International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(6), 747-754.

# Rural Energy Access and Agricultural Productivity in South Africa

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**Received:** 28 April 2025 **Accepted:** 31 August 2025 **DOI:** https://doi.org/10.32479/ijeep.20368

**ABSTRACT**

Access to energy is critical for agricultural productivity and it directly contributes to the promotion of a more commercialized agricultural sector. South Africa embarked on massive electrification programme across the country with the sole aim of promoting access to electricity in the country from 34% in 1991 to 77% in 2002 and to 85% in 2018 but the access to electricity more skewed to the urban areas than the rural areas. This arrangement has a more serious implications on the productive and economic activities located in the rural areas of South Africa since most agricultural related activities takes place in the rural provinces of the country. Therefore, issues related to access to electricity, especially in the rural areas, are crucial for the overall growth and development of the country since it largely determines the viability and productivity of agro-allied industries. Empirical studies conducted in South Africa mainly concentrated on energy policy guarding the provision of energy for industries and population living in the urban areas but largely neglects the relevance of rural energy access as a catalyst for agricultural productivity in South Africa. Hence, this study is premised on a Cobb-Douglas production function which describes the relationship between agricultural productivity as a function of access to electricity. The study found that rural energy access has a significant negative influence on agricultural productivity in South Africa. While urban energy access promotes promote agricultural productivity in South Africa. The result further indicates that labour force participation rate, gross fixed capital formation and adequate rainfall were seen to be relevant drivers of agricultural productivity in South Africa.

**Keywords:** Rural Energy Access, Agricultural Productivity, FMOLS, South Africa
**JEL Classifications:** R1, Q1, Q4, P28, P32

## 1. INTRODUCTION

Access to energy (electricity) has been identified as the backbone of modern economy (Blimpo and Cosgrove-Davies, 2019). The relevance of access to energy cannot be globally underestimated because it is a critical infrastructure for the attainment of Sustainable Development Goal 7 which stipulates that “by 2030, there must be access to affordable, reliable, sustainable and modern energy for all (United Nations, 2024; Blimpo and Cosgrove-Davies, 2019). Thus, access to energy is referred to as “the physical availability of electricity and modern energy carriers and improved end-use devices such as cook stoves at affordable prices for all (Pachauri and Brew-Hammond, 2012).”

In essence, access to energy has become one of the difficult challenges hindering economic development (Ayuk, 2018; Zhang et al., 2019; Zhang, 2024) and therefore remain an essential factor for poverty eradication and economic and social transformation. As such, access to electricity are essential inputs to build factories especially agro-processing plants, farm irrigation and ultimately to enhance overall agricultural productivity (Mulugetta et al., 2018; Zhang et al., 2019; Amuakwa-Mensah and Surry, 2022; Raji et al., 2024). Evidence further reveals that access to reliable, efficient, affordable, and safe energy can have a positive influence on productivity (Terrapon-Pfaff et al., 2018; Saunders et al., 2021; De la Rue du Can et al., 2022; Jaiswal et al., 2022). However, access to energy has been identified to be highly inequitably between the rich and poor, men and women and especially between rural and urban areas (Cecelki, 2003; Danielsen, 2012; ENERGIA, 2019; Acheapong et al., 2021; Ogunro and Afolabi, 2021; Onwusu-Manu et al., 2021; Iddrisu et al., 2024).

Most developing countries are faced with the problem of lack of access to energy in rural areas which is a major barrier to productivity, growth and sustainable development (Goldemberg et al., 2000; Mendeley, 2012; Mulugetta et al., 2018; Ukwandu, 2018; Sy and Mokaddem, 2022; Falcone, 2023). The Energy Progress Report (2022) further emphasizes the challenge of energy inequality in sub-Saharan Africa where rural areas have limited access to energy than urban areas with a rising profile of 72% in 2010 to 83% in 2020. About 80% of the people without access to electricity lived in rural areas in 2020, where three-quarters of them live in Sub-Saharan Africa (Energy Progress Report, 2022).

Conversely, the energy supply system in South Africa is well developed in terms of the production and supply of energy to industry, commerce and middle-class households which is comparable to what is obtainable in the developed economies (Akinbami et al., 2021). The energy generation is mainly focused on the use of coal which accounts for more than 70% of the primary energy demand, and nearly a quarter of final energy consumption (Qase and Annecke, 1999; Akinbami et al., 2021).

Energy consumption in South Africa has witnessed a significant growth starting from 1994. This is attributed to the increase in economic activities coupled by the government policy to provide access to electricity for the previously excluded sections of the population which has led to a steady rise in energy consumption in the country. The agricultural sector is the least served sector in terms of energy consumption comparable to other sectors of the economy which consume the bulk of the energy produced within the economy (Rugumayo, 2010; Chitonge, 2017).

Therefore, access to electricity is critical for agricultural productivity and it directly contributes to the promotion of a more commercialized agricultural sector (World Bank, 2015; Omoju et al., 2020; Amuakwa-Mensah and Surry, 2022; World Bank, 2023; Manasseh et al., 2025). The problem of inefficient energy supply to the agricultural sector is akin to the low rural electrification in sub-Saharan Africa with only about 18% of them having access to electricity (World Bank, 2023). Thus, low electrification is a challenge for both agricultural productivity and post-harvest crop processing, consequently leading to high consumption of processed foods because many agricultural raw materials need to be processed within a few hours of harvesting to ensure food reservation and marketability (World Bank, 2015, 2023).

The massive electrification programme across the country rapidly led to an increased access to electricity in South Africa from 34% in 1991 to 77% in 2002 and to 85% in 2018 but with access to electricity more skewed to the urban areas than the rural areas (Statistics South Africa, 2018; Longe et al., 2020). This arrangement has serious implications on the productive and economic activities located in the rural areas of South Africa since most agricultural related activities takes place in the rural provinces of the country. Therefore, issues related to access to electricity, especially in the rural areas, are very crucial for the overall growth and development of the country, most especially, because it determines the viability of all the agro-allied industries and their productivity.

