanto, 2012, Chamberlin et al., 2014, Chavula, 2014, Benin, 2016, Chikaire et al., 2017) Only 43% of the rural African population has access to electricity (Blimpo and Cosgrove-davies, 2019). These statistics show that much still has to be done regarding infrastructural development in rural communities. Due to the meagre degree of access to infrastructure in these communities, particularly access to electricity, it is vital that efforts made to avail this technology to households be well-guided by a concrete understanding of how these technologies affect the households' activities. This will help ensure that maximum impact is derived from access to the infrastructure.

Conventional energy policies have focused on energy supply, with little attention to the social dimensions of energy (O'Neill-Carrillo et al., 2008, Miller et al., 2013). Emphasis is placed on energy technologies, supply, prices and carbon emissions, with little focus on the human aspect; the societies, social norms and values that affect how energy systems function (Miller et al., 2013). In understanding how agricultural productivity is affected by energy access, it is crucial to consider the role social issues play in this relationship. There is also more focus on the impact of energy on agriculture in the agricultural sector, with very little focus on the gender dynamics of energy access and how they affect agricultural productivity. Policies cannot underestimate the role of agriculture, energy access, and women empowerment in Africa's development. It is essential to understand the relationship between these three factors, how they affect each other and how they work together in addressing poverty alleviation and, at large, the economic growth of the African continent.

South Africa is one of Africa's leading countries in terms of electrification and income per capita (Blimpo and Cosgrove-davies, 2019). However, the country has the highest income inequality in the world, and most of the country's poor population resides in rural areas. The NDP identifies smallholder farmers as key agents in improving rural livelihoods (NPC, 2011). The South African government has assigned significant financial resources to support smallholder farmers in its strategic efforts to eliminate poverty (Thamaga-Chitja and Morojele, 2014). Women are the majority of household heads in rural areas in South Africa, and they comprise most of the smallholder farmers involved in agriculture (Thamaga-Chitja, 2012).

1.2 Specific Problem

The NDP's strategy to reduce inequality and alleviate poverty by supporting smallholder farmers requires an understanding of the infrastructure that is meant to support this strategy and the agents involved in strategy. Women are key agents in smallholder farming (Doss et al., 2011, Patil and Babus, 2018) and electrification is a key infrastructural technology in rural development (Van de Walle et al., 2017). However, there is limited energy research in agriculture in South Africa, and multidisciplinary studies that analyse the energy, gender and agriculture nexus are even fewer (Pouris 2016). Lack of research in strategically identified development sectors hampers economic growth (Masters, 2005, Guloglu and Tekin, 2012, Pouris and Ho, 2014).

Women are, typically, the major users and suppliers of energy resources in marginalised communities (Cecelski, 2000), implying that they are likely to be affected more by the lack of energy access. Therefore, women must play an integral role in defining the way forward on energy access in agriculture. (Doss et al., 2011)Palit and Andalan (2011) state that women farmers' productive potential is undermined by a lack of access to essential resources such as energy. Yet, endeavours aimed at improving energy security in Brazil and China have negatively impacted agricultural activities as women's farmlands were flooded by dam overflows (Mara, 2011, Sovacool and Valentine, 2011, The Mary Robinson Foundation – Climate Justice (MRFCJ), 2013). The lack of a gender perspective has resulted in women being affected more because they lack land rights and have limited access to alternative livelihood options (Mara, 2011). Gender-blind policies sometimes have unintended adverse impacts, and they miss vital opportunities to ensure

projects utilise women's influencing capability within households and communities (FAO, 2008). Thus, it is essential to understand the impact of energy policies and programmes on communities while also considering gender differences.

Electricity access is crucial for women's development in reducing their time burden for collecting firewood used in cooking and heating, supporting livelihood activities, improving health and wellbeing, and allowing for enterprise development and capacity-building (MRFCJ 2011). Women involved in agriculture lack the resources and opportunities to make the most productive use of their time, and this is one of the chief reasons for the underperformance of the agricultural industry globally (Marslen, 2015). In South Africa, women carry most of the burden of productive activities in farming and in the household, and time poverty constrains them from farming beyond subsistence (Thamaga-Chitja, 2012). Studies have shown that rural electrification can be a time-saving technology that empowers women to participate more in income-generating activities (Mathur and Mathur, 2005, Costa et al., 2009, Dinkelman 2011, Grogan and Sadanand, 2013,). Welfare gains through increased income (Mathur and Mathur, 2000, Khandker et al.,2012) and an increase in years completed in school by young girls (Saing, 2018) have been observed in India, Bangladesh and Combodia respectively. However, other studies show a decrease in agricultural participation by women from access to electricity (Grogan and Sadanand, 2013, Van de Walle et al., 2017, Akpandjar and Kitchens 2017, Chhay and Yamazaki 2021). There are very few studies in South Africa that analyse the impact of rural electrification on women's welfare and their time allocation to agricultural activities**.** In a study using provincial data, Dinkelman (2011) showed that electrification moved households time away from agriculture in South Africa. Another study by Rathi and Vermaak (2018) shows welfare gains for rural women in South Africa through increased annual incomes from access to electrification. The study does not focus on households' agricultural participation.

There are mixed findings on the impacts of electrification on agricultural participation in previous studies. Therefore, this necessitates a study that can add to the empirical findings informing energy and agricultural policies in South Africa, and ultimately the national development strategies for the country and the African region. Given the significant contribution of women to smallholder farming in South Africa, a study applying a gender lens will help ensure that research findings assist in effective policy guidance.

1.3 Research Objectives

The general objective is to evaluate the impact of electrification on rural women's participation in agriculture and their welfare .

Therefore, the specific research objectives of this study are to:

- To assess how rural electrification affects the time women allocate to farming activities.
- To assess the impact of rural electrification on the welfare of women smallholder farmers.

1.4 Research Hypotheses

The following are impact hypotheses, which set out base assumptions on cause-effect relationships in this study:

H_0: Access to electricity does not affect the time allocated to agriculture.

H_0: Access to electricity does not affect household welfare.

H_0: There are no gender differences in time allocation to farm activities between electrified and non-electrified households.

1.5 Outline of the Thesis

This thesis was written in the 'paper' format, structured in 5 chapters. Chapter 1 is the introduction, providing the background to the study, the problem statement, the objectives, and the research hypothesis. Chapter 2 reviews the literature on the relationship between electrification and development globally and in the South African context, then it reviews the literature on the social dimension of energy and how this affects women in agriculture. Chapter 3 is a paper that analyses the impact of electrification on the agricultural participation of female-headed households. Chapter 4 is another paper that analyses the impact of electrification on the welfare of smallholder farmers. Chapter 5 is the conclusion; it summarises the whole study, provides recommendations based on the findings, and highlights areas of future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Energy studies have been very significant in the last decade. Identifying the determinants of electricity demand has become crucial for the development of countries worldwide. Though economic growth is directly related to energy use and technological development, electricity research is limited in Sub-Saharan Africa. South Africa experienced a severe electricity crisis in 2008 that resulted in domestic and industrial electricity users suffering from blackouts. Part of the reason was the blackouts lack of research on electricity and energy in general (Kebede et al., 2010). Pouris (2008) states that South Africa produces only 0.34% of the international research publications reporting on energy and fuels topics while the country contributes 0.5% of the academic research papers in all scientific disciplines internationally. Additionally, Pouris (2008) found that energy research literature constitutes 0.45% of the national effort relative to other disciplines. This share of energy literature is relatively minute in contrast to the nation's top disciplines, namely, medicine (6.04%), plant sciences (5.07%), and ecology (3.50%). In 2014, the energy research output had increased to approximately 1% (Pouris, 2016), which is still very low. As one of Africa's leading energy suppliers, these statistics reflect the research gap in energy from a development perspective. The lack of academic research in the field deprives the relevant stakeholders and government of insight and debate based on independent views (Inglesi and Pouris, 2010, Pouris, 2016). Energy interventions in various economic sectors risk being inefficiently structured and implemented if information remains limited.

Energy is a critical input in the development of the agricultural sector, and the sector plays an immense role in rural development (Banerjee et al., 2017). Globally, a gender-focused approach to economic development has developed over the years (Forsythe et al., 2003, Kabeer and Natali, 2013). Energy and agricultural policies have started to adopt a gender perspective in setting goals and in implementation considerations. There has been a growing emphasis on women's role in agriculture, especially in rural communities (Doss et al., 2011, Patil and Babus, 2018). To understand how rural women in agriculture are affected by electrification, one needs to understand the role of rural women in agriculture and their society as this has a bearing on their agricultural activities. Farm activities and off-farm activities are connected, and they affect each other. Electricity does not only affect households' agricultural activities but the activities in their homes

as well. Most studies analyse the impact of energy on agriculture when the households are already on the field, not before they get to the field (Cabraal et al., 2005, Bardi et al., 2013, Elias and Bower, 2015). From studies on the impact of energy on mechanisation in agriculture to agricultural processing studies, the off-farm interaction is often not accounted for in studies on agricultural development. Social matters like gender, energy use by households and how they are intertwined with other factors of critical importance in agriculture are often not considered. Who are the people farming? Where are they coming from before they get to their agricultural field or plots? What roles do they play off the agricultural field that influence their decision to farm, how they perform on the farm? How is the social setting affecting economic wellbeing? This paper expounds on the tri-dimensional nexus between one social factor (gender) and two economic factors (agriculture and energy). This analysis extends to how this tri-dimensional relationship affects the welfare of smallholder farmers. The literature review first discusses electrification in South Africa to establish the key drivers of the country's infrastructural development. The general review of rural electrification literature ends with an analysis of linkages between this technology and agricultural development. The literature review then discusses women's role in agriculture and how a gender perspective enables electrification programmes to impact agricultural development more efficiently. The review concludes by discussing the impact of electrification on welfare.

2.2 Electrification and Development

2.2.1 Electrification in South Africa

In South Africa, the energy sector has been and continues to be at the centre of development. In the early years of the 20th century, the booming mining industry drove electricity supply. Later, the establishment of a local nuclear capacity revealed concerns over the security of power supply (Davidson and Winkler, 2003). Presently, the government's focus is on broadening household access to electricity, addressing inequality in modern energy services, and ensuring the affordability of modern energy (Department of Energy (DOE), 2015a). The energy sector remains at the heart of structural developments in the economy, and in particular, the electricity supply sector plays a critical role in the country’s energy economy (Davidson and Winkler, 2003).

South Africa is the largest producer of coal in Africa and the seventh largest producer in the world (Xiang et al., 2017). Electricity is essential in improving the previously disadvantaged majority's quality of life and supporting large-scale industrial development. On the household side, electricity provision to previously disadvantaged communities has been one of the more successful workings of the government's Reconstruction and Development Programme (RDP) (Borchers et al., 2001). RDP was the first macroeconomic policy adopted by South Africa's democratic government in 1994. Though it only lasted for two years, access to electricity increased from 36% to 63% of the South African population through the implementation of the policy under the Integrated National Electrification Programme (INEP) (Borchers et al., 2001, Mosala et al., 2017). Using a mass electrification initiative, access to affordable electricity was a key policy priority in the White Paper on Energy Policy (Department of Mineral and Energy (DME), 1998). The main goals of government policy for the energy sector at that time, as stated in the 1998 White Paper on Energy Policy, are:

- Increasing access to affordable energy services;
- Stimulating economic development;
- Improving energy governance;
- Managing energy-related environmental impacts;
- Securing supply through diversity (DME, 1998).

Much attention has been centred on increasing access to energy, particularly electricity. Before 1994, the provision of electricity in South Africa was limited to established towns and areas of economic activity (Borchers et al., 2001). Only about 36% of the total population had access to grid electricity in 1993. This figure more than doubled to 86% in 2013 (Department of Energy (DOE), 2015a). From the beginning of the 1990s and mainly from 1994 onwards, after the country's democratisation, the South African economy and society experienced significant structural changes. Among other challenges, poverty-stricken rural areas suffered from a lack of access to essential services such as electricity, which resulted from apartheid policies. In South Africa, the electrification programme became a national electrification programme in 1994. Post-apartheid, the new South African government considered electricity provision a critical factor for the country's growth and development.

After the political restructuring of 1994 and the transition to democracy, the country embarked on eliminating inequalities and providing electricity to most of the population. Eskom, the leading electricity supplier, endeavoured to supply electricity to the majority of households, mainly in the undeveloped rural areas, through the rapid electrification program. The first phase of the INEP (1994-99) was authorised by the government and executed by Eskom and municipalities. The cost of this endeavour to the government amounted to about R7 billion (Borchers et al., 2001) and saw electrification nationally increase to about 66% by 2001. Forty-six percent of the rural population had access to electricity, contrasted with 80% of the urban areas (Davidson and Winkler, 2003). Between 1994 and 2015, the INEP enabled access to electricity to 5.977 million households, resembling 86% access to electricity nationwide (DOE 2015).

South Africa accounts for the most significant percentage of the African continent's electricity generation, generating 43% of the total electricity in 2007 (Amusa et al., 2009). Amusa et al. (2009) show that Eskom, the national electricity provider, produced 82% of its electricity from coal, 5% from nuclear energy and 3% from other sources. This strong dependence on coal contributed to the country's high carbon emissions, which requires a reduction in line with international environmental commitments. The DOE's target has shifted from just access to energy for all to 100% clean, affordable, reliable access to energy by 2025 for all South Africans (DOE, 2015b). Environmental sustainability considerations have become paramount in the energy sector and other economic sectors, globally and locally.

2.2.2 Rural Electrification

Economic growth is directly related to energy use and technological development (Calderón and Servén, 2008, Nkalo and Agwu, 2019, Lewis and Severnini, 2020). National electrification programmes are given priority in many developing countries (Bensch et al., 2011), and the level of electrification is perceived by policy-makers, in general, as one of the crucial development indicators (Rosnes and Shkaratan, 2011, Eberhard and Shkaratan, 2012, Sapkota et al., 2013). Research shows a robust association between electrification and income growth globally (Aklin et al., 2018). In most African countries, electricity is produced as a social facility and is subsidised substantially by the governments (Calderón and Servén, 2008). Electricity supply companies that are government-owned, financed, and operated use distorted prices in rural electrification programmes (Eberhard and Shkaratan, 2012, Calderón and Servén, 2008). This supply model is

unsustainable in satisfying a growing demand for energy that requires huge infrastructural expansion costs. In particular, RE (rural electrification) programmes are challenging to implement because the returns on the investment made in grid extension are minimal given the usually low levels of power consumption in rural areas (Mapako and Prasad, 2007)

RE through the electrical grid is the dominant and most desired means of supply (Aklin et al., 2018, Javadi et al., 2013, Cook, 2011). However, in areas with low load densities, it is desirable to use diesel generators, renewable energy, and hybrids of cost-effective alternatives (Urpelainen, 2014). Large scale and industrial electricity supply are mainly technical activities centred on expansion and economic viability. However, this does not apply to RE. The electrification of rural and remote areas was conceived as a techno-economic activity in the past. Therefore, the pace of electrification has been slow due to the emphasis on cost recovery (Cook, 2011). Presently, the view on RE has expanded beyond the technical and economic issues to include aspects such as social, ethical, institutional, political, and cultural matters (Barnes, 2010, Sovacool and Valentine, 2011, Gaunt, 2005). Governments and development agencies are prioritising rural electrification for social equity goals and economic development reasons (Cook, 2013). Considering these factors, electrification endeavours aimed at development need a multi-dimensional approach for them to be effective. Whether explicitly recognised or not, objectives dictate the type of development and electrification systems planned, financed, and supported (Niez, 2010). Without understanding the challenges to be addressed and the consequences, it is easy to undermine the development intervention (Gaunt, 2003).

Bernard (2010) identified three distinct phases in RE policies globally, between 1980 -2010. In the first period, before the 1980s, RE projects were driven by infrastructural development objectives. Under-development was primarily understood as a lack of equipment to support growth, and infrastructure investments were a high-ranking priority in development policies. This policy priority in this phase is highlighted by Cook (2011). In rural areas, RE projects received enormous support to curb rural migration to the populous urban areas (Rhoda, 1983). Access to electricity could lead to new rural communities and a reliable energy source to support agricultural and non-agricultural economic activities. Finally, RE could contribute to long-term growth through its effects on human capital development, thus enhancing productivity and future incomes (Bernard, 2010).

In the 1980s and 1990s, there was the Structural Adjustment phase. Generally, the favourable cost-benefit analyses performed in the previous period that had steered RE programmes appeared overrated, particularly on the benefits that remained limited or unknown (Pearce and Webb, 1987, Bernard, 2012). Despite high access rates, the connections were low and urban migration was not mitigated (Rhoda, 1983). Limited environmental benefits such as reduced wood fuels for cooking and heating remained. RE programs were thus judged quite negatively over the period because of overestimated benefits, and costs were understated before programme implementation (Barnes, 1982).

The third phase started in the late 1990s when development policies increased their focus on poverty eradication (Bernard, 2012). The adoption of the Millennium Development Goals (MDGs) in 2000 highlighted the importance of energy in the fight against all forms of poverty, the enhancement of health and education, and the support of women empowerment and environmental protection. Many authors (Energy, 2005, Bensch et al., 2011, Assmann, 2012, Nussbaumer et al., 2013) highlighted that it would be impossible to achieve the MDGs without increased investment in the energy sector (Bensch et al., 2011, Energy, 2005, Nussbaumer et al., 2013, Assmann, 2012, Sapkota et al., 2013). Consequently, many RE projects used the MDGs as their main validation (Gaunt, 2003).

The belief that RE helps alleviate poverty is a compelling justification for the support that RE receives from donors and the public sector. In the short and medium run, local economic growth enabled by access to a reliable power source can, directly and indirectly, benefit the poor through higher productivity and better employment opportunities (Khandker et al., 2012b). Additionally, human capital development through improved health and education, enabled by access to electricity, can help remove barriers to the poor's economic and social wellbeing (Peters and Sievert, 2016). RE can reduce environmental pressures in the long run, thereby facilitating the development process' environmental sustainability locally. There is still little evidence to support this "poverty alleviation" belief as results vary across countries (Bernard, 2012).

In South Africa, the National Development Plan (NDP) sets the course of the energy sector as depicted in the statement by the Deputy Minister of Energy in the Annual Performance Plan:

"The NDP defines the path that our country will take over the next 16 years and identifies the role that the energy sector will play during this period. One of the NDP's high-level objectives to be achieved by 2030 is the need to produce sufficient energy to support the industry at competitive prices, ensuring access for poor" (DOE 2015, page 8)

The National Development Plan's two high-level objectives are eliminating poverty and reducing inequality in South Africa by 2030 (NPC, 2011). With the NDP guiding the energy policies in South Africa, this means that the country's electrification goals and programs are socio-economic. Though the MDGs were replaced by the SDGs in 2015, the new development goals are aligned to the NDP (Haywood et al., 2019).

2.2.3 Electrification as a Technology for Development

Private utilities supply electricity to customers based on the full cost recovery from a connection charge and energy sales. RE programs seldom sustain themselves financially (Mulder and Tembe, 2008, Azimoh et al., 2016). However, there are positive externalities that rural populations derive from crucial interactions enabled by the introduction of electricity. These include improved access to communication, education, and economic opportunities (Sanghvi and Barnes, 2001). Gaunt (2003) states that electrification by itself has not been a catalyst to economic development. Economic development should be a precursor to electrification for the technological infrastructure to significantly impact households and the nation (Alobo Loison, 2015, Jimenez, 2017). Nevertheless, RE is vital in the development process and should be part of the broader rural energy development schemes (Gaunt, 2003)

The UN Commission on Sustainable Development identified access to energy as a vital issue for development and poverty alleviation (UNDP et al., 2004). However, the role of electricity supply in reducing and alleviating poverty is ambiguous (Sanghvi and Barnes, 2001, Peters and Sievert, 2016, Lenz et al., 2017). With very little impact research on electrification in the regions where poverty levels are high, it is not surprising that this clarity is lacking. Meeting the energy needs of the poor through electrification has both economic and social dimensions (Rahman et al., 2013). The objectives of many electrification programmes since 1970, and their analysis has been socio-economic. There is little proof of electrification embarked on only for social reasons, with the primary objective of poverty alleviation, and developing countries see electrification programmes

as part of their economic development efforts (Gaunt, 2003). South Africa's electrification programmes first had economic goals, and then after attaining democracy in 1994, the electrification goals became socio-economic (Gaunt, 2005, Pereira et al., 2011). Most recently, the electrification goals became predominantly social, with access to electricity being prioritised for social equity (Pereira et al., 2011).

