# Econometric Analysis of the Effect of Urbanization on Energy Security in Africa: Evidence from Panel Data for Selected African Countries

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**Abstract**
The aim of study was to investigate the effect of urbanization on energy security in Africa. Panel data were collected from 30 African countries including both developing and world development indicators for the period of 2000-2019. Stochastic Impacts by Regression on Population, Affluence, and Technology (STRIPAT) model was used to identify the effect of urbanization and related factor on energy security. Energy efficiency was measured as the ratio of GDP to total energy consumption. Fixed effect regression technique was used to estimate the coefficient and their result indicate that urbanization, industrialization and per capita income can improve energy security in Africa. Industrialization improves energy security based on economies of scale mainly investing in energy saving technology. Government of African countries should optimize industrialization and urbanization while paying attention on improving the technology to reduce energy consumption, invest in energy saving technology to ensure energy security in their development process. Diversifying the source of energy has been considered as a way of ensuring energy sustainability.
**Keywords**: energy security, urbanization, STRIPAT model, panel data, Africa
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## 1. INTRODUCTION
Energy security ensuring diverse energy resource in sustainable quantities at affordable price, by taking into account environmental management requirement and interaction among economic sectors (Trollip et al., 2014).The energy consist four major parts: availability, affordability, efficiency and stewardship(Nathaniel et al, 2015).It is the integral part of economic growth and development process (Opeyemi et al, 2016). Economic growth and development is a dynamic process not one time condition and go hand in hand with sustainable energy development on energy security, affordability and sustainability (Li, M. et al, 2019).

Urbanization is a complex socio-economic process that transforms the built environment, converting formerly rural into urban settlements, while also shifting the spatial distribution of a population from rural to urban areas (UN, 2018). Urbanization is shaped by spatial and urban planning as well as by public and private investments in buildings and infrastructure. An increasing share of economic activity and innovation becomes concentrated in cities, and cities develop as hubs for the flow of transport, trade and information (ibid).

In 1950 the urban share of the world's population was 30 per cent, but by 2050 it will be 66 per cent. Nearly 90 per cent of the increase will be in Africa and Asia, the fastest urbanizing global regions (Economic Report on Africa, 2017).Urbanization exerts a number of influences on energy use. It permits economics of scale in production but require more energy consumption. Recently urbanization and energy consumption increase at enormous rate (Li, M. et al, 2019). According to (United Nation, 2018) revision 55% of the world's population residing in urban areas. Urbanization in developing countries could dramatically increase oil consumption, with implications for global warming and energy security (McDonald, 2008).

As to (Mcdonald, 2008), over 50% of the world population lives in the cities in 2007; urban cities will absorb additional 1.5 billion global population growths over the next 25 years. Moreover new urban life style could lead to dramatically increase resource use such as oil, other fossil fuel which has other implication for energy security. Furthermore Growth and development of cities have been faced series challenge on access to energy, which has been a source of concern in less developed countries (Olurode et al, 2018).

Global GDP growth around 3.25% per annual and 80% of the World GDP growth driving by increased productivity (Energy outlook, 2019). Increased productivity leads to billions of people move from low income in to middle and high income. Higher living standard of living drive increase energy demand and energy consumption per head. The global energy faces a dual challenge i.e. the need for more energy and less carbon (Energy outlook, 2019). The increased the demand for more energy has treat the current energy security scholarship also reflects concerns about the security of the supply of natural gas and other energy resources (Novikau, 2019).Africa is the last continent to urbanize.

According to (UN, 2018) less than 1.4% populations in in Africa during 1950 were urbanized. The growth rate of the urban population between 1980 and 2014 amounted to 4.4 % per year, significantly higher than in other regions. In 2014, 37 % of the entire population of sub-Saharan Africa lived in cities, making it the world's least urbanized region. By 2050 it is expected that this number will rise to 55 %, an increase of almost 800 million people. But ensuring the sustainability of energy connection approaches to natural resource management has been the major concern and area of uncertainty (UN, 2018).

There has been growing gap between demand and supply of energy in most of the LDCs, especially in Africa. Traditional fuels, mainly biomass, provide for about 80% of LDCs' energy supply, albeit very often in an unsustainable and insecure manner (Leuenberger et al, 2006).The economic literature indicates that Sustainable urban development indispensible with energy consumption since energy consumption is normal goods (Liddle et al, 2013). Therefore, it has been mandatory to maintain the energy security for Africa's sustained growth and structural transformation.