South Africa is a major producer and exporter of agricultural products with a highly diversified agricultural sector which produces an extensive variety of agricultural commodities both in large-scale and small-scale commercial farming. Agricultural produce from farms in South Africa include grains (except rice), oilseed, fruits, sugar, citrus, wine, vegetables and livestock production such as cattle, dairy, hogs, sheep, poultry farming and egg production (Fischer and Tramberend, 2019; International Trade Administration, 2024). The agricultural sector is estimated to contribute about 12% of the country's total export earnings (Fischer and Tramberend, 2019; International Trade Administration, 2024). However, despite the contribution and viability of the agricultural sector, the country is still prone to the problem of food insecurity (Zunckel, 2010; Koch, 2011; Fischer and Tramberend, 2019; Statistics South Africa, 2019; Mbajiorgu and Odeku, 2022; Sithole et al., 2023), this is mainly caused by the lack of insufficient energy access for productive agricultural usage, for farm irrigation, cooling of poultry pens and agro-processing (Jamal, 2015; Fischer and Tramberend, 2019; Manasseh et al., 2025).

Also, studies revealed that agricultural productivity in South Africa as well as in SSA has been fluctuating in recent times, Sometime, it remains stagnant whilst in some other time, it may be increasing either at an increasing rate or at a decreasing rate (Ramaila et al., 2011; Maponya and Mpandeli, 2012; Fischer and Tramberend, 2019; Arndt and Pratt, 2022). This is largely caused by the problem of inadequate access to electricity (Ramaila et al., 2011; Omoju et al., 2020; Manasseh et al., 2024). This presupposes present the dare and peculiar challenge of access to electricity in South Africa and Africa inclusive.

In relation to energy access, few studies have been conducted in South Africa (Davidson and Mwakasonda, 2004; Baker and Phillips, 2019; Sarkodie and Adams, 2020), but these studies concentrated majorly on energy policy guarding the provision of energy for industries and population living in the urban areas and households and some examined the provision of energy only from the gender perspective (Sustainable Energy Africa, 2015; Chitonge, 2017). Hence, previous studies access to electricity in South Africa have paid attention on different sectors except the agricultural sector. For instance, Dinkelman (2011) estimates the impact of rural electrification on employment. While Davis (1998) identifies the effects of access to electricity on rural households' choice of fuel. The study by Madubansi and Shackleton (2006) investigates the impact of access to electricity on households' consumption pattern in South Africa. The major limitations of these studies are not only limited to their outdated nature but total neglect of the relevance of electricity in the rural areas as a catalyst for the promotion of food security and the transformation of the agricultural sector to be more vibrant, strong and competitive.

Therefore, the broad objective of this study is to expand the frontiers of knowledge on the significance of energy access in promoting agricultural productivity in South Africa while the specific objective of this study is to investigate the impact of rural energy access on agricultural productivity in South Africa. The remaining section of the study includes literature review in section two, methodology in section three, finding and discussion of results in section four and conclusion and recommendations in section five.

## 2. LITERATURE REVIEW

Empirical studies have shown that agricultural productivity in South Africa has been fluctuating in recent times, Sometime, it remains stagnant whilst in some other time, it may be increasing either at an increasing rate or at a decreasing rate (Ramaila et al., 2011; Maponya and Mpandeli, 2012; Fischer and Tramberend, 2019; Arndt and Pratt, 2022). This is largely caused by the problem of inadequate access to electricity (Ramaila et al., 2011; Manasseh et al., 2025). Similarly, evidence has shown that access to finance, education, economic development, infrastructure and industrialization are the major catalyst of access to electricity (Zhang et al., 2019). The prevalence of these determinants may as well explain rising discuss on energy energy access, especially rural energy access in South Africa.

Several country specific studies on South Africa were reviewed to provide a background information on energy access and agricultural productivity nexus in the country. For instance, Dinkelman (2011) examines the impact of rural electrification on employment growth in South Africa among rural households using the method of instrumental variables and fixed effect model. The study found that rural electrification significantly promotes employment, especially, female employment in the rural areas. However, the study found that rural electrification increases the number of hours of work for both men and women, but the wage was discriminated in favour of the men thereby increasing male earnings.

Similarly, Riva et al. (2018) analysed the causal nexus between electrification and development of poor-rural communities with the aim of developing a more suitable energy model using the literature review approach. The study affirmed that electricity usage has a complex and robust association with the socio-economic development of rural communities through income generation, market creation, revenue generation, improved household income and health and other benefits such as facilitation of learning leading to better educational outcome and social interactions.

Furthermore, David and Grobler (2019) investigate the relationship between agricultural production and information and communication technology spillover in South Africa using the logit regression model. The study found that internet connection positively and significantly promotes household agricultural production while land accessibility has a significant inverse relationship with household food production in the country. This study validates the argument that land accessibility is a major barrier to agricultural productivity in South Africa. Similarly, Ateba et al. (2019) investigate the relationship between electricity and industrial growth in South Africa. The used adopted a bivariate statistics and quantitative research design with a major focus in the Gauteng and North-West Provinces of South Africa. The study found that the unsustainable energy supply hampers the industrial sectors as well as the overall economic growth of the country.