From the broader energy policy context in South Africa, electrification is a driving factor for socio-economic development and must also deliver services that better the lives of the majority (DOE, 2015a). On a practical level, this implies that energy solutions must be for various end uses, critically including cooking and productive uses for all South Africans. The combination of goals shows that economic development ought to result in an increase in total output (economic growth) over time and the advancement of some set of social goals such as equal income distribution among the different races of the country (Davidson and Winkler, 2003).

Sen and Grown (2013) state that, for poverty alleviation, electrification must begin with women as they are more vulnerable to poverty than men. Such an approach implies that South Africa's energy policies also require a key focus on women for them to effectively yield the desired results in the achievement of the development goals. If energy policies in South Africa have to assist in the national task of poverty alleviation, then RE programs need to broaden their scope beyond concerns about access solely to consider the social matters that can hinder the effectiveness of these programs.

In agriculture, the impact of electricity is the provision of energy for agricultural-based industries and farm machinery such as water pumps, fodder choppers, threshers, dryers and grinders. Electricity is a technology that increases irrigation, and all these changes can increase agricultural productivity (Carr and Hartl, 2010). The lack of social considerations and a gender perspective in analysing electrification interventions in agriculture may explain why very few impact studies assess the impact of electrification on women in agriculture. Both electrification and agriculture play essential roles in the development of countries. One of the targeted outcomes by the DOE reflects the importance of the link between agriculture and electrification:

“Outcome 7: Vibrant, equitable, sustainable rural communities contributing toward food security for all” (DOE 2015, page 19)

In the energy centred endeavours in rural communities, the DOE highlights an agricultural impact factor. Based on the significant role women play in the agricultural sector, energy interventions in agriculture will also impact them. Therefore, discussions and analysis of energy interventions in agriculture need to consider how women in agriculture are affected. Access to electricity has the potential to free women's time from domestic tasks and reallocate it to agricultural activities.

2.2.4 The Labour-saving Impact of Electricity

A few impact studies on electrification have shown that electrification can be a labour-saving technology. Time is one of the productive resources required by individuals to engage in activities that result in economic growth and improve welfare (Mare and Girmay, 2016). Access to electricity enables households to use time-saving appliances that free up time for household members, and the saved time may go to other activities (Brenčič and Young, 2009). Most rural women in agriculture-based countries still use firewood for cooking. Cooking on fire is a time-consuming activity that requires continuous attention and inhibits women from being more fully involved in farming (Carr and Hartl, 2010). Dinkelman (2011) found that RE increased employment by increasing both men and women's work hours. He found that women shifted from using wood to using electricity for cooking and lighting. Firewood collection is one of the most time-consuming and tiring tasks that rural women are responsible for (Carr and Hartl, 2010). Women can spend up to five hours a day collecting firewood about three times each week (Sambrook, 2003). Dinkelman (2011) found that access to electricity released time from domestic tasks, enabling women to participate more in the labour market than men. A study on women in Ghana showed that access to electricity increased the time spent on income-generating activities (Costa et al., 2009). Bittman (2004) found that electrical appliances did not reduce women's time burden on domestic chores because the appliances were used to increase output rather than to save labour. For example, instead of making two meals a day, a household would now cook three meals a day because they now had more time.

Carr and Hartl (2010) found electricity to be a labour-saving technology for rural women. Farming activities in rural communities are gendered; males are responsible for land clearing and preparation while women are responsible for planting and everything else leading up to post-harvesting activities. Access to electricity reduced food-grinding processes from several hours to just a few minutes and cut down the time spent collecting water through electric pumps for small

water distribution or irrigation. Carr and Hartl (2010) looked at other non-electric innovations that reduced the time burden of rural women in East Africa, Sri Lanka and India. These include water harvesting tanks, charcoal stoves and intermediate means of transport such as donkeys and carts. In the study, the authors state that time-saving technologies reduce women's time burden, enabling them to participate more in agriculture, but no analysis in the study shows the extent of the impact on agricultural participation. Thamaga-Chitja and Morojele (2014) emphasise the need for social protection programmes that address the time poverty experienced by women smallholder farmers due to cultural norms that stereotype their household roles and limit their market activities. Bekhet (2010) states that the agricultural sector, like other sectors, has become more dependent on energy resources such as electricity and fuels. This dependency is factual, yet, agricultural development endeavours that do not consider the social dimensions of the challenges in the agricultural sector overlook critical factors that can make programmes more effective.

2.3 The Social Dimension of Energy Use, Agriculture and Development

Energy programmes are implemented in a context where people live, and social norms and values affect energy initiatives (Miller et al., 2013). Matters such as justice in electricity access (Monyei et al., 2018) and improving the quality of life through energy interventions reflect a social dimension of energy programmes which is increasingly growing in considerations on the supply of energy, its consumption and impact of energy programmes in societies (Miller et al., 2013). Social structures determine social interactions and, ultimately, how individuals use different technologies and are affected by them. Gender is a social classification that has a pivotal influence in determining the wellbeing of individuals (Lindsey, 2015, Saewyc, 2017). Energy studies have shown differences in the impacts of electrification on households based on gender differences (Aikaeli, 2010, Dinkelman, 2011, Kooijman-van Dijk and Clancy, 2010, Rathi and Vermaak, 2018). Understanding the relationship between gender and development will help contextualise how gender affects agricultural development.

2.3.1 Gender and Development

Gender is a multifaceted construct (Laplanche and Fairfield, 2007) that refers to the different roles, responsibilities, limitations, and experiences of individuals based on their presenting sex or gender

(Khamati-Njenga and Clancy, 2002). Gender classifies individuals with names such as man and woman, which determine roles in society (Bogardus, 2020).

Gender is a product of institutions such as the media, religion, education, and other political and social structures. It is a societal construct deeply embedded in individuals and hardly ever questioned, yet hugely important (Johnson et al., 2007). Even though gender is context-specific and subject to change, men are more esteemed than women and given more power, access, and opportunities in almost all societies worldwide (Lindsey, 2015). Men are generally paid more than women, even for similar work (Adelekan and Bussin, 2018). These vast differences that exist amongst genders affect the lives of individuals in various ways.

Gender roles include social norms, rules, and ideals that dictate different interests, responsibilities, opportunities, limitations and behaviours for men and women (Bryceson, 2019). Informally, by living in a social world, individuals learn the appropriate or expected behaviour for their gender. While individuals can comply with or defy traditional gender roles in their self-expression, gender roles are a powerful social organisation. They influence many aspects of society, from one's choice of occupation to their clothes (Johnson and Repta, 2007). In agriculture, it can even determine input choice for households. Women in many parts of Africa opt to use short-handled hoes for farming even though long-handled hoes are available. The women do not adopt the long-handled hoe for cultural reasons, even though it reduces fatigue and backache from squatting and is more efficient for weeding (Carr and Hartl, 2010). The adoption pattern shows the power of social factors in influencing the impact of innovations. Energy initiatives targeting transformation through electrification are not immune to these social forces within communities (Johnson and Repta, 2007).

Daily household chores are still associated with gender identity's social and cultural construction (Jackson and Scott, 2002). Mare and Girmay (2016) found that mothers carry out about 97.3% of domestic chores, and girls assist their mothers in domestic chores, 78.2% of the time than boys. Their study used surveys carried out in rural Kenya. Johnson and Repta (2007) generalise this gender bias by stating that it is still pivotal for a wife and mother to carry out the everyday housework; to be feminine is to perform femininity. Literature presents evidence of disproportionate gains from technological innovations between male and female households (Bittman, 2004, Mara, 2011, Khandker, 2012). In the context of household chores, the labour-

saving impacts of electricity mentioned above are likely to benefit women and girls more significantly relative to their male counterparts and possibly increase their participation in agriculture.

2.3.2 Women in Agriculture

Women produce half of the world's food and comprise 43% of the developing countries' agricultural labour force (Doss et al., 2011). If one includes the time spent in food processing and preparation, women's labour share could exceed 60% in many African countries and could reach 60% in many Asian ones (Kinkingninhoun-Meˆdagbe' et al., 2008, FAO, 2011a). However, they face a "gender gap" that hinders their productivity, reducing their contributions to agriculture and developing the broader economy. Many factors contribute to the underperformance of the agricultural sector in many developing countries. One of them is that women lack the resources and opportunities they need to use their time efficiently. Women play multi-roles as farmers, workers and entrepreneurs, but they experience more severe limitations than men in accessing productive resources, markets and services (Lal and Khurana, 2011, Mukasa and Salami, 2015). The lack of resources is common across countries. This gender gap impedes productivity and decreases their contributions in agriculture and the attainment of broader economic and social development goals (Mukasa and Salami, 2015). Societies can benefit from increased agricultural productivity, reduced poverty and better economic growth if the gender gap in agriculture is closed (FAO, 2011a).

Women are the primary gatherers of water, food and energy in the developing world. Changes in social norms and the urban migration of rural males in pursuit of a way out of poverty have increased women's participation in agriculture (Bishop-Sambrook, 2003, Marslen, 2015). Women's capacity to produce food and generate revenue is subject to prevailing social constructs that govern their access to resources and services. In general, women have less education than men; they have less access to inputs, credit and information, and they carry the double burden of producing food and nurturing the family more than men. Gender differences become apparent when looking at women's workloads. Women are usually responsible for childcare and household chores. These tasks may be extremely time-intensive, depending on household structure and size. Any changes that affect the family or the environment will have different implications for men and women due to the gender-specific assignment of tasks. For example, deforestation increases the

distance women travel to collect firewood, increasing their time on unpaid work (FAO, 2011b). The increase in time for fetching firewood also reduces the time they can devote to agricultural activities. Research indicates that if female farmers are given the same opportunities and inputs as their male counterparts, they would be efficient in agriculture (Marslen, 2015).

Family farms are essential to global food security and sustainable productivity. They make up approximately 98% of the total number of farms worldwide (Graeub et al., 2016), approximately 75% of farmland (Lowder et al., 2016), and produce about 85% of all food crops (Graeub et al., 2016). Globally, the family farm is the primary institution in which women work as unpaid and unrecognised farmers. Legislation in many developing countries prohibits women from owning resources and land despite their family farm production involvement. Often, women do not access training, extension and institutional credit, leaving them incapable of taking on leadership roles in the family farm or society (FAO, 2014). If women cannot make financial decisions in the home, it implies that even when there is access to electricity, the male household determines the electricity usage and what appliances to buy. The technology's time-saving benefit may end up not benefitting them if, for instance, the male opts to buy a television instead of an electric stove. In these cases, female households will spend the same amount of time collecting firewood despite them having access to electricity, and the time devoted to agriculture does not change, keeping other things constant.

Improving women's profile in agriculture is crucial for global rural development. Women spend 90%, on average, of their earnings on their families. On the other hand, men spend between 30 and 40%, even when the income is meagre (Marslen, 2015). In part, this explains the common phrase, "Empower a woman, empower a nation." If access to electricity can improve households' participation in agriculture significantly to improve their income from agricultural activities, this would result in potential welfare gains in communities. Such gains will be higher if women benefit more from electrification.

Women's empowerment in agriculture is at the forefront of international aid dialogue. Organisations such as the Consultative Group for International Agricultural Research (CGIAR) Consortium, Feed the Future of the United States Agency for International Development (USAID) take women empowerment as a critical intervention strategy. In 2013, the FAO celebrated the International Day of Family Farming to raise global awareness of the family farm in food

production. The international day also highlighted women's vulnerability on family farms to meet the family's needs (Marslen, 2015). In 2011 the FAO's annual report, "The State of Food and Agriculture", focused on women in agriculture (FAO, 2011). The critical area of discussion was closing the gender gap in agriculture, and the report highlighted the role women play in agriculture and the economic impediments created by existing gender differences in agriculture.

A focus on women's participation in agriculture was a significant factor in halving extreme poverty rates in East and South-East Asia between 2000 and 2011. Even though much still needs to be done to empower women and reduce extreme poverty, making gender equity a key objective in development contributes to increasing awareness of the impact of agriculture on women. Consequently, awareness helps in the empowerment of female farmers worldwide (Marslen, 2015). In South Africa, the government's performance monitoring and evaluation department aims to make women and young producers' needs central to agricultural research and rural development as part of the Comprehensive Africa Agriculture Development Program (CAADP) (Tsakani, 2012).

The goals of RE and the empowerment of women in agriculture can occur when these two focus areas of development integrate and synergise efforts to fight poverty and foster equal income distribution in South Africa.

2.4 The Welfare Impact of Rural Electrification

The number of electricity connections cannot be the sole success indicator of electrification policies (Lee et al., 2020). Instead, the impact of electrification on development confirmed through welfare improvement must be used to justify resource allocation (Gómez and Silveira, 2010). RE can improve the quality of household life at the individual level and, at the broader level, it can stimulate economic growth. The household's purchasing power is an indicator that provides the best measure of welfare, whether measured by income or consumption. Research (Kooijman-van Dijk and Clancy, 2010, Khandker et al., 2013, Peters and Sievert, 2016) suggests that interventions in the energy sector, including electrification, might affect economic measures of wellbeing in numerous ways (Peters and Sievert, 2016). There is some evidence that these interventions could directly affect health and education also. In households that rely on traditional fuels, indoor air

pollution may cause respiratory illnesses. Incidences of paraffin poisoning of children and severe burns have also been reported, especially in South Africa (Martins, 2005). This section presents some of the findings on welfare gains from rural electrification based on research.

Income: Martins (2005) carried out a study in the Limpopo and KwaZulu-Natal Provinces of South Africa and found that non-electrified households pay the most for energy sources relative to electrified households. The higher energy bills imply that electricity can improve welfare by increasing disposable income, available for other household needs. Saing (2018) also found an increase in household consumption expenditure as a result of electrification. Akpan et al., (2013) showed that better incomes were gained from micro-enterprises engaged in by electrified households. Positive impacts on income were also found in Bangladesh and Vietnam (Khandker et al., 2013, Khandker et al., 2012a). However, Hwang and Yoon (2021) found that women in rural China did not experience wage income increases because the time saved from household chores was reallocated to unpaid labour.

Education: In South Africa, Martins (2005) found that household members with electricity study for longer at night than those without electricity. Khandker et al. (2012) show that access to electricity in Bangladesh's rural areas increased study hours for both boys and girls aged between 5-18 years of age. However, study time for boys increased by 22 minutes while girls' study time only increases by 12 minutes. This shows that electricity can save time by reducing the time spent on housework and increase the time available for productive activities. Grid electrification also improves boys' completed schooling years by 0.233 grade and girls' schooling years by 0.157 grade. Electrification resulted in higher enrolment in school for boys and girls in Vietnam and Cambodia (Khandker et al., 2013). In Cambodia, access to electricity increased the schooling years completed by boys and girls (Saing, 2018)

Health: Martins (2005) found that the number of accidents related to unreliable energy sources such as open fires is lower for electrified areas than non-electrified areas. Studies from Bangladesh and El Salvador show a decrease in respiratory disease prevalence from access to electricity as households convert to using cleaner energy sources for lighting (Samad et al., 2013, Barron and Torero, 2015)

Quality of life: Martins (2005) found that electrification reduces the estimated distance that household members have to walk to collect firewood, thus improving households' quality of life. Gómez and Silveira (2010) found a strong correlation between electrification and HDI (Human Development Index). This index comprises three indicators that affect the quality of life: social viewpoint (longevity and education) and income, a variable that considers purely economic issues. These studies show evidence of welfare gains from electrification in health, education and economic outcomes. If access to electricity enables women to participate more in farming activities, this could improve their welfare through increased income from agriculture.

2.8 Summary

South Africa generates the biggest share of Africa's electricity. Access to electricity is considered crucial to rural development in the country. In recent years, electrification in South Africa has been driven by social equity objectives. The NDP highlights agriculture in rural areas as a key driver to poverty alleviation. Energy use and electricity supply is a critical input in the development of the agricultural sector. Women are the main users and suppliers of energy in rural communities. Family farms produce most of the food globally, and they remain important to food security in rural areas in South Africa. Women comprise a significant percentage of farmers on these farms and often their work on family farms is unpaid. Support programmes for women in agriculture significantly contributed to the halving of extreme poverty in Asian countries. Given the role of women in smallholder farming in South Africa, similar programme efforts may yield similar results in South Africa. The agricultural sector is not immune to the gender differences that inhibit women from accessing equal opportunities in their livelihood strategies. Energy studies have shown differences in the impacts of electrification on households based on gender differences. Women and girls are likely to benefit more from the labour-saving impacts of electricity relative to men and boys, enabling them to participate more in agriculture. In South Africa, the goals of RE and the NDP can be simultaneously attained through the empowerment of women in agriculture. Rural electrification can reduce the time burden for women and enable them to allocate more time to income generating activities in agriculture. In turn, this will result in welfare gains that would help reduce poverty and gender income inequality in rural areas.

CHAPTER 3: THE IMPACT OF RURAL ELECTRIFICATION ON PARTICIPATION IN AGRICULTURE AMONG FEMALE-HEADED HOUSEHOLDS: A CASE OF MSINGA, SOUTH AFRICA

Abstract

Since independence, South Africa embarked on a multibillion-rand development drive to redress the skewed implementation of infrastructural development during apartheid. Electrical infrastructure can be a time-saving technology that has the potential to free up time for smallholder farmers, enabling them to participate more in agriculture. Research on energy studies in the agricultural sector is limited in South Africa. The limited knowledge undermines the effectiveness of food security strategies and rural development. This study analysed the relationship between access to electricity and female-headed households' participation in agriculture using data from a sample of 242 households in Ward 14 in Msinga Local Municipality of KwaZulu-Natal Province of South Africa. The study used descriptive analysis, Categorical Principal Component Analysis and Principal Component Regression analysis to show the relationship between access to electricity and household participation in agriculture. The study results show that farming in Msinga is still predominantly for subsistence and the majority of the smallholder farmers are women. The results show no statistically significant relationship between access to electricity and female-headed households' participation in agriculture. However, time spent on cooking and firewood collection affect time allocation to agricultural activities. The results also show that household head employment in off-farm employment, high household income per capita, age of household head, household ownership of television, and radio negatively affect participation in agriculture. The results underscore the importance of gender-sensitive policies in agriculture and a focus on youth empowerment. Stakeholders seeking to improve agricultural participation in rural communities need to promote agriculture as a profitable livelihood strategy to prevent deagrarianisation driven solely by the pursuit of better income opportunities.

Keywords: Participation in agriculture, access to electricity, Categorical Principal Component Analysis, female-headed households.

3.1 Introduction

In rural development literature, agriculture is still recognised as a key sector with the potential to lift rural households out of poverty (Christiaensen and Martin, 2018, Osabohien et al., 2021). Women are the main participants in agriculture in the rural areas of South Africa (Thamaga-Chitja, 2012). With limited time in a day, household chores reduce the time available to these women to participate in livelihood activities, agriculture included. Electricity is an infrastructural technology that may help reduce the time burden of household chores for women, enabling them to participate more in agriculture and other economic and social activities (Grogan and Sadanand, 2013, Rathi and Vermaak 2018).