The previous study on the nexus between urbanization and energy security are very limited. For instance (Nathaniel et al. , 2015) provide theoretical explanation about Grand Inga Dam (DRC) and indicate the dam enhances energy security for Africa. Similarly (Olurode et al, 2018) studied urbanization and energy crisis in case of Lagos state Nigeria indicate that urgent need to diversify the sources of generating electricity in Nigeria to maintain energy security. (Hassen et al., 2018) indicate economic growth cause energy demand to grow. Studies by (Avtor et al., 2019; Gungor et al., 2018; Shahbaz et al., 2016 and Xio-doing et al., 2019) indicate urbanization and bigger cities need more energy. Finally studies by (Bellouini et al. ,2016) indicate urbanization positively affect energy intensity due to economic of scale and (Li, M. et al. ,2019) indicate urbanization and industrialization can significantly improve energy efficiency, although energy security level decreases considerably with the rise of energy consumption in case of China. But none of the previous study clearly analysis the impact urbanization on energy security particularly in the Africa.

Therefore the study at hand tried to clearly analysis the impact of urbanization on energy security in Africa. The study would answer the question: Can urbanization improve energy security and efficiency? To what extent urbanization affect energy security? Evidence obtained from World Bank development indicator panel data for the period between 2000 and 2018.

The next part of the study organized as follow: the second part deals with theoretical and empirical review of related literature on energy security. The third part present the method and material used in the study. The forth part deals with the result and discussion and finally the last part provide conclusion and some implication.

## 2. LITERATURE REVIEW

### 2.1. Conceptualizing Energy Security

Sovacool et al (2011) defined energy security as "a complex goal involving questions about how to equitably provide available, affordable, reliable, efficient, environmentally benign, properly governed and socially acceptable energy services." The dimension and components of energy security described as follows in table:

Table 1: Energy security dimensions, values, and components.

| Dimension | Explanation | Underlying value | Components |
|---|---|---|---|
| Availability | Having sufficient supplies of energy. Being energy Independent. Promoting a diversified collection of Different energy technologies.<br>Harnessing domestically available fuels and energy resources. Ensuring prudent reserve to production ratios | Self-sufficiency, resource availability, security of supply, independence, imports, variety, balance, disparity | Security of Supply and Production<br>Dependency<br>Diversification |
| Affordability | Producing energy services at the lowest cost, having predictable prices for energy fuels and services, and enabling equitable access to energy services | Cost, stability, predictability, equity, justice, reducing energy poverty | Price Stability<br>Access and Equity<br>Decentralization<br>Affordability |
| Technology Development and Efficiency | Capacity to adapt and respond to the challenges from disruptions, researching and developing new and innovative energy technologies, making proper investments in infrastructure and maintenance. Delivering high quality and reliable energy services. | Investment, employment technology development and diffusion, energy efficiency, stockholding, safety and quality | Innovation and Research<br>Safety and Reliability<br>Resilience<br>Efficiency and Energy Intensity<br>Investment and Employment |

| Dimension | Explanation | Underlying value | Components |
|---|---|---|---|
| Environmental and Social Sustainability | Minimizing deforestation and land degradation, possessing sufficient quantity and suitable quality of water, minimizing ambient and indoor pollution, mitigating GHG emissions associated with climate change, adapting to climate change. | Stewardship, aesthetics, natural habitat conservation, water quality and availability, human health, climate change mitigation, climate change adaptation. | Land Use<br>Water<br>Climate Change<br>Pollution |
| Regulation and Governance | Having stable, transparent, and participatory modes of energy policymaking, competitive markets, promoting trade of energy technology and fuels, enhancing social and community knowledge about education and energy issues | Transparency, accountability, legitimacy, integrity, stability, resource curse, geopolitics, free trade, competition, profitability, interconnectedness, security of demand, exports | Governance<br>Trade and Regional Interconnectivity<br>Competition and markets<br>Knowledge and Access to Information |

Source: Sovacool et al (2011)

From an empirical perspective, several studies have been under taken to provide an understanding of the impact of corruption on the economy. Some of them are summarized as follow:

The study by Hassan et al (2017) in the case of South Africa for the period of 1970-2014, showed that bi-directional relationship among urbanization/industrialization and energy utilization. Moreover, economic growth causes energy demand to grow. Avtar et al (2019), indicate that bigger cities need more energy for their larger population and the process of urbanization trigger the change in industrial structure should be accompany with energy conservation.

Nathaniel et al (2015), provide theoretical explanation about energy for the case of Grand Inga Dam (DRC) and indicate the dam enhance energy security for Africa. Olurode et al (2018) studied urbanization and energy crisis in case of Lagos state Nigeria indicate that urgent need to diversify the sources of generating electricity in Nigeria to maintain energy security.