In the same vein, empirical evidence from sub-Saharan Africa also emphasizes the need to establish the relationship between rural energy access and agricultural productivity. For instance, Omoju et al. (2020) studies the electricity access and agricultural productivity nexus in sub-Saharan Africa. The study found that overall and urban electricity access have a positive and significant impacts on agricultural productivity while the rural electricity access, yielded an insignificant result. However, Falchetta (2021) observes that a major hindrance to rural development and poverty elimination in sub-Saharan Africa is the lack of electricity access where very few rural dwellers have electricity at home, but the study further identifies the key barrier to rural electrification is the capital-intensiveness of energy supply infrastructure especially among sparsely distributed rural communities with low population and demand density thereby limiting their ability to pay for electricity. Thus, the study argues that the principal aim of the rural electrification programme should be centered around an integrated approach aiming at increasing agricultural productivity and profitability.

Also, Amuakwa-Mensah and Surry (2022) analyze the relationship between rural electrification and agricultural output in sub-Saharan Africa covering a panel of 43 countries over the period 1990-2016 using a panel -fully modified ordinary least squares (P-FMOLS) and fixed effect model. The study reveals that rural electrification promotes agricultural production and that institutional quality and factor input significantly contributes to agricultural productivity in sub-Saharan Africa. Conversely, Shnehal and Manogna (2023) explored role of financial inclusion and foreign direct investment on the relationship between renewable energy consumption and agricultural productivity among Brazil, Russia, India, China and South Africa (BRICS) countries covering the period 2000-2020. The study established that renewable energy, carbon emissions and foreign direct investment have a positive impact on agricultural productivity while financial inclusion in terms of access does not promote agricultural productivity in the BRICS. Although, access to financial services can be beneficial, its usage holds more importance in impacting rural development.

Manasseh et al. (2025) examined the nexus between electricity generation and agricultural development in Africa utilizing the dynamic generalized method of moments estimation approach. The study established that both electric power generation and energy generation capacity have native and significant impact on agricultural development in Africa while Maiga (2024) studies the relationship between agricultural productivity and economic growth among selected five 5 African countries. These countries are Tanzania, Ghana, Kenya, Morocco, and South Africa using a linear regression model. The findings from the study reveal that agriculture significantly contributes to Africa's economic growth. Specifically, findings shows that South Africa shows the highest agricultural productivity, followed by Morocco, Kenya, Ghana, and Tanzania. Nonetheless, South Africa and Morocco have relatively lower contributions to economic growth compared to other countries used in the study.

The major motivation for this study is that previous studies on the relevance of rural energy access as a driver of agricultural productivity and overall economic development are largely regional, sub-regional and mostly panel studies (Omoju et al., 2020; Falchetta, 2021; Dimnwobi et al., 2022; Manasseh et al., 2025). That is, most of them investigated the rural energy access and agricultural productivity either from the sub-Saharan Africa, selected African countries or the whole of Africa perspective. This approach fails to address the problem of country specific and unique peculiarities, and the problem of over-generalization of findings and cross-sectional dependence of each country selected or included in the study. Hence, the focus of this study on South Africa coupled with scarcity of studies investigating the rural energy access and agricultural productivity nexus in the country.

## 3. METHODOLOGY

### 3.1. Data and Sources

Data on macroeconomic variables such as agricultural productivity, access to electricity, labour force participation rate, gross fixed capita formation, access to land were sourced from the World Development Indicator (WDI, 2024) database published by the World Bank. Data on temperature were sourced from the World Data Info (2024) and Trading Economics (2024) while data on rainfall was gotten from the CEIC Economic Data base (2024) and Trading Economics (2024).

### 3.2. Theory and Econometric Modelling

This study is premised on a Cobb-Douglas production function which describes the relationship between agricultural production and electrification following the studies by Kahsay and Hansen (2016), and Adom et al. (2018).

$$Y_t = AL^{\alpha 1} K^{\alpha 2} N^{\alpha 3} T^{\alpha 4} R^{\alpha 5} \quad (1)$$

Where (Y) is the agricultural sector output, (A) is a measure of total factor productivity efficiency, (L) denotes labour, (K) is the capital invested, (N) land, (T) temperature and (R) rainfall.

The total factor productivity could be as an exponential function of electricity (Amuakwa-Mensah and Surry, 2022) and other factors such as innovation. Thus, the total factor productivity is expressed as:

$$A = exp^{f(E)} = exp^{\beta 1E} \quad (2)$$

Where (E) represents the rural electrification rate.

Thus, we derive an expression where agricultural productivity is a function of rural electrification and other relevant variables such as labour, capital, land, temperature and rainfall as specified in equation (3).

$$Y_t = exp^{\beta 1E} L^{\alpha 1} K^{\alpha 2} N^{\alpha 3} T^{\alpha 4} R^{\alpha 5} \quad (3)$$

To derive equation (3), the natural log of equation was taken and transformed to obtain the linear equation (4).

$$\ln Y_t = \alpha_0 + \alpha_1 \ln E_t + \alpha_2 \ln L_t + \alpha_3 \ln K_t + \alpha_4 \ln N_t + \alpha_5 \ln T_{t+} \alpha_6 \ln R_t + \varepsilon_t \quad (4)$$

The study adapted the baseline model of Amuakwa-Mensah and Surry (2022), Dimnwobi et al. (2022), and Shnehal and Manogna (2023) where agriculture productivity is a function of electricity, labour, capital, access to land and other relevant variables like rainfall and temperature to obtain the estimating equation (5).

$$\ln AGP_t = \alpha_0 + \alpha_1 \ln REL_t + \alpha_2 \ln UEL_2 + \alpha_3 \ln LFP_t + \alpha_4 \ln GFCF_t + \alpha_5 \ln ACL_t + \alpha_6 \ln TEMP_t + \alpha_7 \ln RFL_t + \varepsilon_t \quad (5)$$

Where AGP, REL, UEL, LFP, GFCF, ACL, TEMP and RFL stands for agricultural productivity, rural electricity access, urban electricity access, labour force participation rate, gross fixed capital formation as a proxy for capital, access to land, temperature, and rainfall. Conversely, $\alpha_0$ represents the intercept while $\alpha_1 \ldots \alpha_7$ stands for the coefficient of the explanatory variables.