Given that time is a limited resource, domestic chores can compete for time with livelihood activities, agriculture being one. Understanding how access to electricity impacts the time households spend on home-based activities and agricultural activities will provide policy-makers with information on the impact of this infrastructural technology, thus assisting rural development strategies. There is limited energy research in the agricultural sector in South Africa. This study aims to analyse how access to electricity is impacting the participation of women in agriculture.

3.2 Conceptual Framework

Research on the relationship between energy, particularly electricity, and rural development is widespread. The main categories of impact described in the literature are;

(1) reduced indoor air pollution as a result of decreased fuel combustion for lighting and cooking;
(2) the potential rise of productivity in agricultural processing and other manufacturing;
(3) better social services, e.g., health centres (Modi, 2005, Ramani and Heijndermans 2003, Berg 2011).

Literature does not adequately distinguish between household-level impacts and impacts on a broader scale, like the village or national levels (Van de Walle et al., 2013). There is limited knowledge on the impact of RE on households' wellbeing. Some of the household-level measures of impact found in the literature are:

- longer study hours at night and higher enrolment of children in school (Cabraal, 2005, Martins, 2005);
- reduced accidents caused by fires (Martins, 2005);
- increased labour supply to the marketplace from the release of labour from domestic chores (Van de Walle et al., 2013; Dinkelman, 2011).

Sometimes these impact categories have been analysed as though they are distinctly separate. However, these impact categories can also endogenously affect each other. This study will use the Sustainable Livelihood Framework (SLF) to analyse the theoretical link between RE and household participation in agriculture. The link to welfare will also be analysed because welfare gains are the end goal of agricultural programmes. The SLF allows for an analysis that shows the interaction of the various impact categories.

3.2.1 The Sustainable Livelihood Framework

The SLF is a framework for evaluating how household assets and a range of organisational and institutional factors (formal and informal) result in a combination of livelihood strategies and related livelihood outcomes (Angelson, 2011). It shows how households achieve sustainable livelihoods through access to various livelihood resources (Scoones, 2008). The possession of these resources (natural, financial, social, human and physical) determines a household's ability to pursue different livelihood strategies. The resources are a 'capital' base that brings about diverse, productive channels that construct household livelihoods (Scoones, 2008, Angelson, 2011).

The forms of livelihood strategies and activities that households undertake are mediated and influenced by the economic, political, ecological, and institutional environments they find themselves. Electricity is a technology that affects the environment within which households operate. Therefore, it can influence their capital and, in turn, their livelihood activities and strategies. Figure 1 illustrates the livelihood resources that are affected by access to electricity. Electrification enhances households' capital base, subsequently, increasing their ability to participate in agriculture and improving income earnings from farming. The pathways through which electrification affects agricultural participation will depend on the resource impacted. Peters and Sievert (2016) presented a theoretical framework for assessing the impact of electrification on welfare. Their study theorised the use of appliances as the starting point of impact. However, this

study theorises the capitals as the starting point that determines the pathways through which electrification impacts households. Though the approach is different, the impact pathways are similar and both frameworks highlight the time-saving benefit of electrification as a key intermediate impact factor. The theoretical framework presented by Peters and Sievert (2016) has health, income and education as the final impact variables. The SLF framework below expands from that theory by treating these welfare gains as inputs that affect the capital base of households, in turn, affecting the time allocated to agriculture as a livelihood strategy.

The impact of electrification on households' resources can happen in the following ways:
Natural: Reduced pressure on natural resources, e.g., trees, as a source of energy, thus avoiding deforestation and land degradation. Mapako and Passad (2007) observed a decline in the use of wood as fuel as one of RE's impacts. Improved yields from better soil quality can incentivise households to participate more in agriculture.

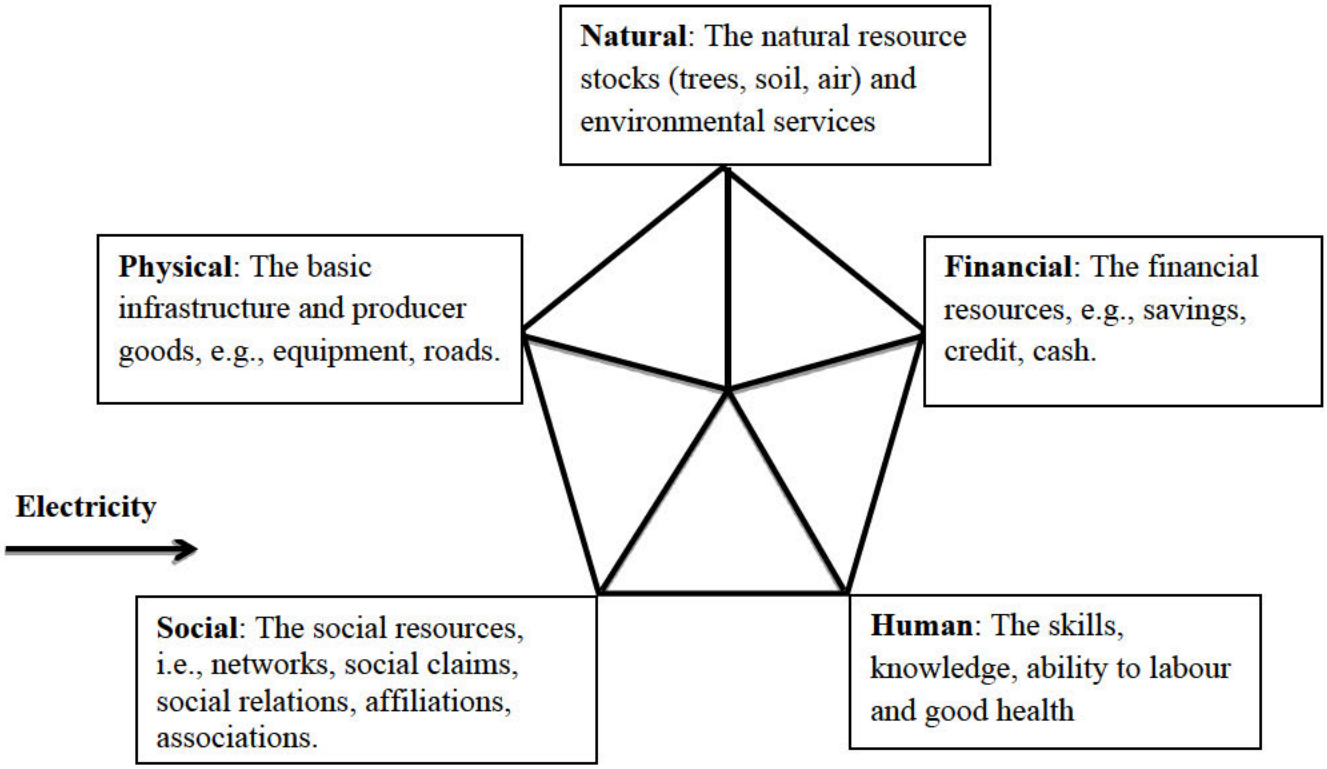

Figure. 1 The Five Capitals of the SLF

Human: The use of clean energy for cooking and heating could improve household health, thus enabling them to engage more in farm and off-farm activities (Cabraal et al., 2005). The fatigue from fetching firewood across long distances can be eliminated, helping households have more

time in agriculture and farm more effectively. Households can also acquire more helpful knowledge in agriculture from media through television, radio and cell phones (Khanal, 2011).

Financial: Access to electricity may improve the financial capital of households through an increase in revenue (Peters and Sievert, 2016). Financial capital improvement may exist if the extra time availed by access to electricity translates to increased participation in cash-generating agricultural activities. Improved efficiency can arise from the use of electrical equipment, thus improving households' incomes from agriculture (Cabraal et al., 2005).

Physical: Households can buy inputs that use electricity to improve their agricultural activities, such as water pumps and mills for processing their produce and fridges for storage, e.g., in a poultry enterprise (Ngwenya, 2013). Mapako and Passad (2007) also found that access to electricity can increase rural communities' machinery use.

Social: Access to electricity enables households to expand their social capital as they can now easily communicate, using mobile phones, with other people or join organisations that can assist them in their agricultural activities and in sharing equipment (Kooijman-van Dijk and Clancy, 2010). Access to media informs them of opportunities to join networks that can benefit them.

The improvement of one livelihood resource can indirectly improve another resource (Peters and Sievert, 2016). For example, a cleaner environment from reduced air pollution is likely to improve households' wellbeing as a cleaner environment is suitable for their health. In this way, improvement in natural capital may also affect their physical capital. Improvements in the five capital bases can enhance households' participation in agriculture as explained above, thus increasing their agricultural output and income.

3. 3 Materials and Methods

This section presents the study site and techniques used to analyse the data. A brief description of the study area is followed by a discussion of the methods and procedures used to collect and analyse the data.

3.3.1 Study Area

The study site was Ward 14 of Msinga Local Municipality. Msinga is one of the four local municipalities in the Umzinyathi District, and it has 19 wards in total. Msinga is mostly rural, with

almost 99% of its population residing in traditional areas (Msinga local Municipality, 2021). Msinga has low economic activity and high levels of poverty. Between 2007 and 2011, the social grant system significantly reduced the number of households with no income source from 71% to 11% of the population (Msinga Municipality Integrated Development Plan (MMIDP), 2012). The majority of the population engages in agriculture for subsistence, and agricultural activities only contribute 18%, on average, to the household income. Despite the low-income contribution of the sector to households' welfare, agriculture is still one of the main economic sectors in the area (Stats SA, 2011). Low soil fertility, adverse climatic conditions, and soil erosion are vital factors that hamper the area's agricultural development capacity. Land degradation is prevalent in Msinga, and the area receives 600-700mm annual rainfall (MMIDP, 2012).

Two sites with similar demographics allowed comparison between households with and without access to electricity. Access to electricity had to be the critical difference between them, and the similarities in demographic and socio-economic factors would ensure that one of the sites is a control. Lastly, both sites needed to have a reasonable level of agricultural activity. With 86% of South Africa already electrified, the starting point in locating the two sites that would meet the criteria was identifying areas in KwaZulu-Natal that had no access to electricity. Ward 14 in Msinga was chosen because it was the nearest location that fit the selection criteria.

According to the Statistics South Africa (StatsSA) census in 2011, Ward 14 had 10567 people, and 99% of this total population is black African. The ward covers an area of 72.2 km^2. The median age was 17 years, and 51% of the population was under 18 years. Females comprised 57% of the population, and they headed most (61%) of the households in the area (Stats SA, 2011). Most of the households in Ward 14 resided in traditional houses (74%), and only 12% of the population had access to water from local or regional service providers. Rivers were the primary water source for households (53%), followed by springs (14%). The average annual income per household was R14 600, about half of the average annual income in KZN. This means that most people were of lowly income relative to incomes in the province. Regarding household goods, 80% of the households had a cell phone, 62% owned a radio, 24% owned TVs, and 21% have stoves (StatsSA, 2011).

3.3.2 Research design and data requirement

The study uses primary data that was collected using structured questionnaires. The questionnaire was administered to a randomly selected sample of households. It collected primary data on household-level characteristics, time spent on different agricultural activities, and time spent on non-agricultural activities. The data was analysed using SPSS and Stata computer software.

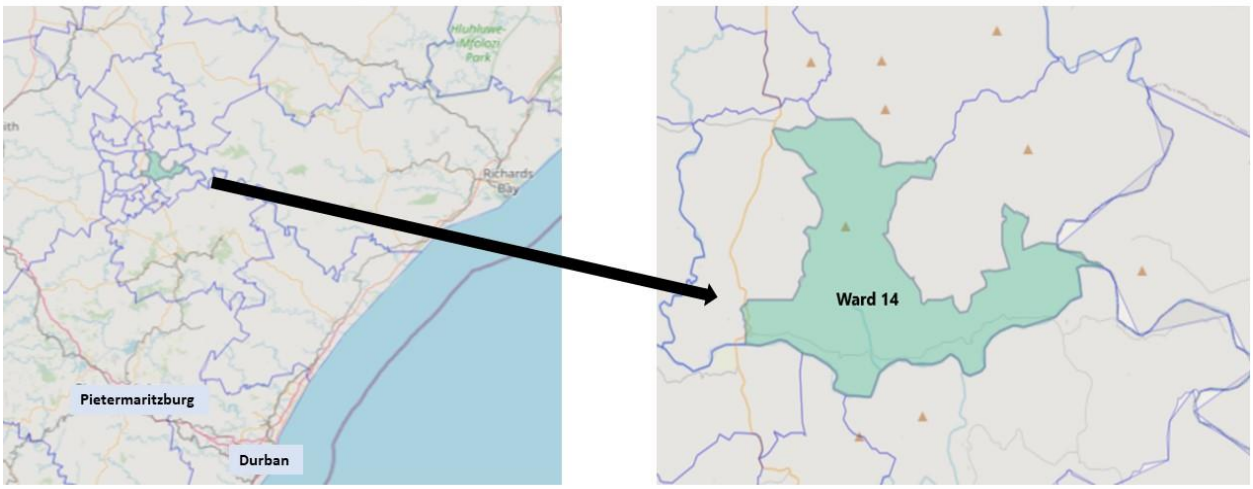

Figure 2. Location of the Study Area: Ward 14, Msinga
Source: www.wazimaps.co.za, 2021

3.3.3 Sampling technique and sample size

The municipality provided information on the number of households in the area and those with electricity. The estimated number of households with electricity was 143, and the estimated total number of households in the study area was 1500, based on information provided by the Ward Councillor. The resources available (time and financial resources) determined the maximum number of households that could be interviewed in the timeframe allocated for data collection. In total, 250 households were interviewed, 125 electrified and 125 non-electrified. Systematic random sampling was used to select respondents from the non-electrified household; every tenth household was selected for an interview. Based on the limited connected households in the study site, all electrified households reached during the data collection period were interviewed. After

data cleaning, 119 questionnaires from electrified households remained appropriate for use in the sample.

3.3.4 Data collection

The questionnaire was pretested in Msinga as part of the reconnaissance survey to improve it. The main aim was to assess whether the questionnaire was relevant and that respondents could understand the questions, how the questions were phrased, and improving the translation of the questionnaire to the local language. Weaknesses of the instrument's ability to collect the required data economically and systematically were also considered, and relevant adjustments were made.

Enumerators were selected from the University of KwaZulu-Natal and trained about the study before the scheduled interviews with the rural households. They were trained on the questionnaire's contents, interpretation, data recording, and general behaviour during the survey. The survey was carried out over two weeks in July 2017.

3.3.5 Data processing and analysis

This section discusses the data analysis techniques applied to assess the impact of electrification on female-headed households' participation in agriculture. Categorical Principal Component Analysis (CATPCA) and Principal Component Regression (PCR) were identified as suitable models for the analysis.

3.3.6 Categorical Principal Component Analysis

CATPCA is a statistical method generally used in dimension reduction for data sets with many variables to create fewer uncorrelated components that represent most of the information found in the original variables. CATPCA, also referred to as non-linear PCA, is used for data sets with varied measurement levels (numerical, ordinal and nominal variables) (Linting and van der Kooij, 2012, Kemalbay and Korkmazoğlu, 2014). Optimal scaling is used in CATPCA to transform categorical variables into numerical values while maximising the variance accounted for by the data's quantifiable variables (Linting and van der Kooij, 2012). The variables selected for analysing rural household participation in agriculture are a combination of nominal, ordinal, and numerical (Table 1), and almost half the variables are categorical in measurement. The high standard deviations in the measurement variables show that the data is heterogeneous (Appendix B). CATPCA identifies nonlinear relationships amongst the variables in the data, thus revealing

underlying relationships in the data. The impact of electricity on a household is often not straightforward and sometimes not easy to establish (Bernard, 2012). Therefore, access to electricity may have a non-linear relationship with the agricultural participation of smallholder farmers. Given the heterogeneity of the data, the mixed measurement nature of the variables used in the analysis and the non-linear impact of the electrification on households, CATPCA was chosen as a suitable method to analyse the data in the study.

PCA was first used to identify subgroups in populations in genetic studies by Cavalli-Sforza et al. (1994). PCA has become a widely used statistical method for analysing population structures and revealing homogenous groups within data sets (Price et al., 2006, Paschou et al., 2008, Intarapanich et al., 2009, Combes and Azema, 2013). In genetics, this assists researchers to more accurately determine different population's genetic predisposition to various diseases (Intarapanich et al., 2009). In agriculture, broad applications of policies without accounting for socio-economic differences in subpopulations hampers the effectiveness of development strategies in communities (Essa and Nieuwoudt, 2003, Mara, 2011). PCA can be used to classify smallholder groups in a population-based on socio-economic characteristics. CATPCA was chosen for data analysis in this study to also contribute to research on its use in population structure analysis to guide policy formulation, and implementation of smallholder farmers' programmes. Following the example of (Essa and Nieuwoudt, 2003), CATPCA was used to analyse underlying relationships between access to electricity and other characteristics of smallholder farmers, including the gender of farmers and time allocated to household chores. This analysis revealed the types of smallholder farmers in the study area. PCR was used to analyse the relationship between the identified groups and their participation in agriculture.

3.3.7 Principal Component Regression

The following regression model was hypothesised to determine the factors impacting household participation in agriculture.

$$Y_i = \beta_0 + \beta_i X_i + \varepsilon_i \qquad (1)$$

Where Y_i = Participation in agriculture, measured in number of hours a household participates in agriculture annually.

B_0 is the intercept of the regression line, and β_i are the coefficients

X= explanatory variables expected to have an impact on household participation in agriculture.

CATPCA was used to construct a new set of variables, principal components, that adequately summarise the information contained by the original variables. This is similar to the transformation of variables into other functional forms in regression analysis.

After the transformation of the explanatory variables into PCs, the estimation PCR model was restated as below:

$$Y_i = \beta_0 + \beta_i PC_i + \varepsilon_i \quad (2)$$

The PCs show characteristics that classify households into smallholder farmer groups based on variables highlighted by high component loadings. Therefore, the PCR model (equation 2) shows the relationship between the identified smallholder farmer groups and time spent on agricultural activities.

When the data was collected, the study's main objective was to compare agricultural participation between households with access to electricity and those without access. Therefore, the analysis of female-headed households' participation in agriculture was based on the results obtained from the whole sample. Most households in the sample (84%) were female-headed. The CATPCA and PCR analysis was repeated using data from the female-headed households only to assess if the results would be different from those obtained from the whole sample.

3.3.8 Description of Variables

This section describes the variables that were used to analyse the factors determining the level of agricultural participation amongst female-headed households (Table 1). The section also presents the *a priori* expectations on how each variable would affect the number of hours households allocate to agriculure activities.

All the variables in Table 1, except TotAgricPart (annual agricultural participation of household) were used in the CATPCA to discover the dimensions of farming in the study area, and to create the principal components used in the PCR . The PCR used TotAgricPart as a dependent variable regressed against the principal components.

Table 1. Description of Variables Used in the Categorical Principal Component Analysis

Variable	Description	Measurement
TotAgricPart	Total annual agricultural participation of household	Hours
Connection	Connection to electricity	1= Connected, 2 = Not connected
IncomeperCap	Income per Capita; Total income of the household divided by family size	Rands
Gender	Gender of household head	1= Male 2 = Female
GenderFarmer	Gender of the household member participating in farmer	1= Not farming 2= Male 3= Female 4= Male and Female
Age	Age of household head	1= Under 21years 2= 22-35years 3= 36-55years 4= 56-64years 5= 65+years
Employment_Wk	Employment hours per week of household	Hours
PlotSize	Size of plot owned by household	Hectares
Education	Level of Education of household head	1 = Not attended formal education 2= Primary school 3=Secondary school 4=Tertiary school
MainOccupation	Main Occupation of household head	1=Fulltime farmer 2=Regular salaried job 3=Temporary job 4=Unemployed 5=Self-employed 6=Student 7=Retired

Table 1 (Continued).