## 4. FINDINGS AND DISCUSSION

The preliminary test of the unit root was carried out on all the variables used in the study using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) techniques with the view to determine the degree of the stationarity of the variables. The results are presented in Table 2.

Table 2 indicates that all the variables utilised in this study are a mixture of variables stationary at levels and first difference, hence, these variables are a combination of order I(0) and I(1) series. These implies that the variables are integrated of order zero and one.

Furthermore, the existence of a long-run relationship among the variables was examined using the Johansen cointegration test. The null hypothesis, which posits no cointegration among the variables was rejected. Table 3 reveals the presence of at least two (2) cointegrating equations among the variables. Therefore, this study founds the existence of a long-run relationship among the variables used in the model.

The maximum lag length for this study was determined using the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQC). The AIC, SIC and HQC recommended a maximum lag length of two (2). Thus, the study investigating the relationship between rural energy access and agricultural productivity in South Africa is based on the maximum lag

**Table 1: Energy consumption in South Africa by sectors**

| Sectoral Energy Consumption | 1994 | 2004 | 2009 | 2014 |
|---|---|---|---|---|
| Agriculture | 1.4 | 2.9 | 2.7 | 2.1 |
| Commerce | 2.0 | 6.7 | 8.0 | 9.4 |
| Industry | 43.9 | 36.2 | 34.3 | 35.2 |
| Mining | 2.5 | 7.0 | 6.5 | 5.0 |
| Residential | 15.4 | 17.9 | 20 | 21 |
| Transport | 35.8 | 25.7 | 27.1 | 26.2 |
| Others | 0.2 | 2.9 | 0.8 | 1.1 |

Source: Chitonge (2017)

**Table 2: Unit root test**

| Variables | Augmented Dickey-Fuller (ADF) test | | | Phillip-Perron (PP) test | | |
|---|---|---|---|---|---|---|
| | Level | First difference | Status | Level | First difference | Status |
| ln (AGP) | −1.01 | −5.29* | I (1) | −1.12 | −4.40* | I (1) |
| ln (REL) | −5.01 | - | I (0) | −5.44 | - | I (0) |
| ln (UEL) | −2.35 | −2.93*** | I (1) | −2.35 | −2.93*** | I (1) |
| ln (LFP) | −0.57 | −5.99* | I (1) | −0.49 | −6.14* | I (1) |
| ln (GFCF) | −1.31 | −3.95* | I (1) | −1.11 | −3.97* | I (1) |
| ln (ACL) | −1.72 | −3.18** | I (1) | −1.98 | −3.18** | I (1) |
| ln (TEMP) | −1.78 | −5.27* | I (1) | −1.74 | −5.28* | I (1) |
| ln (RFL) | −2.55 | −6.61* | I (1) | −2.59 | −6.61* | I (1) |
| **Critical value** | **Level** | **First difference** | | **Level** | **First difference** | |
| 1% | −3.67 | −3.66 | | −3.65 | −3.65 | |
| 5% | −2.96 | −2.96 | | −2.95 | −2.96 | |
| 10% | −2.62 | −2.62 | | −2.62 | −2.61 | |

Source: Authors' computation
* = 1%, ** = 5% and *** = 10% significant level. For the ADF test, the automatic maximum lag length based on SIC is applied while for the PP test, the automatic maximum lag length based on the Newey-West bandwidth is applied

**Table 3: Johansen cointegration test**

Series: ln (AGP) ln (REL) ln (UEL) ln (LFP) ln (GFCF) ln (ACL) ln (TEMP) ln (RFL)
Unrestricted cointegration rank test (Trace)

| Hypothesised No. of CE (s) | Engen-value | Trace statistic | 0.05 critical value | Probability |
|---|---|---|---|---|
| None* | 0.99 | 294.12 | 159.53 | 0.00 |
| At most 1* | 0.96 | 179.95 | 125.62 | 0.00 |
| At most 2 | 0.71 | 94.93 | 95.75 | 0.06 |
| At most 3 | 0.64 | 62.49 | 69.82 | 0.17 |
| At most 4 | 0.48 | 36.00 | 47.86 | 0.40 |
| At most 5 | 0.34 | 18.82 | 29.80 | 0.51 |
| At most 6 | 0.25 | 7.85 | 15.49 | 0.48 |
| At most 7 | 0.01 | 0.26 | 3.84 | 0.61 |

Trace test indicates at least two (2) cointegrating equations at the 0.05 level
Source: Authors' computation

**Table 4: Lag length selection criteria**

Endogenous variables: ln (AGP) ln (REL) ln (UEL) ln (LFP) ln (GFCF) ln (ACL) ln (TEMP) ln (RFL)
Sample: 1990 2023

| Lag | LogL | LR | FPE | AIC | SIC | HQC |
|---|---|---|---|---|---|---|
| 0 | 366.27 | NA | 1.48 | −27.56 | −27.17 | −27.45 |
| 1 | 510.25 | 188.28 | 4.01 | −33.71 | −30.23 | −32.71 |
| 2 | 633.17 | 85.09* | 2.64* | −38.24* | −31.66* | −36.35* |

*Indicates lag order selected by the criterion
LR: Sequential modified LR test statistic (each test at 5 per cent level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion
Source: Authors' computation

length of two. Therefore, the estimating technique of fully modified least squares (FMOLS), dynamic least squares (DOLS), canonical cointegrating regression (CCR) and the ordinary least squares (OLS) was conducted using a conservative maximum lag of two (2).

Sequel to the confirmation of the long run cointegration among the variables as well as the determination of lag length, four estimation techniques of fully modified least squares (FMOLS), dynamic least squares (DOLS), canonical cointegrating regression (CCR) and ordinary least squares (OLS) were adopted for robust empirical analysis to investigate the relationship rural energy access and agricultural productivity in South Africa. The result of the FMOLS, DOLS, CCR and OLS are presented in Table 5 below.