Cooking_Wk	Time spent cooking each week by the household	Hours
Leisure_Wk	Time spent on leisure each week by the household	Hours
PrivateEnter_Wk	Time spent on private enterprise each week by the household	Hours
CollectingFire_Wk	Time spent collecting firewood each week by the household	Hours
SocialGrpPart	Participation in a social group	1= Yes 2=No

Access to electricity: Households with access to electricity are expected to participate more in agricultural activities as they are likely to spend less time on domestic activities such as cooking, firewood collection.

Plot Size: Households with bigger plots of land for farming are likely to participate more in agriculture (Babulo et al., 2008), and households with smaller plots are likely to seek off-farm employment (Alasia et al., 2009) to compensate for the limited returns on small plots.

Gender: Gender discrimination against women is still prevalent in societies and in (Jahan and Umana, 2003), and it may disadvantage women in accessing inputs vital for their participation in agriculture, such as land (Kinkingninhoun-Mêdagbé et al., 2010). Women tend to be time-poor due to the domestic burden they carry (Thamaga-Chitja and Morojele, 2014). This may also constrain their participation in agricultural activities. However, if off-farm work opportunities favour male employment, then female-headed households may participate more in agriculture to feed their families due to the limited off-farm opportunities.

Age: Older households are likely to have more responsibilities than younger household heads. This could lead to them participating more in agriculture to care for their families. They may also have an advantage in ownership of farming assets and knowledge due to them having a longer time to acquire farming implements and knowledge needed in farming. This advantage could capacitate them to participate more in agriculture. Conversely, old age may reduce one's physical ability to participate in agriculture actively.

Employment Hours: The more hours households spend in the jobs they are employed in, the less time they have available to commit to other activities, including agriculture. In rural communities, households in off-farm employment tend to earn higher incomes than those participating in subsistence farming; therefore, they are likely to participate less in agriculture.

Education: Households with higher education levels have better chances of being employed; therefore, they are expected to participate less in agriculture. In farming, education increases one's efficiency. Therefore, it is expected that farming households with better education levels will spend less time farming.

Main Occupation: Household heads who are unemployed are more likely to participate in agriculture as they may not have other means of sustenance. Household heads with other occupations (employed, student, small business) are likely to participate less in agriculture due to their occupations' time commitment requirement. Retired household heads are likely to participate less in agriculture because the households in the other categories have a higher physical ability to participate in agriculture.

Time: Domestic chores (cooking and collecting firewood) and leisure compete for time with agricultural activities (Baland et al., 2010). Households (Baland et al., 2010). Households that spend a lot of time on these activities are expected to participate less in agriculture.

Social Group Participation: Social capital can affect household participation in agriculture. Social groups aid in the transfer of knowledge and impact the adoption of farming technologies (Van Rijn et al., 2012). The impact of belonging to a social group will vary depending on the purpose of the group. It is, therefore, expected that this could have either a negative or positive impact on time spent on farming activity.

3.4 Results

This section presents the findings of the study.

3.4.1 Household demographics

The results show that most households (69.1%) are female-headed, and the average number of individuals per household is six. Most of the household heads are single (48.6%), and 39.9% are

married. Three quarters (76%) of the sampled household heads are between 21-64 years. This means that majority of the population is under the retirement age and can actively engage in agricultural activities. The age group with the highest frequency is 36-55 years (38.3%). There are households whose heads are under 21 years (7%) and elderly household heads above 65 years (16.9%). Old age limits one's physical ability to work. Therefore, elderly household heads are expected to participate less in agriculture compared to younger households.

Table 2. Occupation of Household Heads

Description	Frequency			Percentage
	Female	Male	Total	
Unemployed	103	37	140	57.6
Fulltime Farmer	27	3	30	12.3
Retired	18	10	28	11.5
Student	11	8	19	7.8
Regular Salaried Job	3	8	11	4.5
Temporary Job	5	2	7	2.9
Total	168	75	243	100

In terms of occupation, the modal group is the group with unemployed household heads, which comprises 57% of the sample. It is 4.6 times bigger than the second occupational grouping, which is fulltime farmers, 12.3%. Therefore, with high unemployment in the sample, farming is the main livelihood occupation, and 90% of these fulltime farmers are women. Retired household heads comprise 11.5% of the sample, and there are 7.8% of households headed by students (19 household heads).

3.4.2 Descriptives of Participation in Agriculture

As shown in the results of descriptive statistics, 12.3% of the household heads are fulltime farmers (Table 2), and females comprise most of these farmers (90%). However, even though there are very few fulltime farmers, 82% of households participate in agriculture to some degree. Out of the households participating in agriculture, 72% of households cultivate crops and 63% of households rear livestock.

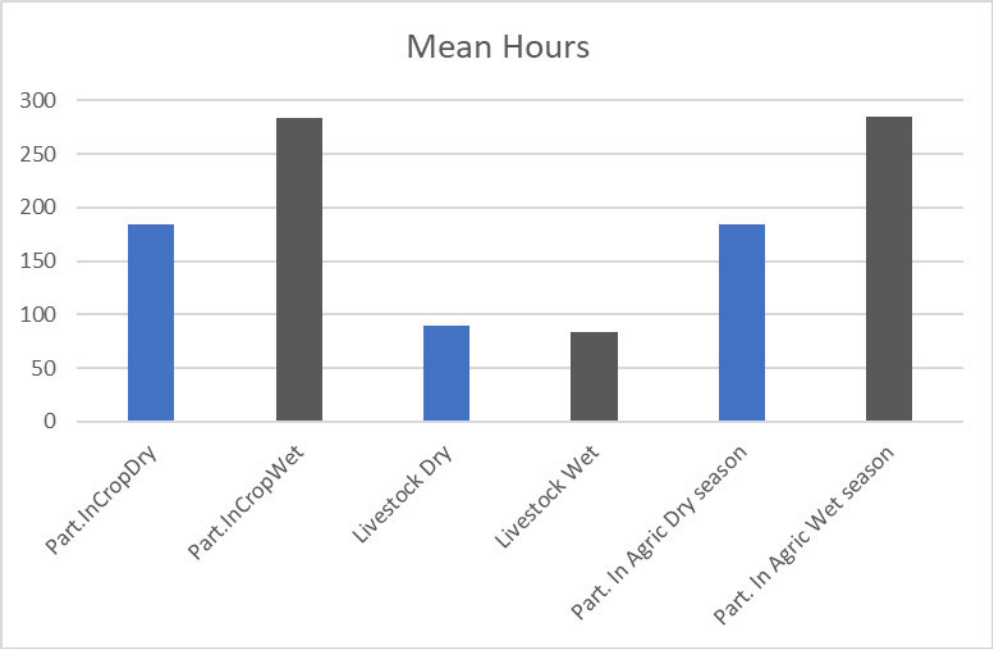

Figure 3. Time Spent on Agricultural Activities

Households spend more time on cropping activities than on livestock rearing activities (Figure 3). Time spent on agricultural activities in the wet season is higher than in the dry season. However, livestock activities in the dry season are slightly higher than in the wet season.

Females comprise 84% of the individuals who are farming amongst households participating in agriculture, and the majority (83%) are from female-headed households. Among the few men farming (14%), 84% are from male-headed households, and only male-headed households have both a male and female farmer. This implies that agricultural participation could remain predominantly female-oriented if male-headed households are not actively engaged to support farming or participate in it.

The Department of Agriculture, Fisheries and Forestry has two classes of small-scale farmers; emerging farmers are those producing to sell, and subsistence farmers produce for home production (DAFF, 2012). This definition does not cater for the size of land cultivated. Therefore, the classification in Table 3 was applied, and it shows the distribution of types of farmers in the area.

The biggest farmer grouping amongst households cultivating crops in the area is small scale farmers, who comprise 43.6% of all households (Table 3). A third of the households did not grow

any crops in the year. Medium-sized farmers comprise 24.3% of the households in the area, and only 1.6% of households are large scale farmers. Even though 51% of households have access to electricity, there is a disproportionate weighting of farmers' participation in agriculture amongst the groupings based on electrification.

Table 3. Type of Farmers

Type of Farmer	**Land Cultivated**	**Electrified**	**Non-electrified**	**Total Frequency**	**Percentage**
Not Farming	0 Hectares	46	28	74	30.5%
Small Scale Farmer	0.01-1.0 Hectares	49	57	106	43.6%
Medium Scale Farmer	1.0-3.0 hectare	26	33	59	24.3%
Large Scale Farmer	Above 3hectares	3	1	4	1.6%
Total		124	119	243	100%

More households are participating in farming amongst non-electrified households. However, for the few large-scale farmers, the majority (75%) of them have access to electricity.

The majority of households in this community own livestock (77%). Chicken rearing is the most common livestock production in the community, followed by goats and cattle rearing. The majority of households in this community own livestock (77%). Chicken rearing is the most common livestock production in the community, followed by goats and cattle rearing.

Table 4. Livestock Ownership

Livestock	Percentage of households	Mean	SD
Cattle (n=109)	45	8.36	7.03
Goats (n=135)	56	10.75	7.67
Sheep (n=17)	7	7.76	6.80
Pigs (n=3)	1	15	13.23
Chickens (n=147)	60	12.48	8.40
Donkeys (n=10)	4	5.30	2.41

The percentage of households participating in chicken rearing is 60%, 56% for goats and 45% rear cattle. Few households own sheep (7%), donkeys (4%) and pigs (1%).

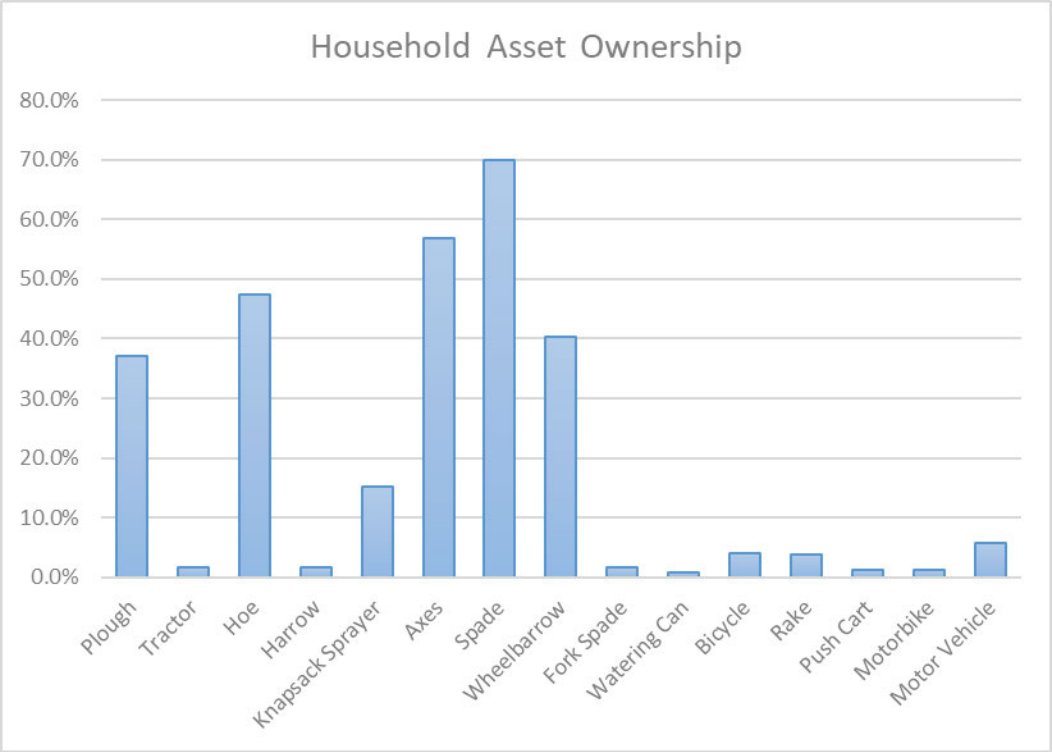

Figure 4. Household Asset Ownership

There is a fair proportion (at least 37%) of households with farming equipment (hoes, spades, ploughs), indicating a notable proportion of households participating in agriculture. The findings support this; the results show that 44% of households grow most of their food (Table 5).

Table 5. The Proportion of Food Consumed That is Bought

Percentage of food consumed that is bought	Frequency	Percent
Less than 35%	43	17.7
Between 35%-50%	65	26.7
More than 50%	135	55.6
Total	243	100

Few households, 10.3%, receive agricultural extension services in the area. Out of this group of households, 4% receive agricultural services from LIMA, 3.7% Department of Agriculture. The Municipality services 0.4% of the households with agricultural extension services, and other unknown service providers serve 3.0% of households participating in farming.

The t-test results (Table 6) show a statistically significant difference in agricultural participation between television (TV) and radio owners and households that do not own a TV or a radio. Total agricultural participation (time spent on crop cultivation and livestock rearing) is negatively affected by owning a radio and a TV.

Table 6. TV and Radio Ownership

Activity	Description	N	Mean (Hours)	T-test
Total agricultural participation	Owns Radio	119	583.50	*
	No Radio	123	705.03	
Total agricultural participation	Owns TV	92	550.10	*
	No TV	152	703.64	

Note: * p<0.10
Source: Survey data (2016)

The results further show no statistical difference in time spent on livestock rearing throughout the year. However, households have a difference in time spent on crop production in the wet season and the dry season. Households that own a TV and those that own a radio spend more time in regular salaried employment. Radio ownership has no statistically significant impact on leisure hours, but TV ownership positively impacts household leisure time (Appendix D).

3.4.3 Categorical Principal Component Analysis

CATPCA was used to analyse 24 variables, and eight components were identified as useful in explaining the variation in the data (Appendix C). The analysis showed that the eight components account for 50% of the data. The elbow criterion is generally preferred for eigenvalue selection, but the scree plot did not reveal a clear elbow point for this method to be applied. Therefore, following the example of Kemalbay and Korkmazoğlu (2014), the eigenvalue one criterion was used to select the significant principal components.

A second CATPCA analysis was done using the variables with high component loadings to determine if results could be obtained that accounted for a higher level of variation in the data. This second analysis identified six components to explain the variation in the data. The six components accounted for 62% of the variation in the data. The first analysis (with 24 explanatory variables) and the second analysis (with 15 explanatory variables) had similar results that highlighted the same important variables to explain the variation in the data. The second analysis' results were chosen because the selected components had a higher cumulative variation accounted than the first analysis. Choosing the second analysis' results also eliminated redundancy. The second analysis highlighted two variables not highlighted in the second analysis: TV ownership and radio ownership. To ensure that these two variables were not excluded in the data analysis, their relationship with agricultural participation was analysed separately using t-tests.

The results (Table 7) show that the first two components account for the highest variance, 28.8%, and the last four PCs account for 33.2% of the variance. The six PCs selected accounted for 62% of the total variance in the transformed variables, which is substantive (Hair et al., 2010).
The order of the PCs indicates the relative importance of each PC based on the magnitude of the eigenvalue. Each PC is revealing a group of variables that are related in the data.

Table 7. **Categorical Principal Component Analysis Model Summary**

	Variance Accounted For	
Component	Eigenvalue	Cumulative
Comp1	2.26621	15.11%
Comp2	2.05689	28.82%
Comp3	1.45265	38.50%
Comp4	1.26793	46.96%
Comp5	1.18928	54.89%
Comp6	1.06220	61.97%
Comp7	0.96635	68.41%

Households with the related characteristics are represented as a group in the data that is unique to other groups represented by other principal components.

Table 8. Matrix of Component Loadings

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
Connection	0.1518	**-0.5141*** **	-0.0996	0.1940	-0.1165	0.0095
IncomeperCap	**0.3054***	0.2666	-0.1725	**-0.3170***	-0.1107	-0.1376
Age	-0.1157	-0.2484	**0.4449****	**-0.4922****	-0.0024	-0.1032
Education	**0.3175***	**0.3121***	-0.2431	**0.3499***	0.2664	0.0755
GenderFarmer	-0.0051	0.0959	-0.2697	**-0.3350***	**0.4501****	**0.3811***
Gender	**-0.3488***	0.0452	-0.1568	**-0.3363***	-0.1613	-0.0052
FamilySize	0.0269	-0.1539	**0.4882****	0.1378	**0.3543***	**0.3763***
PlotSizeH	0.1320	-0.1112	0.2493	0.2211	**0.3470***	**-0.5042****
SocialGrpPart	-0.1323	**0.3453***	**0.3190***	0.0131	0.1619	-0.0492
MainOccupation	**-0.3937***	-0.2127	-0.2484	0.1091	0.2859	0.0290
Cooking_Wk	0.1904	-0.2927	-0.0993	0.1105	-0.2910	-0.0616
Leisure_Wk	-0.2930	**0.4095****	0.2046	0.2207	-0.1801	-0.1232
Employment_Wk	**0.4712****	0.1654	0.2280	-0.1681	-0.1660	0.0154
PrivateEnter_Wk	0.0989	0.0018	0.1937	0.1136	-0.2812	**0.6275*****
CollectingFire_Wk	**-0.3213***	0.1139	0.0277	0.2996	**-0.3113***	0.0857

Note: Variance accounted for by variable; *** Excellent; **Very Good, *Good
The dominant loadings are in bold font style.

Component 1 distinguishes households that score high values on variables measuring time spent collecting firewood, time spent in a regular salaried job, employment in a regular salaried job, household head gender and education, from those that score low on these variables. Component 2 distinguishes households that score high values on variables measuring access to electricity, time spent on leisure, participation in a social group and education, from those that score low on these variables. Component 3 distinguishes households that score high values on variables measuring family size and age, from those that score low on these variables. Component 4 distinguishes households that score high values on variables measuring age, education, gender of farmer,

household head gender and income per capita, from those that score low on these variables. Component 5 distinguishes households that score high values on variables measuring gender of farmer, family size, size of plot owned, and time spent collecting firewood, from those that score low on these variables. Component 6 distinguishes households that score high values on variables measuring time spent on a private enterprise, size of plot owned, gender of farmer, and family size, from those that score low on these variables.

3.4.4 Description of the Principal Components

The principal components show homogenous groupings of households within the data. These homogenous groups show the dimensions of smallholder farmers.

Component 1 represents a male-headed household that is well educated, employed in a regular salaried job and spends many hours in off-farm employment. The household income per capita is high. This component is the most significant in the data. Based on the household characteristics highlighted by the most variation, it will be referred to as the Employed Group.

Component 2 represents a household with access to electricity that belongs to a social group and has a well-educated household head. The household's leisure hours are high, and they spend little time cooking. This is the second most important component, and based on the household characteristics highlighted by the most variation, it will be referred to as the Connected Group.

Component 3 represents a household headed by an elderly person and has a big family size. The household head participates in a social group. This is the third most important component, and based on the household characteristics highlighted by the most variation, it will be referred to as the Elderly Household Head Group (Elderly HHH Group).

Component 4 represents a household headed by a young individual, that is well-educated but has a low income per capita, and the farmer is a male household member. This is the fourth most important component, and based on the household characteristics highlighted by the most variation, it will be referred to as the Young Household Head Group (Young HHH Group).

Component 5 represents a household with a big family and a big farming plot. The agricultural participant is a female, and the households spend little time collecting firewood. This is the fifth

most important component, and based on the household characteristics highlighted by the most variation, it will be referred to as the Female Farmer Group

Component 6 represents households that spend a lot of time on a private enterprise. They have small plots, a big family, and the agricultural participant is female. This is the sixth most important component, and based on the household characteristics highlighted by the most variation, it will be referred to as the Entrepreneurial Household Head Group (Entrepreneurial HHH Group).