**Table 5: Estimate of rural energy access and agricultural productivity in South Africa**

| Estimation Techniques | FMOLS | DOLS | CCR | OLS |
|---|---|---|---|---|
| | Dependent variable: ln (AGP) | | | |
| **Variable** | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| C | 135.86 | 77.04 | 203.16 | 77.04 |
| | (0.98) | (0.32) | (0.90) | (0.35) |
| | 0.34 | 0.75 | 0.38 | 0.73 |
| ln (REL) | −0.45* | −0.33** | −0.36* | −0.33** |
| | (−2.70) | (−2.10) | (−3.26) | (−2.31) |
| | 0.01 | 0.04 | 0.00 | 0.03 |
| ln (UEL) | 5.49** | 4.39 | 5.01 | 4.39 |
| | (2.05) | (1.04) | (1.18) | (1.14) |
| | 0.05 | 0.31 | 0.25 | 0.27 |
| ln (LFP) | 1.25* | 1.22 | 1.22*** | 1.22*** |
| | (2.98) | (1.62) | (1.87) | (1.77) |
| | 0.00 | 0.12 | 0.07 | 0.09 |
| ln (GCFC) | 0.42* | 0.41* | 0.36** | 0.41 |
| | (5.09) | (2.78) | (2.60) | (3.05) |
| | 0.00 | 0.01 | 0.02 | 0.00 |
| ln (ACL) | −12.54 | −7.87 | −17.20 | −7.87 |
| | (−1.30) | (−0.47) | (−1.08) | (−0.52) |
| | 0.20 | 0.64 | 0.29 | 0.61 |
| ln (TEMP) | −0.07 | −0.15 | 0.09 | −0.15 |
| | (−0.34) | (−0.41) | (0.23) | (−0.45) |
| | 0.73 | 0.69 | 0.82 | 0.66 |
| ln (RFL) | 0.97* | 0.93* | 0.99* | 0.93* |
| | (5.86) | (3.32) | (4.98) | (3.64) |
| | 0.00 | 0.00 | 0.00 | 0.00 |
| R-squared | 0.92 | 0.92 | 0.91 | 0.92 |
| Adjusted $R^2$ | 0.89 | 0.90 | 0.88 | 0.90 |

Source: Authors' computation
t statistics are in ()
*Implies level of significance at 1%
** implies level of significance at 5%
*** implies level of significance at 10%

## 4.1. Estimate of Rural Energy Access and Agricultural Productivity in South Africa

In all the estimated models, it is highly evident that rural energy access has a significant negative influence on agricultural productivity in South Africa. The coefficient of rural energy access in all the models (1-4) are negative and statistically significant at 1 and 5% level respectively. The finding suggests that although agricultural activities are predominantly situated in the rural areas, the rural energy access does not promote agricultural productivity because the provision of electricity in the country does not follow the traditional rural and urban dichotomy as it concerns the agricultural sector, hence, agricultural productivity has been on the increase in South Africa. Conversely, the coefficient of urban energy access in the model (1) further reveals that urban energy access has positive and significantly promote agricultural productivity in South Africa. The findings supports the study by Omoju et al. (2020), World Bank (2023) and Manasseh et al. (2024) which argues that expanded access to electricity especially in the rural areas has not always been accompanied by increases in productive use that will enhance increased agricultural productivity but also negate studies such as Goldemberg et al. (2000), Magalhaes et al. (2021), and Amuakwa-Mensah and Surry (2022) which argue that rural energy access have positive and promote agricultural productivity. Instead, this study revealed that urban energy access has positive and significantly promote agricultural productivity which is in line with the study by Omoju et al. (2020). There is a strong and valid argument, that the agricultural sector in South Africa is seriously leveraging on alternative energy sources and the use of renewable energy (Britz, 2011; Falchetta, 2021, World Bank, 2023).

Similarly, the coefficient of labour force participation rate in the various models except in model 2 were found to exert strong, positive and significant effect on agricultural productivity in South Africa. The coefficient of labour force in models (1, 3 to 4) were found to be positive and statistically significant at 1 and 10% respective levels. This finding shows that the agricultural sector is a major employer of labour directly and indirectly and the active workforce remains a viable component for the promotion of agricultural productivity in the country. This finding is in line with the outcome of studies such as Sandrey et al. (2015), Visser and Ferrer (2015) and Diao et al. (2018) who established the pivotal role of labour force in promoting agricultural productivity and in South Africa inclusive.

Furthermore, the estimated models (1 to 4) revealed that gross fixed capital formation is a major driver of agricultural productivity in South Africa. The coefficients of fixed capital formation are positive and significant at 1 and 5% level. The finding suggests that the agricultural sector heavily rely on the domestic investment in the country which over the years have served as a source of capital for the procurement of machineries and tractors and other equipment required to obtain a viable and robust agricultural sector as it is in South Africa. Hence, the importance of domestic investment as a driver of agricultural productivity in South Africa cannot be underestimated. The finding is in line with the empirical arguments of studies by Syed and Miyazako (2013), Pienaar (2017), Adetutu and Ajayi (20200 and the African Union (2022) who emphasized the importance of domestic investment as channel for the provision of riskless funding which will serve as a catalyst for the promotion of agricultural productivity in South Africa and all developing economies at large.

In all the estimated models, it is evident that adequate rainfall is a major driver of agricultural productivity in South Africa. The coefficient of rainfall in all the models (1 to 4) are positive and statistically significant at 1% level. This finding suggests that rainfall exerts strong positive influence on the agricultural productivity in South Africa over the study period. The findings clearly support previous empirical evidence which argues that South Africa has developed a viable and robust precipitation management systems which maximises the use of rainfall and other alternative water sources for irrigation thereby promoting all year-round cultivation thereby promoting farm yield and the sustainability of the agricultural sector of the country (Bennie and Hensley, 2001; Belloumi, 2014; Ongono-Olinga, 2023).