3.4.5 Principal Component Regression

Table 9. Principal Component Regression Results

Variable	Coefficient	Standard Error	t	P>|t|
Employed Group	-31.1477	22.22198	-1.40	0.162
Connected Group	-38.1967	23.32533	-1.64	0.103
Elderly HHH Group	94.2663	27.75577	3.40	**0.001**
Young HHH Group	117.4425	29.70887	3.95	**0.000**
Female Farmer Group	-145.7673	30.67552	-4.75	**0.000**
Entrepreneurial HHH Group	-36.59901	32.45857	-1.13	0.261
Constant	646.0331	33.38366	19.35	0.000

	Number of observations = 243		
Model	SS = 15011610.1	DF = 6	MS = 2501935.02
Residual	SS = 63379832.5	DF = 235	MS = 269701.415
Total	SS = 78391442.6	DF = 241	MS = 325275.696

Note: Statistically significant p-values are in bold font style.
Source: Survey Data (2017)

The regression results show that there is a negative relationship between participation and the Employed Group. This means that agricultural participation is low among high income earning

households with a male household head that is well educated, employed in a regular salaried job and spends many hours in employment. Households with these characteristics spend 31 hours less in agricultural activities, in a year, compared to households who score lowly on these characteristics; households whose household heads have low education, do not have a regular salaried job and spend little or no time in employment. However, even though the relationship between agricultural participation and the Employed Group is as expected, the relationship is not statistically significant.

The Connected Group is negatively related to participation in agriculture. This means that well-educated male-headed households with access to electricity, belonging to a social group, participate less in agriculture. The households spend little time cooking and more hours on leisure than other households. Households with these characteristics spend 38 hours less in agricultural activities than households who score lowly on these characteristics; female-headed households with no access to electricity that spend little time on leisure activities, whose household head has low education and belongs to a social group. However, even though the relationship between agricultural participation and this household group is as expected based on the variable with the highest weight (connection to electricity), the relationship is not statistically significant.

The Elderly HHH Group has a positive relationship with participation in agriculture. This means that households that have big families and are headed by an elderly person who participates in a social group spend 94hours more in agriculture than households that score lowly on these variables; households with a young household and small families that belong to a social group. The relationship between agricultural participation and the Elderly HHH Group is statistically significant at 1% level of significance.

The Young HHH Group has a positive relationship with participation in agriculture. This means that low-income households headed by a young, well-educated male and the household farmer is male spend 117 hours more on agricultural activities compared to households that score lowly on these socio-economic attributes; high-income households headed by an older female who has low levels of education, and the household farmer is female. The relationship between agricultural participation and the Young HHH Group is statistically significant at all levels of significance.

The Female Farmer Group is negatively related to participation in agriculture. This means that households with a big family that spend little time collecting firewood and have a big farming plot,

whom the agricultural participant in the home is Female spend 146 hours less time participating in agricultural activities than households that score lowly on these variables. The relationship between agricultural participation and the Female Farmer Group of households is statistically significant at all levels of significance.

The Entrepreneurial HHH Group is negatively related to participation in agriculture. This means that households that spend a lot of time on a private enterprise, have small plots, big families, and the agricultural participant is female spend 37 hours less on agriculture than households that score lowly on these variables; households that do not have a private business, have a big plot, small families and the farmer is male. The relationship between agricultural participation and this group of households is statistically insignificant.

3.4.6 Female-Headed Households Results

Given that the data mostly comprised female households, the assumption made was that the results would sufficiently reveal the relationship between access to electricity and participation of female-headed households in agriculture. The results for the CATPCA and PCR analysis of female-headed households, excluding male-headed households, reveal very similar findings to those obtained from the whole sample (Appendix E). The table below summarises the comparative key findings.

Table 10. Female-Headed Households Results

	Results for the Whole Sample		**Results for female-headed households only**	
	Household Group Identified	**Relationship with Agricultural Participation**	**Household Group Identified**	**Relationship with Agricultural Participation**
Connection to Electricity	Connected household	Negative	Non-connected household	Positive
Age	Elderly household Young household	Positive***** Positive*****	Elderly household Young household	Positive***** Positive*****
Employment and Income	Entrepreneurial household Employed Group	Negative Negative	Entrepreneurial household High Income Group	Negative Positive*****

** Statically significant*

The results from the CATPCA and PCR analysis of female-headed households concur with the findings from the full sample data. The results from the analysis exclusive to female-headed households additionally highlight household income as a key determinant of the time households spend in agricultural activities.

3.5 Discussion

The general discourse in rural development is that agriculture is the cornerstone sector of rural economies. Therefore, the narrative in development programmes is that agricultural initiatives must be endorsed and supported (Banchirigah and Hilson, 2010). Ward 14 in Msinga has high unemployment, and agriculture is the main occupation for economically active household heads, reflecting the vital role agriculture plays in this community. The results of this study partially support the argument by Banchirigah and Hilson (2010). However, other factors need to be considered in determining if agriculture is the main sector that needs to be supported by relevant stakeholders working towards the economic growth of communities. Even though Ward 14 has high unemployment, there is a vast gap between the number of individuals who participate in farming and those that identify as fulltime farmers. This suggests that agriculture is not a desirable occupation for many households, but a food security strategy generally resorted to out of necessity. Collier and Dercon (2014) and support this view, stating that most smallholder farmers in Africa farm by default and not out of entrepreneurial initiative. Bryceson (1999) states that smallholder farmers in distress are moving away from agriculture and adopting livelihood diversification as an adjustment process, resulting in deagrarianisation in Africa (Bryceson, 1999, Bryceson, 2002). The low incomes earned by households from agriculture in this community (Table 13) could be disincentivising households from injecting more time into agriculture. The returns from agriculture in this community could be explained by the land in the area not being well suited for agriculture. Most households own small plots of land, and they have no access to extension services. These three resources (land size, soil fertility and agricultural extension services) have been shown to impact agricultural participation and returns from agriculture (Babulo et al., 2008, Cawley et al., 2018).

Women are pivotal to the success of agricultural development strategies in rural communities (Ogunlela and Mukhtar, 2009). Women head most of the households in Ward 14, and they are the

main agricultural participants in this area. This is contrary to a study that drew a sample from the whole Msinga area that showed that most farmers were male (Baiyegunhi, 2015). Women are the main economic agents sustaining the livelihoods of households in Ward 14, and in several countries in Africa, they are the main participants in agriculture (Ogunlela and Mukhtar, 2009). Women are pivotal to the success of agricultural development strategies in rural communities (Ogunlela and Mukhtar, 2009). The study shows a strong correlation between the gender of the household head and the gender of the farmer in the home. Female-headed households have a higher number of households participating in agriculture, and men are likely to participate in agriculture when the household head is male. Additionally, the results show that gender of farmer affects the level of household participation in agriculture. However, when only female-headed households are analysed, other factors (age, income, off-farm employment) besides gender of farmer determine level of agricultural participation.

Given that women are the majority of farmers in the area, it implies that any factors limiting their participation in agriculture will significantly impact the level of agricultural participation in this area. The contradictory findings to Baiyegunhi (2015) on the gender compositions of household heads show that agricultural development strategies need to consider the microdata in implementation to allow for effective community-level projects. The CATPCA results show distinct groups of smallholder farmers in the data, further supporting the argument for clustering populations at the community level when implementing agricultural programmes in rural areas.

In rural KZN, access to electricity is a labour-saving technology that results in households shifting away from using firewood for cooking and increases the effective workday for households. Rural electrification releases women to participate more in market work (Dinkelman, 2011, Ilahi and Grimard, 2000). Even though some households with access to electricity still use firewood for cooking and heating, they spend less time cooking and collecting firewood than non-electrified households. This implies that households are experiencing the time benefit of having access to electricity. However, in this study, the shift toward more participation in livelihood activities is not experienced in the agricultural sector when connection to electricity alone is compared. The use of firewood by some electrified households could be preventing households from experiencing the time-saving benefit of access to electricity significantly enough for them to commit more time to farming activities. Despite the higher time apportioned to domestic chores amongst non-

electrified households, the PCR and t-test results show that these households spend more time farming than electrified households. This implies that the time spent on household chores is not constraining agricultural participation amongst households.

The t-tests results show that households with access to electricity spend more time on leisure, and the PCR support this finding by depicting a negative relationship between agricultural participation and Connected households who also spend a lot of time on leisure. The t-test also shows a negative relationship between TV and radio ownership and time spent on agricultural activities. This finding concurs with Ilahi and Grimard (2000), who found that access to electricity significantly increased the time spent on leisure by households while reducing the time spent on work activities. If households are mainly farming to produce food for home consumption, spending more time on leisure would compromise their food security. All things being constant, the shift in time away from agriculture to leisure suggests that agricultural participation could be both a livelihood activity and a social activity. Therefore, as households get access to electricity, they participate less in agriculture, shifting the social component away from agriculture to leisure through watching television and listening to the radio. The majority of households in the area receive social grants. If the gains on time spent on agriculture are negligible, the financial support from social grants could be buffering households from the impact of diverting time away from agriculture to leisure activities when they have access to electricity. Sinyolo et al (2017) found that social grants had a disincentive effect on agricultural entrepreneurship. On the other hand, could also be a wealth effect from access to electricity (Ilahi and Grimard, 2000) that enables households to spend less time in agriculture. Gustavsson and Anders (2004) found that access to TV and radio integrated rural households in Zambia into a global society and resulted in them preferring to own leisure goods than productive agricultural appliances. Similarly, this study shows that TV and radio ownership negatively impact agriculture as households that own a TV and a radio participate less in agriculture. On the other hand, TVs and radios have proven to be an effective way to disseminate agricultural information to farmers in rural areas (Khanal, 2011, Nazari and Hasbullah, 2010, Yahaya, 2002). Rathi and Yermaak (2018) found that access to electrification reduced households work hours due to higher productivity. The results of this study show that it is unlikely that access to these information technologies (TVs and radios) could be resulting in households accessing information that enables them to be more labour efficient and reducing the number of hours spent in agricultural activities. There is instead a consistent positive relationship between ownership of

radios and televisions and leisure. This suggests that access to electricity reallocates female-headed households' time to more leisure and not agricultural activities.

There is a decline in agrarian activities in rural areas in some parts of the world as fewer households are obtaining their livelihood from agriculture. South Africa and other African countries are also experiencing this change (Banchirigah and Hilson, 2010, Bryceson, 2002). China, an emerging economy like South Africa, also experienced high levels of deagrarianisation in the 1980s and 1990s as villagers sought better income opportunities in non-farming activities, considered to be of better status. In China's case, access to electricity was not the driver of deagrarianisation but industrialisation and off-farm entrepreneurship (Guang and Zheng, 2005). The results (Table 13) show that households that earn income from fulltime salaried jobs have higher incomes compared to other work-income streams in the study area, and the PCR results show that these households are participating less in agriculture. Most households in the study area do not earn an income from their agricultural activities. Therefore, higher incomes earned from off-farm employment possibly eliminate the need for some households to continue farming to contribute to their consumption needs.

In rural communities in Africa, off-farm entrepreneurship is usually a risk mitigation strategy for households participating in farming. Households also engage in entrepreneurship because of seasonality in farming and sometimes to take advantage of available business opportunities (Nagler and Naudé, 2014). Off-farm entrepreneurship was a contributor to deagrarianisation in China (Guang and Zheng, 2005) and the results of this study show that households engaged in entrepreneurship participate less in agriculture. Smallholder farmers also engage in entrepreneurship because of seasonality in farming and sometimes to take advantage of available business opportunities (Nagler and Naudé, 2014). Off-farm entrepreneurship was a contributor to deagrarianisation in China (Guang and Zheng, 2005) and the results of this study show that households engaged in entrepreneurship participate less in agriculture. The entrepreneurial households in this study have small plots for farming. When households have small plots, they are less likely to participate in agriculture (Babulo et al., 2008). The results suggest that entrepreneurial households. When households have small plots, they are less likely to participate in agriculture (Babulo et al., 2008). The results suggest that entrepreneurial households could be participating less in agriculture because of the constraints associated with owning small plots. Table 13 shows

that the average income from entrepreneurship is higher than income obtained from farming. The higher incomes obtained by households from operating a small business could further explain why entrepreneurial households participate less in agriculture. Essa and Nieuwoudt (2003) identified a similar type of smallholder farmer group in KwaZulu-Natal. Their study showed that farmers with small plots and high off-farm earnings do not invest in agriculture.

The positive relationship between the elderly group of households and agricultural participation is contrary to a priori expectations. Elderly households may have retired, and they have lesser chances of finding employment. Therefore, the limited alternatives in livelihood strategies possibly compel them to farm for sustenance. The results also showed that elderly households had big families. Households with bigger families were expected to participate more in agriculture because their food demands would be higher. Baiyeghuni (2014) found that in Msinga, elderly households with big family sizes are more likely to be poor. Therefore, this income disadvantage could explain why they are participating more in agriculture. On the other hand, the Entrepreneurial Group and Female Farmers Group also have big families, but they have a negative relationship with agricultural participation. This shows that the relationship between family size and participation in agriculture is ambiguous. All things held constant, the case of elderly households with big families suggests that old age is the main characteristic affecting the level of agricultural participation.

The CATPCA results show groups in the data based on a combination of socio-economic characteristics. The a priori expectations of this study are based on how individual attributes affect participation. The results show that the interaction of the different household characteristics sometimes results in the impact of the individual characteristics not being consistent with a priori expectations in each group. In spite of the inconsistencies in how some of the socio-demographic characteristics are related to participation in agriculture, amongst the six groups identified in the data, the two groups with female farmers both participate less in agriculture (the Entrepreneurial Group and the Female Farmers Group). Similar to the Entrepreneurial Group, households in the Female Farmers Group also have big families. The critical difference between the two groups is that the Female Farmers Group has big plots. Logically, access to a big plot size cannot be the reason for their low participation in agriculture. Therefore, the results suggest that the gender of the farmer is the key variable related to the low participation of this group in agricultural activities.

The descriptive results show that when only the gender of the farmer is compared, households with female farmers participate more in agriculture. It may seem as though the PCR results contradict this finding, but PCR results show how participation in agriculture is influenced by the gender of the farmer when other factors, in conjunction with the gender of the farmer, are considered. A study using data from Burkina Faso similarly found that households with female farmers participated less in agriculture than households with male farmers (Udry, 1996). In the Burkina Faso study, the difference in participation was due to a difference in the type of crop cultivated by the different genders. Secondly, the Burkina Faso study also showed that female farmers participated less in agriculture on plots owned by men, and they participated more in farming on plots owned by women. Therefore, gender alone was not a determinant of time spent on agricultural activities, as this study shows.

The Female Farmers Group, like the Employed Group, also spend less time collecting firewood. A study in China found that poorer households rely more on firewood as an energy source compared to households with better incomes (Démurger and Fournier, 2011). This suggests that the Female Farmers Group could have high incomes that enable them to use alternative energy sources such as electricity or gas, thus resulting in them collecting less firewood. The results of this study show that households with higher incomes participate less in agriculture. Therefore, the Female Farmer Group could be participating less in agrarian activities due to this wealth effect. The results from female-headed households reveal a group with female farmers having a positive relationship with agricultural participation. This further supports the reasoning that the gender of the farmer is possibly not the key determinant of participation in agriculture but rather a combination of other characteristics and gender, such as the household's level of income.

The Young HHH group has a positive relationship with agricultural participation. This is contrary to the other two groups (Employed Group, Connected Group) that have household heads with high levels of education. This suggests that a high level of education alone does not result in a disinterest in agriculture. The Young HHH Group has low income, and the Employed Group showed that high income levels are negatively related to participation in agriculture. The consistency suggests that low income levels are positively related to household participation in agriculture, as shown in findings in Pakistan (Khan et al., 2012). The positive association of young household head age

with agricultural participation was consistent even when data for female-headed households only was considered.

South Africa has been experiencing persistently high youth unemployment (Spaull, 2013, Wilkinson et al., 2017), and in rural areas where there are fewer work opportunities, young people experience much higher unemployment than in urban areas (White, 2012). While youth unemployment amongst all education levels in South Africa has been fluctuating, the unemployment rate amongst youth with tertiary education has been consistently rising (Oluwajodu et al., 2015, Spaull, 2013). This suggests that in spite of their high levels of education, the Young HHH group participates more in agriculture due to the lack of employment opportunities. Studies on rural youth employment show a growing disinterest in agriculture as a livelihood choice amongst youth (Biriwasha, 2012). Part of the contributing factors to youth moving away from agriculture include limited access to farming resources (Bezu and Holden, 2014), lack of infrastructural support and the downgrading of farming as a career option (Biriwasha, 2012, White, 2012). The high level of participation amongst the Young HHH group contradicts the regional trend of decline in agricultural participation amongst African youth. Furthermore, elderly and younger persons tend to have lower incomes than middle-aged persons (Gibson and Scobie, 2001, Linting et al., 2007). Both the elderly and young household head groups in this study have a positive relationship with agricultural participation. This further suggests that the age of household head and income are key determinants of household participation in agriculture.

3.6 Conclusion

The study analysed the impact of access to electricity on female-headed households' participation in agriculture. Women were identified as the main participants in agricultural activities, and they engage in crop and livestock production.

The CATPCA identified key groupings in the data based on the socio-economic characteristics of the households. Six groupings were identified that differentiated households based on the gender of the farmer, age of household head, access to electricity, involvement in entrepreneurial and off-farm activities. The factors impacting household participation in agriculture were analysed using Principal Component Regression, t-tests and descriptive analysis. Connection to electricity and

high income negatively affects the number of hours a household participates in agriculture annually. Households headed by young and elderly individuals participate more in agriculture than middle-aged households. Leisure, TV and radio ownership also negatively impact household participation in agriculture. The effect of the age of household head and gender on agriculture participation depends on the interaction of these variables with other socio-economic characteristics. Contrary to deagrarian trends among young people in Africa, young household heads from this study area participate more in agriculture. Though the results suggest that youth are engaging in agriculture due to lack of employment opportunities, supporting them in their agricultural endeavours could create success stories of young emerging farmers and attract young people to see agriculture as an attractive career choice. With South Africa's youth comprise a third of the population, they have the potential to be key agents in the agricultural strategies aimed at poverty alleviation in South Africa. Youth empowerment in agriculture can, in turn, curb rural-urban migration and aid rural development efforts.

Policies aimed at improving agricultural participation need to be gender and age-sensitive, accounting for the diverse needs and type of support required by different demographic groups amongst smallholder farmers. Food security programmes aimed at promoting agriculture in rural areas need to find ways to make agriculture attractive to households and offer support that ensures better incomes are obtained from agriculture. The study highlights the need to research how other technologies outside of agriculture are affecting farming activities in rural areas. Though access to electricity was expected positively affect agriculture the results showed contradictory findings. Drawing assumptions of positive externalities or positive spillover effects from technology adoption can result in policy-makers drawing inaccurate conclusions. Statistical analytical methods that show interactions amongst household characteristics are encouraged in research to ensure that underlying patterns in data are not missed in determining relationships amongst variables of interest. The use of CATPCA for population stratification could assist in policy implementation being more effective at the community level. Its use in population analysis could reveal useful information in research on households. Television and radio programmes that promote agriculture need to be created to encourage electrified households to participate in agriculture and reverse deagrarianisation trends amongst electrified households.

CHAPTER 4: IMPACT OF RURAL ELECTRIFICATION ON SMALLHOLDER FARMERS' WELFARE: THE CASE OF KWAZULU-NATAL

Abstract

Access to electricity is crucial to improving rural households' welfare and the achievement of Sustainable Development Goals in South Africa. Most smallholder farmers in South Africa are located in rural areas, and they are critical agents in the implementation and success of poverty alleviation and food security strategies. Access to electricity has the potential to increase the working hours for smallholder farmers, and subsequently, their incomes. In some rural communities, infrastructural development has had unintended negative impacts on households. Examples include hydroelectric projects in Brazil and China that have devastated agricultural activities due to flooding of dams. There are very few studies that assess the impact of rural electrification on households in South Africa, nor the welfare gains premised to be the drivers of electrification programmes. This study examined the impact of rural electrification on the welfare of smallholder farmers in South Africa. Data was collected from 243 randomly selected households in Ward 14, in Msinga, KwaZulu-Natal. The study used the Ordinary Least Squares regression to analyse the impact of electricity and other household attributes on smallholder farmers' welfare. The econometric results show that smallholder farmers with access to electricity have higher income per capita than households without access. The study also found that age, gender, education, time spent in off-farm employment, and occupation of the household head impact of smallholder farmers.

Keywords: rural electrification, welfare, income, smallholder farmers, Ordinary Least Squares regression

4.1 Introduction

South Africa's first democratically elected government recognised poverty as a threat to development (Seekings and Nattrass, 2015). More than half of the South African population live in poverty, and rural households are more vulnerable to poverty than urban residents (StatsSA, 2017). Smallholder farmers have been identified as critical agents in achieving poverty alleviation in South African (Pienaar and Traub, 2015) and the rest of the world (Terlau et al., 2019). Economic growth is closely related to energy use. The use of electricity in rural communities will determine the benefits households experience from accessing it (An, 2008). Information on how rural electrification is impacting the welfare of smallholder farmers will empower policy-makers and extension officers on their strategic efforts to support smallholder farmers.

The primary use of electricity in rural communities is for lighting (Bernard, 2012), and the second most significant use is for televisions (An, 2008). Studies in Vietnam, India, Bangladesh, and Nigeria have shown a positive relationship between household welfare and access to electricity. These welfare impact studies have shown households benefitting from rural electrification (RE) through positive impact on income (Khandker et al., 2013, Khandker et al., 2012a), education through long study hours for households (Khandker et al., 2012a), higher enrolment in school for boys and girls (Khandker et al., 2013), better incomes from micro-enterprises (Akpan et al., 2013). Some literature supports an increase in agricultural productivity through access to electricity as the key driver to rural development, and others state the impact of electrification on non-farm activities as the key to poverty alleviation (Cook, 2011). Dinkelman (2011) showed that rural electrification in South Africa improved income for households. The increase in income was attributed to households having more time to participate in off-farm employment. Given that countries and communities are different, the broad application of development policies in one country based on outcomes from other countries or communities is not ideal. Impact findings cannot be transferred, and studies are needed to assess how different areas respond to infrastructural development (Peters and Sievert, 2016)

There is a vast literature on how RE relates to development. However, many of the claimed benefits of RE lack empirical evidence to support them. Few impact studies assess whether the goals set at the onset of RE development projects were achieved (An, 2008, Bensch et al., 2010). South Africa is one of the leading countries in RE in Africa, yet its research in energy studies remains

very low compared to the rest of the world (Pouris, 2008, Pouris, 2016). The emphasis on energy studies in the field of agriculture, based on annual publications, is also much lower than the world average (Pouris, 2016). While impact findings cannot be transferred between countries, empirical studies from South Africa can still help other African countries determine considerations in RE programmes. In turn, this could help guide energy policies for smallholder farmers on the continent.

This study aims to add to the literature on empirical studies that analyse the impact of rural electrification on smallholder farmers in South Africa.

4.2 Methodology

4.2.1 Conceptual framework

The Sustainable Livelihood Framework was used in Chapter 3, Section 3.2.1, to show how access to electricity can impact a household's income through the different types of household capital. The Logic Model is also useful in conceptualising how access to electricity can impact the income of female-headed households. Logic models are a graphic way to explain concepts by showing the relationship between actions and results (Knowlton and Phillips, 2012). The results chain or pipeline logic model describes how programme activities or interventions and the planned outputs lead to expected direct results and more indirect results (Bensch et al., 2010). The process is linear, with inputs and activities at the front and long-term outcomes at the end (Funnell and Rogers, 2011, Bensch et al., 2011).

The impacts of RE take time to manifest; hence, this raises the question of the appropriate timing for their measurement. Assessing RE's impact on clearly stated objectives attained in the relatively short run, through simple causal chains may overcome this challenge. On the other hand, researchers may use intermediate indicators of the impact that are possibly affected in the short run, and expected to link to the outcome in the longer run (Bernard, 2012).

Figure 5 shows how participation in agriculture is measured by time allocation to agriculture. Time allocation to agriculture is an intermediate indicator of the impact of RE. The final outcome that can be affected is the smallholder farmer's welfare. RE's impact on smallholder farmers can be

assessed through their level of participation in agriculture, and changes in their welfare that emanate from changes in the intermediate indicator can indicate impact.

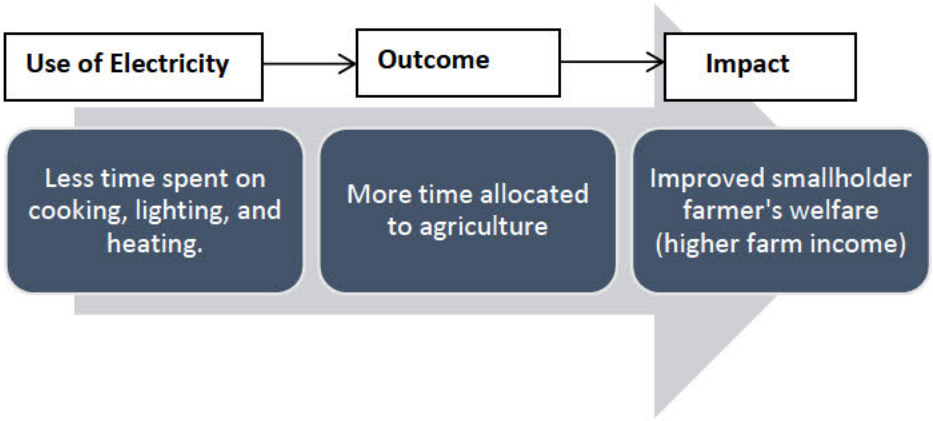

Figure 5. Logic Model for Impact of Electrification on Smallholder Farmer's Welfare
Source: Own Illustration

The collection of firewood and cooking on traditional stoves consume a substantive amount of time for rural households. Being connected to electricity may free up time for smallholder farmers to engage in other activities (Cecelski and Unit, 2000, Dinkelman, 2011). Electricity can also extend working hours because households with lighting can work long hours outside the house without sole reliance on daylight lighting (Kooijman-van Dijk and Clancy, 2010). This reallocation of time can affect their agricultural activities. In rural areas, when women involved in agriculture are connected to electricity, they can engage more in agriculture. Since women are more burdened by domestic chores (Thamaga-Chitja and Morojele, 2014), they are likely to benefit more from the technology's labour-saving aspect; hence, one would expect the increase in agricultural participation to be more significant for female smallholder farmers than for female smallholder farmers. Higher participation in agriculture can enable smallholder farmers to earn an income from agricultural activities (Thamaga-Chitja and Morojele, 2014). Therefore, the income gap between male and female smallholder farmers (Adegbite and Machethe, 2020) could be reduced by access to electricity.

4.2.2 Data Processing and Analysis

This section discusses the data analysis techniques applied to assess the impact of electrification on smallholder farmers' welfare.

Four enumerators conversant with the local language collected data using a structured questionnaire. The data collection process is described in section 3.3.4, and the study site is discussed in detail in Chapter 3. Data analysis used descriptive statistics and Ordinary Least Squares (OLS) regression. The variables used in the OLS regression are described, including a priori expectations in Table 11.

4.2.3 Descriptive Techniques

Descriptive statistics were used to summarise smallholder farmers' characteristics. Descriptive statistics analysed the demographics of the sample, the sources of energy used by the households, and compared income levels of electrified and non-electrified smallholder farmers. This was done using histograms, means, t-tests, and pie charts. Martins (2005), Dinkelman (2011) used descriptive statistics to analyse households' welfare before and after electrification in KZN.

4.2.4 Econometric analysis

The study applied the OLS regression analysis to determine the impact of electrification on welfare. It evaluates how the dependent variable responds to changes in the independent variable/s. OLS regression is one of the techniques used to analyse data, and it is the foundation of many other data analysis techniques (Craven and Islam, 2011). The strength of this methodology lies in its ability to detect linear relationships with ease, enabling testing hypotheses without difficulty. Various studies have applied this methodology to determine the factors that influence rural welfare. Jaim and Hossain (2011) applied a multiple regression model to determine how participation in agriculture affects women's income. Aikeli (2011) applied the OLS model to analyse determinants of rural income in Tanzania, and similarly, Talukder (2014) for rural households in Bangladesh. In a study to measure rural electrification's economic impact, Akpan (2013) evaluated the impact of electrification on micro-enterprise profitability in Nigeria using OLS regression analysis. OLS regression analysis enables us to compare welfare differences between households using one group as a base comparison. This allows us to compare income differences between electrified and non-electrified households, and assess gender differences in income between male-headed households and female-headed households.

This study follows the multiple regression model used by Talukder (2014) and Fadipe et al. (2014).

The model applied has the following specifications:

$$Log(Y_i) = \beta_0 + D_i + \beta_i X_i + \varepsilon_i$$

Log(Yi) = Income per Capita , measured as the amount of total household annual income (including remittances) divided by household size.

B_0 is the intercept of the regression line, and β_i are the coefficients

D is a dummy variable representing connection to electricity. (=1 for connection to electricity and =0 for no connection).

X is a vector of independent variables: Level of Education; Gender; Age of household; Time spent in Agriculture, Off-farm Employment and Private Enterprise; Type of Occupation

ε_i is the error term.

Adoption of a technology is usually subject to self-selection, which creates an endogeneity problem in regression estimation. However, in the case of rural electrification in South Africa and especially KZN, rural electrification was a government programme initiated to address the economic discrimination of apartheid. Post-apartheid, the government partnered with Eskom to roll out electricity in the homelands as an essential service for all citizens (Dinkelman, 2011). Smallholder farmers could not self-select to adopt electrification because the government determined access in communities. In the study site, all the electrified households were in one area adjacent to the non-connected households. This eliminates the endogeneity problem that may arise from self-selection in the adoption of the technology.

4.2.5 Description of Variables

The explanatory variables used in the OLS regression are described in Table 11 and the *a priori* expectations are detailed below:

Access to electricity: Higher incomes are expected for smallholder farmers with access to electricity because electricity is expected to reduce the time burden of domestic tasks, therefore enabling electrified households to supply more labour to income-generating activities (Dinkelman, 2011).

Table 11. Description of variables used in Ordinary Least Squares Regression

Variable	Description	Measurement	Expected Sign
Log_IncCap	Income per Capita	Total household income divided by the number of households.	
Connection	Connection to electricity	1 = Not connected 2 = Connected	+
Gender	Gender of household head	1 = Female 2= Male	+
Age	Age of household head	1= 13-21year 2= 22-35years 3= 36-55years 4= 56-64years 5= 65+years	+/-
Employment_Wk	Time spent by the household head in employment per week	Hours per week	+
PrivateEnter_Wk	Time spent by the household head in a private business per week	Hours per week	+
TotalAgricPart	Time spent by households in agricultural activities annually	Hours per year	+
Education	Level of education of household head	1 = Not Attended formal education 2= Primary school 3=Secondary school 4=Tertiary school	+
MainOcupation	Main Occupation of household head	1=Fulltime farmer 2=Regular salaried job 3=Temporary job 4=Unemployed 5=Self-employed 6=Student 7=Retired	+/-

Gender: Gender discrimination against women may disadvantage women in accessing inputs such as land (Jahan and Umana, 2003). Women's domestic burden may also constrain their participation in income-generating activities, thus lowering their income relative to men (Carr and Hartl, 2010).

Age: Older households are likely to have more work experience in farm and off-farm activities. Hence income is positively related to age. On the other hand, old age may reduce one's ability to be actively involved in income-generating activities, thus reducing one's income (Fadipe et al., 2014).

Employment Hours: Smallholder farmers sometimes engage in off-farm employment as an income diversification strategy (Khanal and Mishra, 2014). The more hours households can spend in employment, the higher their income they will generate (Dinkelman, 2011). When the household head is employed in off-farm employment, it may reduce the need to farm for subsistence.

Private Enterprise Hours: Income diversification enables households to earn multiple income streams (Alobo Loison, 2015). Access to electricity has been shown to increase the time spent by rural households in private enterprises (Akpan et al., 2013). A positive relationship is expected between income and time spent by smallholder farmers in private enterprises.

Education: An individual's education level determines the type of jobs they qualify for hence determining their income (Aikaeli, 2010). In farming, education increases one's efficiency; hence it is expected that a household's level of education will be positively related to their income.

Main Occupation: Income is not only determined by the number of hours worked, but it also varies amongst different types of occupations. People in fulltime employment are likely to earn more than those employed part-time. Retired household heads are likely to earn less than other household heads because the households in the other categories have a higher physical ability to participate in various income-generating activities. Students might not be able to work; hence their income is likely to be limited. Unemployed household heads are expected to earn less than employed ones unless their remittances from employed family members are high.

4.3 Results and Discussion

This chapter presents the findings of the study. The descriptive analysis uses frequencies and means in analysing the socioeconomic characteristics of the smallholder farmers sampled. The main factors analysed include household income sources, ownership of various assets, the participation of households in various income and non-income generating activities.

4.3.1 Descriptive Results of Household Welfare

Education is an essential factor for capacitating individuals to generate income both on the farm and off-farm (Fadipe et al., 2014). The majority of the household heads do not have any formal education (42.4%), 23.9% attended primary school as their highest education, and a third of the households (30.9%) have a high school education. Only 2.9% of the household heads have a tertiary education. One can, therefore, expect that majority of the smallholder farmers will be low-income earners.

The analysis in Section 3.4.1 identified a group of households headed by individuals under 21 years. Households under 21 years have minimal work experience, if any, or are in school. Therefore, their ability to earn income off-farm is limited. Additionally, most (70.6%) of these households are students (Table 12). Therefore, they have limited time to participate in income-generating activities. These households are expected to have low incomes.

Table 12. Households Headed by Individuals Under 21 years

Occupation	Frequency	Percent
Student	12	70.6
Unemployed	3	17.6
Fulltime Farmer	1	5.9
Regular Salaried Job	1	5.9
Total	17	100

Amongst the income-generating occupations (farming, regular salaried job, temporary job), women are the majority of participants (73%). Amongst the household heads employed in a regular salaried job, 72% are men, and 71% of household heads employed in part-time jobs are women. Despite households participating in various occupations, majority of the households surveyed

(82%) qualify as smallholder farmers as per DAFF's definition. Few households did not participate in agricultural activities in the year the survey was conducted.

Figure 6. shows that the main social groups are for religious purposes. 19% of households belong to a savings and credit group where households save money together. A tenth of the households belong to a women's association, which serves as a funeral group for assistance. Very few households participate in groups whose sole focus is to assist with farming (12%) or business marketing activities (0.4%).

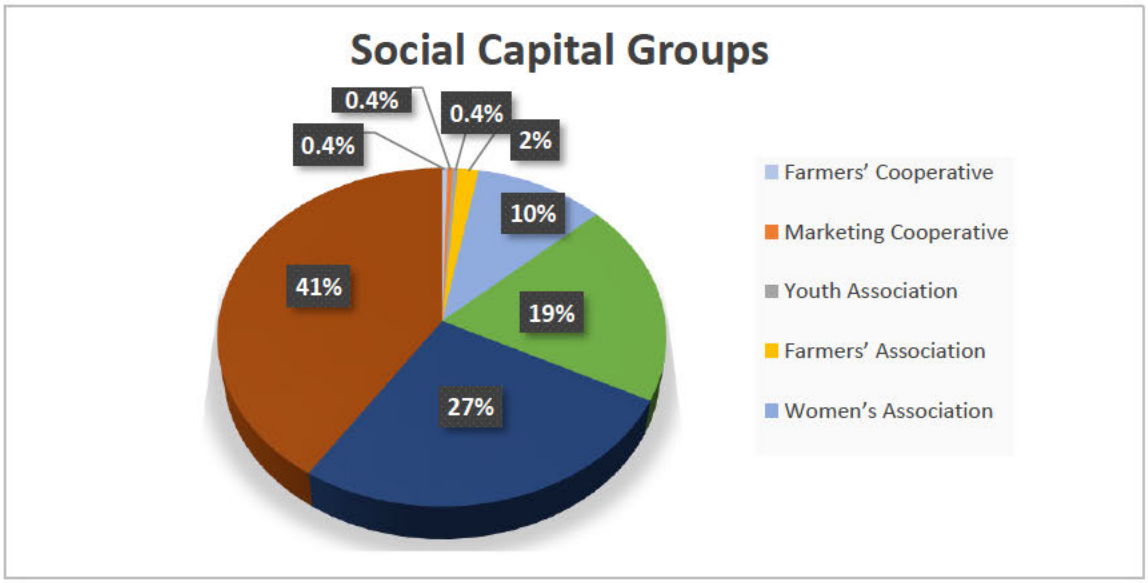

Figure 6. Social Capital Groups

Social grants are the primary income source for households, and 89% of households receive a social grant from the government. The social grants constitute 52% of the households' total income in the study area. Income from salaried employment is the second largest contributor to households' incomes, constituting 23% of this community's total income. Even though the percentage of households that earn an income from a salaried job is significantly smaller (69% less) than those receiving social grants, households who have fulltime off-farm employment earn twice much as households earning from social grants on average.

While most households are headed by women (67%), only 27% of the households earning from fulltime off-farm employment are headed by women (Table 2). This reflects that the higher income earning occupation in the community is skewed against women.

Table 13. Household Sources of Income

Income Source	Household Participation	Proportion of Total Income	Mean Income	Standard Deviation
Social Grant	89%	52%	R21,056.96	R15,484.47
Employment	20%	23%	R42,425.42	R56,665.98
Remittances	26%	17%	R21,056.96	R15,484.47
Small Business	11%	5%	R16,248.15	R17,325.31
Farm	28%	3%	R4,261.54	R6,601.94
Livestock	17%	2%	R4,068.00	R6,765,60
Crops	19%	1%	R2,530.56	R4,689.94
Credit	8%	1%	R2,651.00	R5,854.51
No Income	0.4%	0%	R0.00	R0.00

The percentage of households receiving remittances (26%) is 6% higher than that of households earning an income from a salaried job. However, remittances contribute less to the total income of households.

They contribute 17% of total household income, which is less than the contribution of salaried employment income by 6 %. Small businesses contribute 5% of households' total income in this community, and 11% of households operate small businesses.

Farm income from the sale of livestock and crops constitutes 3% of households' total income in the sample. There is a small difference in the number of smallholder farmers earning an income from farming, 19% in crop cultivation and 17% in livestock rearing. However, the percentage contribution of livestock income to households' revenue is twice the crop sales value (2% livestock, 1% crops).

Table 14. Social Grants Participation and Income

Type of Grant	Household Participation	Share of Total Income
Child Support	81%	27%
Old Person	37%	21%
Disability	6%	3%
Foster care	2%	1%

Among the households receiving social grants, 81% receive child support grants, and 37% receive Old Person's grants. Child support grants constitute 27% of households' income in this area, and Old Person's grants constitute 21% of the sample's income. Very few households receive a disability grant (6%) and a foster care grant (2%). These two grants also contribute minutely to the households' income in the area, 3% and 1%, respectively.

4.3.2 Descriptives on Energy Sources

Grid electricity is the primary source of energy for all appliances amongst appliance owners. There are 63.8% of households in this community that own a stove (Figure 7). Grid electricity is the main energy source for stove owners, with 52.9% using it as the main energy source. Firewood is the second primary source of energy for stoves, followed by paraffin and gas. These energy sources are used by 18.1%, 16.8%, and 7.7% of stove owners, respectively.