A salient issue found in the study has to do with the problem of access to land which has remain a highly volatile and topical issue caused by a prolonged years of unfavourable land acquisition and distribution for farming in the country between the white minority who owns most of the big and lucrative farm lands and the majority blacks who are only left with heritage (communal) land to farm on. The study found that the coefficient of access to land in all the models (1 to 4) are negative but statistically insignificant. This study further validates inequality in historical land acquisition and distribution in South Africa and calls for an equitable land distribution in the country which in line with the arguments alighted in previous studies carried out in Africa and South Africa in particular (Hendricks, 2003; FOA, 2010; Andrew, 2020; Mukarati et al., 2020; Wegerif and Guerena, 2020).

## 5. CONCLUSION AND RECOMMENDATIONS

The study expands on the relationship between rural energy access and agricultural productivity literature with specific focus on South Africa and conclude that rural energy access has a significant negative influence on agricultural productivity in South Africa even though agricultural activities are predominantly situated in the rural areas of the country. However, urban energy access was found to be positive and significantly promote agricultural productivity in South Africa. This presupposes that the provision of electricity in the country does not follow the traditional rural and urban dichotomy as it concerns the agricultural sector, hence, the constant increase in agricultural productivity in South Africa. Furthermore, labour force participation, gross fixed capital formation and adequate rainfall were also found to be relevant drivers of agricultural productivity in South Africa.

This study strongly advocates the need to revisit inequality is the acquisition and distribution of land for farming in South Africa which has remain volatile and topical issue of concern in the country especially between the government, the white minority who owns most of the big and lucrative farmlands and the majority blacks who are only left with heritage (communal) land to farm on.

## 6. ACKNOWLEDGMENT

We recognise the support of this research work by National Electronic Media Institute of South Africa (NEMISA), Johannesburg.

## REFERENCES

Acheapong, A.O., Dzator, J., Sharbas, M. (2021), Empowering the powerless: Does access to energy improve income inequality? Energy

Economics, 99, 1-24.

Adetutu, M.O., Ajayi, V. (2020), The impact of domestic and foreign R&D on agricultural productivity in Sub-Saharan Africa. World Development, 125(1), 1-10.

Adom, D., Joe, A.A., Hussein, E.K., (2018), Theoretical and conceptual framework: Mandatory ingredients of quality research. International Journal of Scientific Research, 7, 438-441.

African Union. (2022), Boosting Investment in Agriculture Research in Africa: Building a Case for Increased Investment in Agricultural research in Africa. Ethiopia: African Union.

Akinbami, O.A., Oke, S.R., Bodurin, M.O. (2021), The state of renewable energy development in South Africa: An overview. Alexandria Engineering Journal, 60, 5077-5093.

Amuakwa-Mensah, S., Surry, Y. (2022), Association between rural electrification and agricultural output: Evidence from Sub-Saharan Africa. World Development Perspective, 25, 1-17.

Andrew, N. (2020), South Africa's land ownership system as a barrier to social transformation: Land conflict and the forced displacement of black farm dweller families. Revue Internationale des Études du Développement, 243, 233-261.

Arndt, C., Pratt, A. (2020), South African Agricultural Production in the Global Context: Comparisons using FAO Data. SA-TIED Working Paper, 96.

Ateba, B., Prinsloo, J.J., Gawlik, R. (2019), The significance of electricity supply sustainability to industrial growth in South Africa. Energy Report, 5, 1324-1338.

Ayuk, E.T. (2018), Energy in Africa: Challenges and Opportunities. Berlin: Springer Open.

Baker, L., Phillips, J. (2019), Tensions in the transition: The politics of electricity distribution in South Africa. Environment and Planning C: Politics and Space, 37(1), 177-196.

Belloumi, M. (2014), Investigating the impact of climate change on agricultural production in Eastern and Southern African countries. AGRODEP Working Paper Series 0003, 1-25.

Bennie, A.T.P. & Hensley, M. (2001), Maximizing precipitation utilization in dryland agriculture in South Africa: A review. Journal of Hydrology, 241(1&2), 124-139.

Blimpo, M.P., Cosgrove-Davies, M. (2019), Electricity Access in sub-Saharan Africa: Uptake, Reliability and Complementary Factors for Economic Impact. Washington, DC: The World Bank.

Britz, P.J. (2011), Overview of renewable energy in the South African agricultural sector. Journal of Processing and Energy in Agriculture, 15(3), 208-211.

Cecelki, E. (2003), Enabling Equitable Access to Rural Electrification: Current Thinking on Energy, Poverty and Gender. Washington, DC: The World Bank Publication.

CEIC Economic Data Base. (2024), South Africa ZA: Average Precipitation in Depth. Available from: https://www.ceicdata.com/en/south-africa/land-use-protected-areas-and-national-wealth/za-average-precipitation-in-depth

Chitonge, H. (2017), The Political Economy of Energy Policy in South Africa: From a Gender Agenda to a Class Project. Working Paper MSSRF/2017/WP/12.

Danielsen, K. (2012), Gender Equality, Women's Rights and Access to Energy Services: An Inspiration Paper in the Run-up to Rio+20. Denmark: Ministry of Foreign Affairs of Denmark.

David, O.O., Grobler, W. (2019), Agricultural production in South Africa: Information and communication technology spillover. International Journal of eBusiness and eGovernment Studies, 11(2), 17-41.

Davidson, O., Mwakasonda, S. (2004), Electricity access for the poor: A study of South Africa and Zimbabwe. Energy for Sustainable Development, 8(4), 26-40.

Davis, M. (1998), Rural household energy consumption: The effects of access to electricity evidence from South Africa. Energy Policy, 26(3), 207–217.

De la Rue du Can, S., Letschert, V., Agarwal, S., Park, W.Y., Kaggwa, S. (2022), Energy efficiency improves energy access affordability. Energy for Sustainable Development, 70, 560-568.

Diao, X., McMillan, M., Wangwe, S. (2018), Agricultural labour productivity and industrialization: Lessons for Africa. Journal of African Economies, 27(1), 28-65.

Dimnwobi, S.K., Okereke, K.I., Onuoha, F.C., Ekesiobi, C. (2022), Energy Poverty, Environmental Degradation and Agricultural Productivity in Sub-Saharan Africa. AGDI Working Paper, WP/22/096.

Dinkelman, T. (2011), The effect of rural electrification on employment: New evidence from South Africa. American Economic Review, 101, 3078-3108.

ENERGIA. (2019), Gender in the Transition to Sustainable Energy for All: From Evidence to Inclusive Policies. International Network on Gender & Sustainable Energy.

Energy Progress Report. (2022), Access to Electricity: Tracking SDG 7. Ch. 1. Energy Progress Report. p1-54.

Falchetta, G. (2021), Energy access investment, agricultural productivity and rural development: Time for an integrated approach. Environmental Research: Infrastructure and Sustainability, 1, 1-9.

Falcone, P.M. (2023), Sustainable energy policies in developing countries: A review of challenges and opportunities. Energies, 16, 1-19.

Fischer, G., Tramberend, S. (2019), South African Agriculture Towards 2030/50. Austria: International Institute for Applied Systems Analysis.

FOA. (2010), Africa's Changing Landscape: Securing Land Access for the Rural Poor. Accra, Ghana: The Publication of FAO.

Goldemberg, J., Amulya, K.N.R., Kirk, R.S., Robert, H.W. (2000), Rural Energy in Developing Countries. Ch. 10. p367-389.

Hendricks, F.T. (2003), Land inequality in democratic South Africa. Research in Rural Sociology and Development, 9(9), 185-202.

Iddrisu, A., Phimister, E., Zangelidis, A. (2024), The Role of Energy Poverty on the Gender-Health. AFREXIMBANK Policy Research Working Paper Series APRWPS/2024/06.

International Trade Administration. (2024), South Africa Country Guide: Agricultural Sector. Country Commercial Guides. United States: International Trade Administration.

Jaiswal, K.K., Chowdhurry, C.R., Yadav, D., Verma, R., Dutta, S., Jaiswal, K.S., Sangmesh, B., Karuppasamy, K.S. (2022), Renewable and sustainable clean energy development and impact on social, economic and environmental health. Energy Nexus, 7, 1-14.

Jamal, N. (2015), Options for the supply of electricity to rural homes in South Africa. Journal of Energy in Southern Africa, 26(3), 58-65.

Kahsay, G.A., Hansen, L.G, (2016), The effect of climate change and adaptation policy on agricultural production in Eastern Africa. Ecological Economics, 121, 54-64.

Koch, J. (2011), The Food Security Policy Context in South Africa: Country Study. Brazil: International Policy Centre for Inclusive Growth.

Longe, O.M., Myeni, L., Ouahada, K. (2020), Renewable Energy Solution for Electricity Access in Rural South Africa. South Africa: University of Johannesburg.

Madubansi, M., Shackleton, C.M. (2006), Changing energy profiles and consumption patterns following electrification in five rural villages in South Africa. Energy Policy, 34(18), 4081–4092.

Magalhaes, M., Ringler, C., Schmitter, P. (2021), Accelerating rural energy access for agricultural transformation: Contribution of the CGIAR research program on water, land and ecosystems to transforming food, land and water systems in a climate crisis. WLE Legacy Series, 3, 1-18.

Maiga, Y. (2024), The impact of agricultural productivity on economic growth in Africa. Journal of Agricultural Studies, 12(2), 25-57.

Manasseh, C.O., logan, C.S., Okanya, O., Igwemeka, E., Odidi, O., Onoh, C.F., Nnamdi, K.C., Madubuike, K., Ejim, E.P. (2025), The nexus between electricity generation and agricultural development in Africa. International Journal of Energy Economics and Policy, 15(1), 317-329.

Maponya, P., Mpandelis, S. (2012), Climate change and agricultural production in South Africa: Impacts and adaptation options. Journal of Agricultural Science, 4(10), 48-60.

Mbajiorgu, D.G., Odeku, K.O. (2022), Fighting food insecurity, hunger and poverty: The content and context of the socio-economic right of access to sufficient food in South Africa. Obiter, 43, 467-488.

Mendeley, K. (2012), Energy for sustainable development: A case of developing countries. Renewable and Sustainable Energy Reviews, 16(2), 1116-1126.

Mukarati, J., Mongale, I.P., Makombe, G. (2020). Land distribution and the South African economy. Agricultural Economics-Czech, 166(1), 46-54.

Mulugetta, Y., Hagan, E.B., Kammen, D. (2018), Energy access for sustainable development. Environmental Research Letters, 14, 020201.

Ogunro, T., Afolabi, L. (2022), Evaluation of access to electricity and the socioeconomic effects in rural and urban expanses of Nigeria. International Journal of Social Economics, 49(1), 124-137.

Omoju, O.E., Oladunjoye, O.N., Olanrele, I.A., Lawal, A.I. (2020), Electricity access and agricultural productivity in Sub-Saharan Africa: Evidence from panel data. In: Osabuohien, E.S., editor. The Palgrave Handbook on Agricultural and Rural Development in Africa. Berlin: Springer International Publishing.

Mukarati, J., Mongale, I.P., Makombe, G. (2020), Land distribution and the South African economy. Agricultural Economics-Czech, 166(1), 46-54.