About half of the households in the area own an iron (52.3%), and 58.3% of these households use grid electricity as the source of energy for their irons, while 36.2% use firewood (Figure 7). The use of solar energy for ironing is uncommon in the area, and only 2.4% of households use it for ironing. Very few households own a microwave (4.9%), and all of them use grid electricity. A third of the households own a fridge (29.2%), and the majority of them (73.2%) use grid electricity as the primary source of energy. The remaining owners use gas (25.4%) and solar (1.4%).

Almost half of the households own a radio (49%), which is more than the number of television owners (37%). Grid electricity is the most used energy source for radios, with 57.1% of radio owners using it to power their radios.

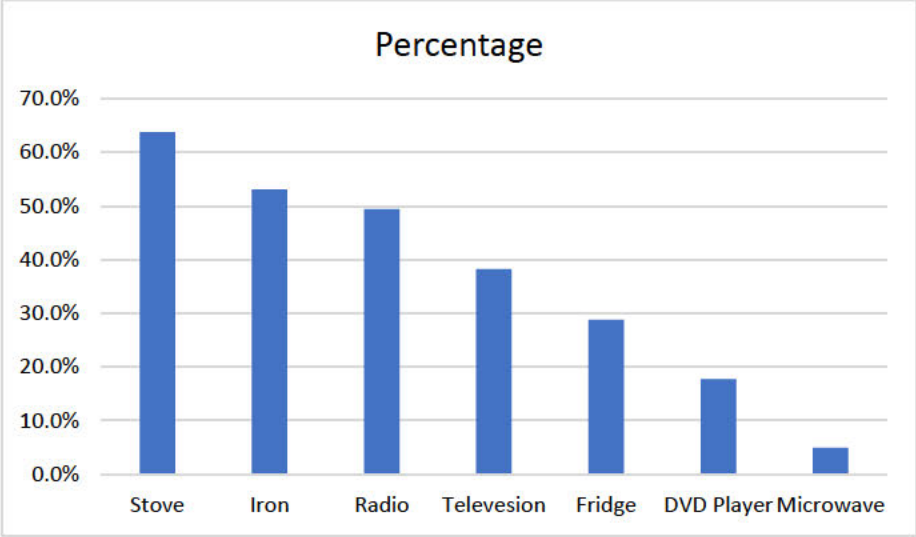

Figure 7. Appliance Ownership

The second main source of energy for radios in the area is dry cell batteries (26.1). Amongst the television owners, 80.9% use grid electricity for their televisions, and 6.7% use car batteries. Solar energy is used by 5.6% of television owners, and 4.5% use generators.

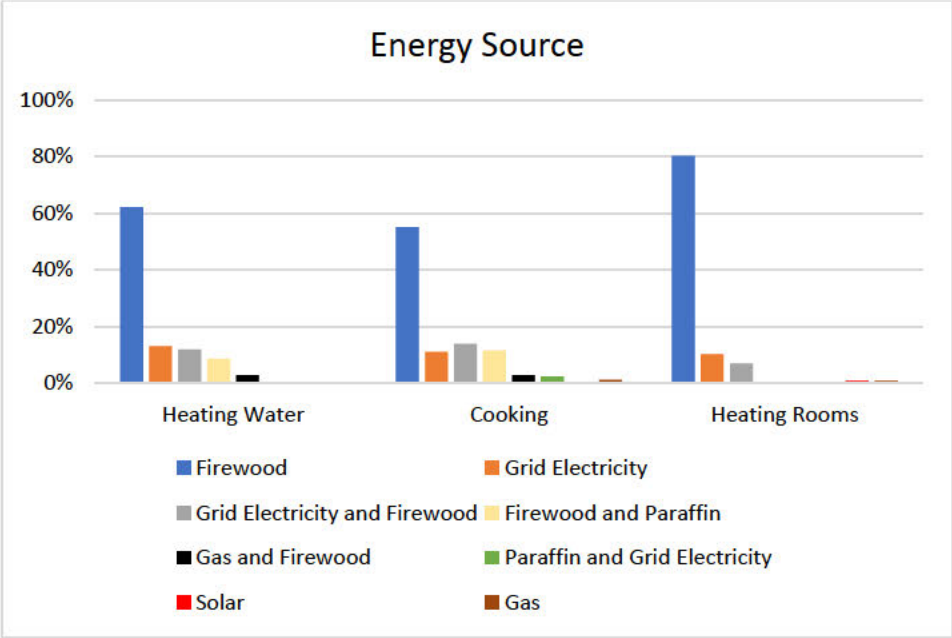

Figure 8. Energy Sources

Firewood is the main energy source for cooking, heating rooms, heating water and cooking, as shown in Figure 8. The use of grid electricity for cooking, heating rooms, and heating water is minimal. Less than 13%of households use grid electricity for each of these activities. Some households use a combination of grid electricity and firewood for heating water (12%), cooking

(14%), and heating rooms (7%). There is similar firewood and paraffin usage amongst households for cooking (12%) and heating (9%).

The potency of firewood as an energy source in this community is further highlighted in how it is also the other energy source in households with combinations of energy sources. Very few households use gas for heating water and cooking (3%). These households use it in conjunction with firewood. Only 1% of households use gas only for heating rooms and cooking. Solar energy is the least common energy source, and it is used for cooking by 1% of households.

Candles are the main source of lighting for households in this community (34%). Only 13% of households use electricity only for lighting, and a third (30%) of the households in the area use both electricity and candles for lighting. Other households (13%) use both candles and firewood. Only 1% of households use solar only for lighting, and 1% use both solar and candles. A combination of paraffin and candles is used by 5% of households for lighting.

4.3.3 Multiple Regression Results

The multiple regression results (Table 15) show that access to electricity, age, gender, education, time spent in regular salaried employment, and occupation of household head impact smallholder farmer's income.

The results show that smallholder farmers with access to electricity have 26% more income per capita than those without electricity, holding all other factors constant.

Contrary to a priori expectations, the age of the household head is negatively related to income per capita. This implies that as the household head's age increases, the income per capita for that home decreases. With the base comparison group being household headed by individuals who are under 21years, households headed by individuals aged 22-35 have 77% less income per capita, households headed by individuals aged 36-55years earn 90% less income, households headed by individuals aged 55-64years earn 70% less income and household headed by individuals older than 65years earn 74% less income.

The age group with the least income per capita compared to households headed by individuals under the age of 21years is 36-55years. This is also the age group that has the average family size that is the largest.

Table 15. Multiple Regression Results

LnIncomeperCap	Coef.	Std. Err.	P>t
Constant	9.041252	0.3725139	0
Connection			
Connected	0.2608388	0.1210075	**
Age			
22-35 years	-0.7711805	0.3179502	**
36-55 years	-0.902982	0.3244103	***
56-64 years	-0.7036789	0.3540384	**
65+ years	-0.7400975	0.3728974	**
Gender			
Male	-0.2390223	0.1404691	*
Education			
Primary School	0.1509947	0.1539467	
Secondary School	0.3413137	0.1682687	**
Tertiary	0.7496954	0.3613166	**
MainOcupation			
Regular Salaried Job	-0.1625398	0.3396646	
Temporary Job	-0.2476012	0.3799848	
Unemployed	-0.0618533	0.1907036	
Self-Employed	0.2061783	0.3767543	
Student	-0.9918514	0.3367412	***
Retired	0.1704474	0.2639655	
Employment_Wk	0.014844	0.0043487	***
PrivateEnter_Wk	0.00193	0.004654	
TotAgricPart	-0.0000622	0.0001049	

Note: * p<0.1; ** p<0.05; *** p<0.01
Source: Survey Data 2017

Male-headed households earn 23.9% less than female-headed households. Education has a positive impact on household earnings, as expected. Households with household heads who have secondary education earn 34% more than homes with household heads with no formal education.

Fulltime farmers was the base comparison group for Main Occupation. Households headed by students have a lower income than fulltime farmers. Households headed by fulltime farmers earn 99% more than student-headed households. Households headed by individuals in other occupations (regular salaried job, self-employment, and temporary jobs) have no statistically significant difference in earnings than households headed by fulltime farmers. The same applies to households headed by unemployed individuals. Even though there is no statistically significant difference in income between households headed by fulltime farmers and retired households, the coefficient for the retired household head is positive.

The number of hours spent participating in agriculture and private business have no statistically significant impact on smallholder farmers' income. However, the coefficient for time spent on a private business has a positive coefficient, while time spent on agricultural activities has a negative coefficient.

4.4 Discussion

The census in 2011 showed that females headed 62% of households in the study area, and a very small percentage of the population was employed (13.2%). The majority of the households were not economically active (discouraged workers, unemployed, and not economically active). This study's results show similar findings and that most of the economically active households are fulltime farmers. Amongst households who did not consider farming as the main occupation of the household head, most households participate in some form of agriculture; crop cultivation or livestock rearing. Therefore, agriculture is still an important economic activity in the area despite its low-income contribution.

The descriptive results (Figure 8) variables show that the use of grid electricity is low. The electricity demand is low when households have low incomes (Louw et al., 2008). This implies that despite smallholder farmers being connected to electricity, the use of electricity is possibly limited by income. This, in turn, limits the time-saving benefit of access to electricity that households can experience. Therefore, the impact on farm income would be negligible, as depicted by the results.

There is a link between education attainment and household income (Gregorio and Lee, 2002). Smallholder farmers with high education levels and off-farm employment tend to have higher incomes than less educated households (Jansen et al., 2015). This study's descriptives results show that the households in this study have low levels of formal education and unemployment is high. Therefore, the average income of smallholder farmers is low, as expected.

Households with access to electricity have higher incomes (Fadipe et al., 2014). Electricity access in rural areas increases the participation of rural households in off-farm employment (Dinkelman, 2011). The results of this study confirm the observations from these previous studies. Households not connected to electricity earn more from farm income and participate more in farming, yet their income from farming activities has no significant impact on household per capita income. The contribution of farming income through crop and livestock income is very low, similar to Fadipe et al. 's (2014) findings in Nigeria. Darko et al. (2018) found that many people involved in agriculture in Malawi were involved in subsistence farming and this limited welfare gains from farming. They also observed that meaningful welfare gains from agriculture required a significant increase in productivity (Darko et al., 2018). Dinkelman (2011) states that land in KZN's ex-homelands is not well-suited for agriculture. This could be part of the reason why income from crop production in the study area is low. However, considering that more than half of the households in this study farm most of their food (Table 5), the contribution of agriculture to the welfare of households may be understated when only the monetary income from agriculture is considered.

The regression results show that households headed by individuals with regular salaried jobs have bigger family sizes than households headed by fulltime farmers. This suggests that the value of the high income earned from the regular salaried job is diminished by the number of individuals supported by that income, thus reducing welfare gains compared to farming households.

The results show no significant difference between the main types of occupation except for student-headed households. The majority of the households in Msinga engage in informal activities and subsistence activities (MMIDP, 2012). Therefore, if most activities amongst the economically active population yield no income or very little income, the difference in income from the various types of occupation would be negligible or absent, as this study shows. Though most occupations have no impact on the income of smallholder farmers, the number of hours spent in a regular

salaried job has an impact on welfare. This suggests that there is a threshold at which the number of employment hours in a regular salaried is not negatively affected by the negative income impact of family size and the negative impact of most salaried jobs being in the low-income category.

With social grants being the primary source of income, this could explain why OLS results show that households headed by retired have higher incomes than households headed by fulltime farmers. Table 13 supports this explanation as it shows that income from farming activities is significantly lower than income from social grants. Machethe (2004) found that the old-age pension was the second largest contributor to household income in rural SA. Even though there is no statistically significant relationship between a retired smallholder farmers and income, the positive coefficient shows that retired households are likely to earn more than fulltime farmers.

The census of 2011 showed that only 13% of individuals over the 15years of age were employed in the study area (StatsSA, 2012). The results of this study show that there are still high levels of unemployment in the area. Households headed by individuals under the age of 21years of age have an income advantage from receiving remittances. In spite of social grants being the main source of income for the whole sample, the results show that households headed by individuals under the age of 21years are the only ones whose main income stream is not social grants but remittances. Most child-headed households in South Africa have a living parent (Meintjes et al., 2010). This implies that the household heads under the age of 21years are possibly receiving remittances from their parents, thus giving them an income advantage over older household heads in an area with limited employment opportunities in the community (Meintjes et al., 2010). Though these young households have relatively higher incomes, majority (67%) of them still participate in agriculture. Therefore, smallholder farming is consistently present across age and income.

The majority of the households headed by students have access to electricity, yet their income is lower than that of households headed by fulltime farmers, even though only about half of households headed by fulltime farmers have access to electricity. This implies that the income impact of access to electricity is jointly affected by other variables, the main occupation of the household head is one of them. The results show that a significant number of households headed by students are students between the age of 22-55years. These households are mainly in the working population group. The results suggest that they do not benefit from the remittances income advantage that households headed by individuals under the age of 21years have. Given that these

household heads are studying, this suggests that the studies' commitment disadvantages them financially as it takes time away from income-generating activities.

Male-headed households generally have better access to education and employment opportunities than female-headed households (Jahan and Umana, 2003). In South Africa, female-headed households are generally poorer than male-headed households (Rogan, 2016). The results of this study support the findings that male-headed households are more educated compared to female-headed households. Additionally, households employed in off-farm employment earn higher salaries, and literature states that women are often discriminated against in these employment opportunities. The descriptive results showing the main occupations in this study area show that most household heads in fulltime off-farm employment are males, and off-farm employment has the highest average income per household. Even though most household heads engaged in income-generating activities are women, their concentration is in lower-income earning occupations, farming, and temporary jobs. This suggests that female-headed households are economically disadvantaged because their access to gainful employment is limited. However, contrary to the conclusions related to the disadvantages women face in employment and education, the OLS results show that female-headed households have higher income per capita than male-headed households. This suggests that other factors besides education are influencing the gender advantage female-headed households have in per capita income. In developing countries, households headed by men have bigger family sizes (Bongaarts, 2001). A study in the Philippines showed a strong relationship between poverty and big family sizes (Orbeta Jr, 2005). This study shows that female-headed households have smaller family sizes, and a higher percentage of them have access to electricity compared to male-headed households. Given that the results also show that households with access to electricity are better off than those without access to electricity, this suggests that family size and access to electricity of female-headed households could be the reason female-headed households have higher income per capita than male-headed households. Though the male-headed households have higher incomes and are employed in higher income-generating activities, the results suggest that the size of the family diminishes the welfare gain.

Education positively impacts household income per capita (Aikaeli, 2010, Gyimah-Brempong et al., 2006). Even though all levels of education impact income per capita positively, one cannot be substituted for the other. There has been debate on whether African countries should focus more

on primary education than on higher education levels since primary school education has been shown to have a higher level of social returns (Gyimah-Brempong et al., 2006). Similar to findings by Aikeli (2010) and Gyimah-Brempong et al. (2006), the results of this study support the argument that education has a positive impact on income per capita. However, contrary to these studies, this study shows that only higher levels of study impact smallholder farmers' income. Dinkelman (2011) states that formal jobs in KZN rural areas are concentrated in civil services, mainly teaching and domestic work. The study area's low education levels inhibit households from benefiting from the civil service opportunities available. Employment in domestic work provides low income. The employment opportunities in the area do not align with the education levels of the working population, where teaching and civil services are concerned. Therefore, the communities remain disadvantaged economically because most individuals can only be employed in low-income paying jobs such as domestic work.

Participation in agriculture is not significantly contributing to household income per capita. Part of the reason could be that households participating in agriculture are mostly engaged in subsistence farming. The OLS results support the findings of the PCR results in chapter 3 by confirming that smallholder farmers employed in off-farm employment have relatively high incomes. This supports the finding that high income is negatively related to participation in agriculture.

4.5 Conclusion

Access to electricity, education level, time spent on off-farm employment positively affect the welfare of smallholder farmers. Age of household head, having a male household head, and having a student household head are characteristics negatively related to income per capita.

The data shows that off-farm employment currently has the highest per capita contribution to smallholder farmers relative to other income streams. Agricultural activities have no significant impact on smallholder farmers' income. While there are very few households involved in fulltime farming, most households still participate in subsistence farming. Therefore, smallholder farmers are crucial to the food security of households in this community. There is great potential for home gardening to improve food security because many smallholder farmers produce a significant

proportion of their food. Therefore, agriculture is still a potent economic activity in this area and critical to these households' food security. Future studies can investigate if farming is the preferred means of earning an income or if smallholder farmers prefer to find off-farm employment. This will ensure efficient allocation of resources in rural development programmes. Empowering smallholder farmers who prefer off-farm work with skills to be more employable can positively affect the smallholder farmers who remain in agriculture. Higher incomes from off-farm employment can create a higher food demand that will increase the incomes of the fewer farmers supported by extension officers and agricultural programmes. With low levels of education in the area, policy-makers need to consider options that create employment for smallholder farmers with low education levels, such as craft-based work like sewing, carpentry, and building work. These courses may be an excellent short-term income improvement strategy while also implementing long-term strategies that enable households to increase their income. Additionally, with fewer farmers, extension officers will focus more on smallholder farmers committed to improving agricultural output as they will contribute more towards the attainment of poverty alleviation goals through agriculture. Given the low rainfall in the area, farmers may need to explore the cultivation of drought-resistant crops or other farming systems that cater to the water challenge.

The need for extension services to help smallholder farmers increase the income contribution of agriculture to smallholder farmers' welfare is imperative. If incomes from agriculture remain low, rural communities are more at risk of deagrarianisation as smallholder farmers may seek better income opportunities in off-farm income on the basis of necessity.

The use of electricity for domestic activities is impeded by low incomes, even though smallholder farmers now have grid electricity. Most smallholder farmers use electricity for lighting, and very few use it for cooking. The results for agricultural participation show that time reduction in cooking and firewood collection has a significant impact on the reallocation of time amongst household activities. Ensuring that smallholder farmers can reduce their cooking time and firewood collection will impact smallholder farmers more than only ensuring they have access to electricity. Therefore, development policies need to focus more on high impact electrification activities than on access to electricity alone.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Smallholder farmers and women are critical agents in the attainment of the NDP goals, and rural electrification is a critical infrastructural technology in meeting the energy needs of the development plans. Empirical studies on the impact of rural electrification have shown that the effects of the technology on welfare indicators vary across countries. South Africa needs to substantially increase its energy research output to better guide energy policies with evidence-based programme results, especially in the agricultural sector. This study assessed the impact of the gender, energy, agriculture link on poverty alleviation. Statistical analysis of data from rural households was used to determine the impact of electrification on smallholder farmers' agricultural participation and female-headed households' welfare.

5.2 Summary of Results

The results of the study show that women are critical to the economic development of rural communities in South Africa. The study showed that they comprise the majority of smallholder farmers and household heads. The results showed clusters of smallholder farmers in the data based on related socioeconomic characteristics. Based on the characteristics of these smallholder clusters, household income, employment of household head in off-farm employment, access to electricity were shown to have a negative relationship with time spent on agricultural participation. The results suggest that access to electricity alone does not affect time spent on agricultural activities by households, but rather the time saved from firewood collection and lower cooking times. The ambiguous results on the relationship between gender of farmer show that gender alone is not determinant of smallholder farmers' participation in agriculture. Other characteristics such as the age of household head, and access to electricity contribute to a households' level of agricultural participation. Plot size and education of household head also had an inconsistent relationship with the level of agricultural participation. This suggests that, independently, these two variables do not determine the agricultural participation of households but rather their interaction with other variables like income and age. The results of the study also show that time spent in off-farm employment positively affects smallholder farmers income. The results suggest

that most smallholder farmers participate in agriculture out of necessity and not out of interest in agriculture and farming.