Onwusu-Manu, D.G., Sackey, D.M., Osei-Asibey, D., Agyapong, R.K., Edwards, D.J. (2021), Improving women's energy access, rights and equitable sustainable development: A Ghanian perspective. Ecofeminism and Climate Change, 3(1), 23-40.

Pachauri, S., Brew-Hammond, A. (2012), Energy Access for Development. Ch. 19. United Kingdom: Cambridge University Press. p1456.

Pienaar, L. (2017), Domestic agricultural investment in South Africa: Tracking the main indicators over the past decades. Elsenburg Journal, 14(3), 62-66.

Qase, M., Annecke, W. (1999), Energy Provision for the Urban Poor: South African Country Case Study. Energy and Development Research Centre. South Africa: University of Cape Town.

Raji, E., Ijomah, T.I., Eyieyien, O.G. (2024), Improving agricultural practices and productivity through extension services and innovative training programs. International Journal of Applied Research in Social Sciences, 6(7), 1297-1309.

Ramaila, M., Mahlangu, S., Du Toit, D. (2011), Agricultural Productivity in South Africa: Literature Review. South Africa: Department of Agriculture, Forestry and Fisheries, Republic of South Africa.

Riva, F., Ahlborg, H., Hartvigsson, E., Pachauri, S., Colombo, E. (2018), Electricity access and rural development: Review of complex socio-economic dynamics and causal diagrams for a more appropriate energy modelling. Energy for Sustainable Development, 43, 203-223.

Rugumayo, A. (2010), Energy Access for Rural Communities in Sub-Saharan Africa. ASADI 6th Annual Meeting, Cape Town, South Africa.

Sandrey, R., Punt, C., Jensen, H.G., Vink, N. (2011), Agricultural Trade and Employment in South Africa. OECD Trade Policy Working Paper, 30. p1-36.

Sarkodie, S.A., Adams, S. (2020), Electricity access and income inequality in South Africa: Evidence from Bayesian and NARDL analysis. Energy Strategy Reviews, 29, 1-11.

Saunders, H.D., Roy, J., Azevedo, I.M.L., Chakravarty, D., Dasgupta, S., de la Rue du Can, S., Druckman, A., Fouquet, R., Crubb, M., Lin, B., Lowe, R., Midlener, R., McCoy, D.M., Mundaca, L., Oreszczyn, T., Sorrell, S., Stern, D., Tanaka, K., Wei, T. (2021), Energy efficiency improves energy access affordability. Annual Review of Environmental and Resources, 46(1), 135-165.

Shnehal, S., Manogna, R.L. (2023), The dynamic nexus of between agricultural productivity and renewable energy consumption in BRICS: The role of financial inclusion and foreign direct investment. International Journal of Energy Sector Management, 18(6), 1750-6220.

Sithole, Z., Siwela, M., Ojo, T.O., Hlatshwayo, S.I., Kajombo, R.J., Ngidi, M.S.C. (2023), Contribution of fruits and vegetables to the household food security situation of rural households in Limpopo. Nutrients, 15, 1-14.

Statistics South Africa. (2018), Statistical Release: General Household Survey. South Africa: Statistics South Africa.

Statistics South Africa. (2019), Towards Measuring the EXTENT OF FOOD SECURITY in South Africa: An Examination of Hunger and Food Adequacy. Pretoria: Statistics South Africa.

Sustainable Energy Africa. (2015), State of Energy in South African Cities. Sustainable Energy Africa. Cape Town, South Africa p1-36.

Sy, S.A., Mokaddem, L. (2022), Energy poverty in developing countries: A review of the concept and its measurements. Energy Research and Social Science, 89, 102562.

Syed, S., Miyazako, M. (2013), Promoting Investment in Agriculture for Increased Production and Productivity. Rome: FAO Publication.

Terrapon-Pfaff, J., Grone, M.C., Dienst, C., Ortiz, W. (2018), Productive use of energy: Pathway to development. Renewable and Sustainable Energy Review, 96, 198-209.

Trading Economics. (2024), South Africa Average Precipitation. Available from: https://tradingeconomics.com/south-africa/precipitation

Ukwandu, D.C. (2018), Absence of electricity as a barrier to inclusive growth and development in Nigeria. African Journal of Public Affairs, 10(3), 23-42.

United Nations. (2024), Sustainable Development Goals. Energy-United Nations Sustainable Development. Available from: https://www.un.org/sustainabledevelopment/energy/.

Visser, M., Ferrer, S. (2015), Farm Workers' Living and Working Conditions in South Africa: Key Trends, Emergent Issues and Underlying and Structural Problem. Pretoria: The International Labour Organization.

Wegerif, M.C.A., Guerena, A. (2020), Land inequality trends and drivers. Land, 9(101), 1-23.

WDI (2024), Data Bank: World Development Indicators. Publication of the World Bank Group. Available from: https://databank.worldbank.org/source/world-development-indicators.

World Bank. (2015), Electrifying Rural Areas. Washington, D.C: EBA Publication. p93-97.

World Bank. (2023), Accelerating the Productive Use of Electricity: Enabling Energy Access to Power Rural Economic Growth. Washington, D.C: World Bank Publication.

World Data Info. (2024), The Climate of South Africa. Available from: https://www.worlddata.info/africa/south-africa/climate.php

Zhang, J. (2024), Energy access challenge and the role of fossil fuels in meeting electricity demand: Promoting renewable energy capacity for sustainable development. Geoscience Frontiers, 15(5), 1-14.

Zhang, T., Shi, X., Zhang, D., Xiao, J. (2019), Socio-economic development and electricity access in developing economies: A long-run model averaging approach. Energy Policy, 132, 223-231.

Zunckel, H. (2010), The Southern African Response to Food Security and the Global Food Crisis. Geneva: International Institute for sustainable Development.