Households with access to electricity have higher incomes than non-electrified households. Female-headed households had higher incomes per capita than male-headed households. The results suggest that access to electricity and smaller family sizes are the reason for the higher incomes amongst female-headed households. Age of household head has a negative relationship with income. Younger household heads where benefitting from remittances, thus they had higher incomes relative to other age groups.

5.3 Policy Recommendations

Based on the findings of this study, the following interventions are recommended to policy-makers:

- Policies seeking to promote agricultural participation need to research the aspirations of the targeted communities before developing programmes so that the goals of the initiatives align with the aspirations of households.
- Agriculture needs to be promoted as a profitable business and career option to entrepreneurs, women and youth in rural communities. Support needs to be provided to smallholder farmers committed to agriculture as fulltime employment and those passionate about farming. The evidence of their success in agriculture will encourage others to consider farming as a viable and desirable occupation. Therefore, policies that seek to improve agricultural participation and productivity in rural areas must focus on creating awareness amongst households on the benefits of farming beyond subsistence – farming as a business.
- Female-headed households require more support through programmes that can directly alleviate the time burden of domestic chores to enable them to participate more in income generating activities. Access to electricity alone is insufficient when households have affordability challenges due to low incomes. Forest rehabilitation programmes can be started to replenish wood supplies closer to households.
- Agricultural policies need to research and account for the impact of non-agricultural technologies on agriculture by analysing the various ways the technologies impact

smallholder farmers. The conjoint effects of various technologies necessitate an increase in multidisciplinary approaches in agricultural research.

- The implementation of agricultural policies at the community level needs to be guided by the micro-data statistics of the community to be more effective.
- Programs that curb students dropping out of school at primary education level require increased support to ensure households attain higher levels of education.

5.4 Study Limitations

In some interviews, respondents did not know the exact age of the household head. Therefore, age was captured as a range and translated to an ordinal variable instead of being captured as a specific numerical variable. The use of exact age in the analysis would have allowed for the analysis of the linear relationship between the income of smallholder farmers and age. However, the comparison of income comparison amongst different age groups of household heads still provided useful information on how the age of household heads affects the income of smallholder farmers.

5.5 Areas for Future Research

There is limited research in the discipline of agriculture on the use of CATPCA to classify populations or determine trends in data. Using CATPCA for clustering and determining homogenous groups in data could aid in predictive modelling for behavioural studies on smallholder farmers. Predictive behaviour modelling can assist agricultural marketing companies and improve technology adoption research.

Though characteristics associated with a higher level of agricultural participation were identified in the study, more research is needed to understand why electrified households choose to participate less in agriculture. Responses from households would provide more accurate information than the inferences drawn from the results. This will help stakeholders in agricultural development structure agricultural promotion initiatives in line with the aspirations of rural households and smallholder farmers.

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APPENDIX A: HOUSEHOLD SURVEY QUESTIONNAIRE

University of KwaZulu-Natal

Discipline of Agricultural Economics

THE IMPACT OF ELECTRIFICATION ON RURAL WOMEN'S PARTICIPATION IN AGRICULTURE AND THEIR WELFARE

All the information provided here will be treated as **STRICTLY CONFIDENTIAL.**

Enumerator	
Date of Interview	
Name of Interviewee	
District	
Is the district area connected to the Eskom grid?	Yes = 1; No = 0

1. Household Demographics

1.1 How many people reside at your household? _____ (Household being a group of people who constantly live, cook and eat together)

(*Record household head* details in the first row*).

Name of Household member	**Relationship** *of each member with the head of household*	**Age** *Age of each household member*?	**Gender** *of each household member?*	**Marital Status** *of each member?*	**Education Level** *of each household member?*	**Main Occupation** *of each household member?*

Key

Relation to household head	**Age**	**Gender**	**Marital status**	**Education level**	**Main occupation**
1=Household head* 2=Spouse 3=Daughter /son 4=Other (specify e.g., cousin)	**1= 0-12years** **2= 13-21year** **3= 22-35years** **4= 36-55years** **5= 56-64years** **6= 65+years**	**1=Male** **0=Female**	1=Single 2=Married 3=Divorced 4=Widowed	1 = Not Attended formal education 2= Primary school 3=Secondary school 4=Tertiary school	1=Fulltime farmer 2=Regular salaried job 3=Temporary job 4=Unemployed 5=Self-employed 6=Student 7=Retired 8=Infant(under age) 9=Other (specify)

** Household head refers to the household head that stays in the household for 4 or more days per week.*

2. Time Allocation

2.1 How many hours per season do household members spend on farming activities listed below?

Crop productive	**Season**	**Household Member**						
Planting	Dry							
	Wet							
Monitoring	Dry							
	Wet							
Weeding	Dry							
	Wet							
Harvesting	Dry							
	Wet							

Activity	Season	Household Member						
Threshing and grinding	Dry							
	Wet							
Livestock and poultry activities	Dry							
	Wet							
Fishery activities	Dry							
	Wet							

2.2 How many hours per week do household members spend on off-farm activities listed below?

Activity	Household Member						
Employment							
Private enterprises							
Collecting firewood							
Firewood preparation							
Cooking							
Studying							
Leisure activities							

3. Income and expenditures

5.1Source of household income for members residing at the house.

Income source		Monthly (ZAR)	Annual (ZAR)
Employment			
Small businesses			
Agricultural activities	Farming		
	Livestock Production		
	Others (specify)		
Welfare grants	Child support		
	Disability		
	Older Persons		
	Social relief of distress		
	Care dependency		
	Foster care		
	War Veteran's		
	Grant in aid		
Remittances			
Others, (specify)			

3.2 Acess to Credit

3.2.1 Have you received any formal or informal credit in the last 5years? Yes /No

If No, skip to 5.3. If Yes, proceed to 5.2.2

3.2.2 When was this credit received (year)?_____

3.2.3What was the source(s) of the credit(if applicable)?

3.2.4What was the amount received from each source?

Source of Credit	**Amount** (ZAR)

3.3 What were the household's expenditures for each of the following categories in the last year? *(fill in the amount for each category, if nothing was spent for any of the categories, fill in a "0")*

Category		**Monthly** (ZAR)	**Annual** (ZAR)
Food			
Water supply			
Clothes			
Housing			
Transport			
Energy expenditure	Electricity		
	Paraffin		
	Firewood		
	Gas		
	Diesel/Petrol for generator		
Cellphone			
Medical care/health			
Education/school			
Entertainment			
Agricultural expenditures (e.g. seeds, fertilizer, rent, labour)			

What proportion of food consumed by the household is bought?	

1= less than 35%; 2= 35%- 50 %; 3= More than 50%

4. Energy

4.1 Main energy sources.

Do you have access to electricity in your household	Yes = 1; No = 0	
Which is the main and secondary source of energy for the following?	Main	Secondary
Lighting		
Cooking		
Heating rooms		
Heating water		

Key

1=Paraffin; 2=Electricity; 3=Solar System; 4=Gas; 5=Candle;
6=Coal; 7=Firewood; 8=Car batteries; 9=Batteries;
10=Generator (petrol/diesel); 11= Other (specify)_____

4.2 Do you own the following appliances *(Indicate number owned in the appropriate box below, zero if not owned).*

Appliance	**Yes = 1; No = 0**	**Energy source for appliance**	**Value of each appliance** (ZAR)
Stove			
Fridge			
Television			
Radio			
Iron			
DVD player			
Microwave			

Key

1= Electricity; 2=Gas; 3=Firewood; 4=Solar System; 5=Paraffin;
6=Batteries; 7=Car batteries; 8=Dry cell batteries; 9=Generator (petrol/diesel);
10=Not applicable – no appliance

‘

4.3 How satisfied or dissatisfied are you with the electricity being provided in your neighbourhood based on the following *(if applicable)*?

	Satisfaction
Availability	
Affordability	
Reliability	
Quality	

Key

1=Very satisfied	2=Satisfied	3=Neither nor
4=Dissatisfied	5=Very dissatisfied	6=Do not know

4.4 How has electricity improved your life *(if applicable)*?

……
……
……
……
……

4.5 Households without access to electricity ONLY.
How will you use welectricity when your village gets connected to the electricity grid?

……
……
……
……

5. Farm Information

5.1 Land ownership

5.1.1 What is the size of your farming area?
5.1.2 What type of tenure do you have for the land?

5.1.3 How much did you pay for renting land in the last year (if applicable)?

Plot Number	**Area**	**Tenure:** 1=Owned 2=Rented (hired-in) 3=Borrowed 4=Other (specify)	**Rent per year** (ZAR) (where applicable**)**

5.2 Land Utilisation

5.2.1 How much land is being utilised for crop production? _____
5.2.2 How much land is fallow? _____
5.2.4 How much land is being used for pasture? _____
5.2.5 What other uses do you have for you land? _____
5.2.6 How many hectares of land do these activities use (if applicable)? _____

Land Use	**Season**	**Area (*Specify units of measurement)***
Crops	Wet	
	Dry	
Fallow	Wet	
	Dry	
Others (specify)		

5.3 Farm Assets Ownership

5.3.1 What working farm assets do you own?
5.3.2 How many of each type of asset do you own?
5.3.3 What is the value of each asset?

Farm assets	**Yes = 1; No = 0**	**Number owned**	**Value of each asset** (ZAR)
Tractor			
Plough			
Hoe			
Harrow			
Knapsack Sprayer			
Axes			
Spade/Shovel			
Grain Mill			
Wheelbarrow			
Push Cart			
Vehicle			
Motorbike			
Bicycle			
Other (Specify)			
Total value of assets			

5.4 Livestock Ownership

5.4.1 What type of livestock do you own?

5.4.2 How many of each type of livestock do you own? *(Indicate number owned in the appropriate box below, zero if not owned).*

Livestock Type	**Yes = 1; No = 0**	**Number currently owned**
Cattle		
Goats		
Sheep		
Pigs		
Chickens		
Donkeys		
Rabbits		
Other (Specify)		

5.5 Agricultural Extension Services

5.5.1 Do you receive extension services? Yes/No
5.5.2 If Yes, who provides extension services to you?
5.5.3 What type of extension services do you receive?

Source	Type of Service

Key

Type of Service
1=Crop; 2=Livestock; 3=Agricultural marketing 4=Health 5=Business/Entrepreneurship

5.5.3 How many times, on average, per month do you get extension support?_____

5.6 Labour supply

5.6.1 Do you hire labour for your farm activities? Yes/No
5.6.2 If yes, for which crop(s) do you hire labour for?
5.6.3 During what operations do you hire labour for the crop(s) mentioned?

Crop	Farm Operations

Key

Farm operations 1 = Land preparation; 2 = Planting; 3 = Weeding; 4 = Spraying and Irrigation; 5 = Harvesting

6. Social Capital

Current membership in formal and informal institutions.

Household Member	Type of group	Most Important Group Function	Role In the Group

Key

Type of group	Most important group function	Role in group
1. Input supply/farmer coops/union 2. Crop/seed producer and marketing group/coops 3. Local administration 4. Farmers' Association 5. Women's Association 6. Youth Association 7. Church/mosque association/congregation 8. Saving and credit group 9. Other, (specify) _____	1. Produce marketing 2. Input access/marketing 3. Seed production 4. Farmer research group 5. Savings and credit 6. Funeral group 7. Tree planting and nurseries 8. Soil & water conservation 9. Church group/congregation 10. Input credit 11. Other, (specify) _____	1. Official 2. Ex-official 3. Ordinary member

APPENDIX B: MEANS FOR CONTINUOUS VARIABLES

Variable	N	Mean	Std. Deviation
TotAgricPart	243	643.37	570.66
Family Size	243	5.71	2.73
Income per Capita	243	7235.63	9858.46
Plot Size (H)	243	0.79	1.15
Employment_Wk	243	6.45	16.18
PrivateEnter_Wk	243	3.31	12.87
CollectingFire_Wk	243	13.86	12.20
Cooking_Wk	243	10.43	7.75
Leisure_Wk	243	9.12	13.10

APPENDIX C: CATEGORICAL PRINCIPAL COMPONENT ANALYSIS RESULTS WITH 24 VARIABLES

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8	Comp9	Comp10
Connection	-0.0049	0.4897	0.0831	-0.1166	-0.1089	0.0914	-0.2507	0.0172	-0.1088	-0.0365
Age	-0.0799	0.058	0.4614	0.0474	-0.2051	-0.0848	0.4015	0.0293	-0.0129	0.0778
Education	0.2772	-0.0701	-0.3049	0.2031	0.3209	0.0508	-0.2932	-0.1596	-0.0025	-0.0765
Gender	-0.3037	-0.1481	-0.0078	0.0682	-0.1434	0.2269	0.205	0.19	0.1103	-0.3612
GenderFarmer	-0.0137	-0.0791	-0.0867	0.5347	-0.0226	0.0297	-0.0435	0.3225	0.0171	0.3668
FamilySize	0.0423	0.0471	0.4414	0.0842	0.2832	-0.2328	-0.1886	0.1185	0.0000	0.2253
PlotSizeH	0.1218	0.0643	0.1654	0.1375	-0.0599	-0.1440	-0.2200	-0.5809	-0.3020	-0.1892
FarmAssets	0.0793	-0.0973	0.0853	0.4171	-0.1234	0.3209	0.1159	-0.3358	0.2959	0.2301
ReceiveExtServ	0.1093	0.0605	0.0402	-0.3648	0.0354	-0.1450	-0.1285	0.0153	0.6857	0.0519
SocialGrpPt	0.0248	-0.3713	0.1476	-0.0169	0.2209	-0.0310	0.0204	-0.0846	0.2404	-0.3960
CellphoneExp	0.3545	0.0145	0.2460	-0.0208	0.1229	0.0892	0.0959	0.1035	-0.0029	-0.2493
CookingTim_Wk	0.1271	0.2575	0.0476	-0.1674	-0.2278	0.2668	-0.2184	-0.0064	0.2465	0.1621
Collecting_Wk	-0.2632	-0.1748	-0.0245	-0.3152	0.1550	0.0775	-0.1524	0.0458	-0.2292	0.4098
Leisuretim_Wk	-0.1303	-0.4234	-0.0387	-0.2739	0.2124	-0.0005	0.0749	-0.2419	-0.0183	0.2447
Employment_Wk	0.4215	0.0418	-0.0991	-0.0731	0.0608	-0.2505	0.2801	0.1364	-0.0357	0.1120
PrivateEnt_Wk	0.1688	0.0118	0.1643	-0.1813	0.2633	0.4372	0.0960	0.2524	-0.3288	-0.1070
Employment_Wk	0.3838	-0.0024	-0.1923	0.0171	0.0232	-0.2875	0.2623	0.1117	-0.0409	0.0958
SmallBusin_Wk	0.2861	-0.0205	0.0979	-0.0295	0.1797	0.5334	0.0766	-0.0837	0.0678	0.1719
GrantsIncome	-0.1049	-0.0014	0.4825	0.1549	0.2642	-0.1524	-0.1017	0.0054	0.0698	0.0663
Remittances	-0.0141	-0.1389	-0.0171	0.1823	0.0673	-0.0024	-0.4348	0.4198	0.0795	-0.1873
TVOwn	-0.2350	0.4141	-0.1081	0.0717	0.4083	0.0107	0.1726	-0.0345	0.0612	-0.0645
RadioOwn	-0.2430	0.3115	-0.1838	0.1200	0.4359	0.0074	0.2335	-0.1050	0.1565	-0.0145

APPENDIX D: TV AND RADIO OWNERSHIP T-TEST RESULTS

Activity	Description	N	Mean	T-test
Part. In Agric Wet season	Owns TV	92	239.1276	**
	No TV	150	315.174	
Part. In Agric Dry season	Owns TV	92	161.4337	NS
	No TV	150	199.6623	
Livestock Wet	Owns TV	92	72.08696	NS
	No TV	150	91.744	
Livestock Dry	Owns TV	92	77.47826	NS
	No TV	150	97.056	
TotAgricPart	Owns TV	92	550.1087	**
	No TV	150	703.64	
Employment Hrs/Wk	Owns TV	92	9.130435	**
	No TV	150	4.853333	
Leisure time Hrs/Wk	Owns TV	92	12.53804	**
	No TV	150	7.083333	
Part. In Agric Wet season	Owns Radio	119	250.7432	*
	No Radio	123	320.6293	
Part. In Agric Dry season	Owns Radio	119	159.4903	NS
	No Radio	123	209.9341	
Livestock Wet	Owns Radio	119	83.80252	NS
	No Radio	123	84.72439	
Livestock Dry	Owns Radio	119	89.48319	NS
	No Radio	123	89.73902	
TotAgricPart	Owns Radio	119	583.5042	*
	No Radio	123	705.0325	
Employment Hrs/Wk	Owns Radio	119	8.319328	*
	No Radio	123	4.699187	
Leisure time Hrs/Wk	Owns Radio	119	9.668067	NS
	No Radio	123	8.662602	

Note: * $p<0.10$; ** $p<0.05$;

Source: Survey data (2015)

APPENDIX E: SUMMARY OF CATPCA AND PCR OF FEMALE-HEADED HOUSEHOLDS ONLY

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
Connection	**0.5068**	0.1751	0.0773	**0.3087**	0.0673	-0.0130
IncomeperCap	-0.2604	**0.4174**	0.0759	-0.0728	-0.1314	0.1496
Age	0.1386	-0.2504	**0.3401**	**-0.5121**	-0.2443	0.2644
Education	**-0.3095**	**0.3478**	-0.2926	0.1699	**0.3600**	-0.1435
GenderFarmer	0.1067	-0.1609	0.4740	**0.3826**	0.0424	**-0.3298**
FamilySize	0.0536	**-0.3672**	0.0517	-0.0903	**0.6070**	0.0448
PlotSizeH	0.1410	0.0652	**0.3333**	-0.0353	0.1191	**-0.4940**
SocialGrpPart	**0.3442**	0.2292	0.0025	0.1478	-0.1011	0.2621
MainOccupation	0.2898	-0.1153	**-0.4494**	-0.1606	-0.1068	-0.2037
Cooking_Wk	0.2124	0.2941	0.0647	0.1349	-0.2980	**0.0318**
Leisure_Wk	**-0.4041**	**-0.3471**	0.0084	0.2315	-0.2823	-0.0859
PrivateEnter_Wk	0.0720	-0.0786	0.0744	0.2454	**0.3512**	**0.6129**
Employment_Wk	**-0.3164**	0.2657	**0.4799**	-0.0396	0.0540	0.1053
CollectingFire_Wk	-0.1008	-0.3113	-0.0805	**0.5208**	-0.2967	0.1638
Characteristics Highlighted Similar to Results of Full Sample	• Not Connected • Low Leisure • Low Education • Partipates in Soc Grp • Low Employment Hrs	• High Income • High Education • Low Firewood Collection Hrs	• Elderly household head	• Young household head • High Firewood Collection Hrs • Male Farmer	• Big family • Low Cooking Hrs • Low Firewood Collection Hrs	• Private Enterprise • Small Plot
Comparative Group in Full Sample	**Comp 2**	**Comp 1**	**Comp 3**	**Comp 4**	**Comp 5**	**Comp 6**
Relationship with Agricultural Participation	Positive	Negative	Positive	Positive	Negative	Negative
Statistically Significant	No	**Yes**	**Yes**	**Yes**	No	No

APPENDIX F: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

08 June 2017

Ms Dionne Faral Makuwaza (211547088)
School of Agricultural, Earth & Environmental Sciences
Pietermaritzburg Campus

Dear Ms Makuwaza,

Protocol reference number: HSS/0207/017M
Project title: The Impact of Electrification on rural women's participation in Agriculture and their Welfare in South Africa

Approval Notification – Expedited Application

In response to your application received on 06 March 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Maxwell Mudhara
Cc Academic Leader Research: Professor O Mutanga
Cc School Administrator: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 8087/8350/4557 Facsimile: +27 (0) 31 260 4609 Email: simbop@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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