Xio-dong et al (2019) measured the impact of urbanization on energy consumption using CGE model in case of China using 2007 data. Their studies found that urbanization impose positive pull effect on energy demand. The increase of energy demand will correspondingly lead to energy price up, as coal price increasing 2.17%， oil price increasing 2.25%， gasoline price increasing 2.21%， electricity price increasing 2.25%， gas price also increasing 2.26%. They conclude that, future process of urbanization, governments should improve the energy efficiency to reduce the energy consumption and increase energy intensity.

Shahbaz et al (2016) investigated the relationship between urbanization, industrialization, energy prices and energy consumption using data of Chinese economy. They found that industrialization leads urbanization and urbanization has positive impact on energy demand due to an increase in urban density.

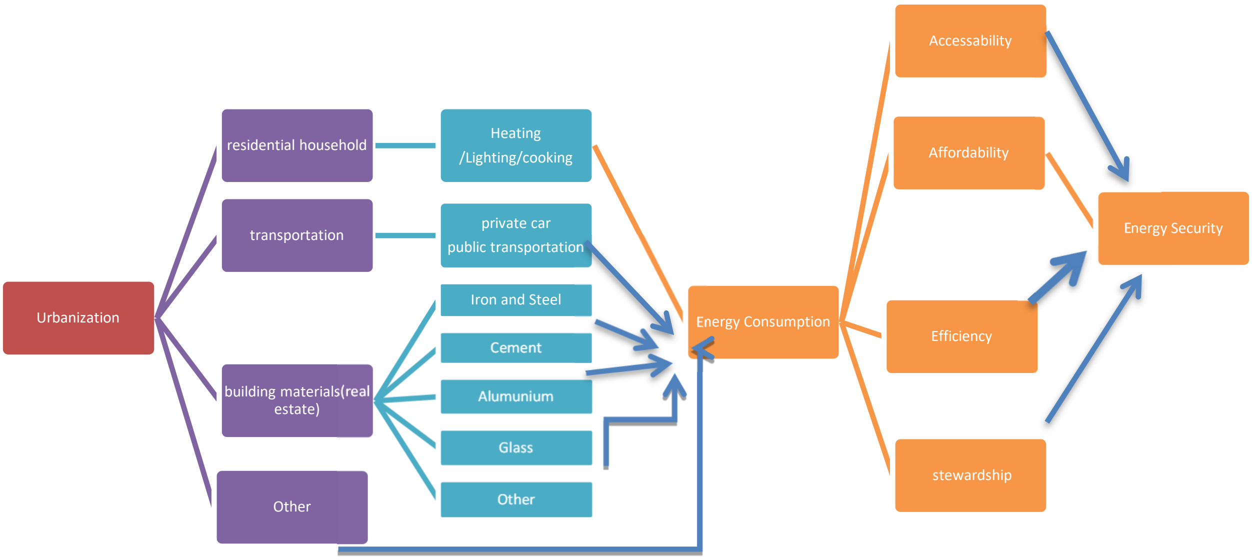
Bellouini and alshehry (2016), studied the impact of urbanization on energy intensity in Saudi Arabia for the period of 1971-2012 analyzed through ARDL model. Their study indicates that there is long run relationship between urbanization and energy intensity. Urbanization positively affects energy intensity.

Gungor et al (2017), investigate the relationship among energy consumption, urbanization, industrialization and economic growth in the case of South Africa for the period of 1970-2014. Their study utilized Johansen co-integration test and vector error correction model with granger causality test as estimation techniques. The results confirm that there is a long-run equilibrium relationship between these variables in case of South Africa. More so, urbanization, financial development, and industrialization are positively correlated to the energy consumption in the long run.

Li, M. et al (2019) studied the impact of urbanization and industrialization on energy security using 30 provinces in china for the time range of 2006 to 2016. Their results demonstrate that urbanization and industrialization can significantly improve energy efficiency. Although energy security level decreases considerably with the rise of energy consumption and population growth, the increase in urbanization and industrialization levels can increase energy security through energy efficiency improvements.

Based on the previous literature we construct the following conceptual framework relating urbanization with energy security.

Fig 1: Conceptual framework of links between urbanization and energy security




Source: Adopted from Zhou, W. et al (2011).

## 3. MATERIALS AND METHODS

### 3.1 STIRPAT Model Specification

The aim of this study was to analysis the effect of Urbanization and other related variable on energy security. According to (Li, M. et al., 2019) improving the energy efficiency is an important means of for ensuring energy security. Which indicate energy efficiency is used as a proxy for energy security.

As (Li, M. et al., 2019) two standards are used to measure energy efficiency: (1) the gross domestic product is produced by unit energy consumption. The ratio between gross domestic product (GDP) and total energy consumption (Enco) is used to express energy productivity. This indicator is created by dividing the gross domestic product (GDP) by the gross inland consumption of energy in each given calendar year. The indicator measures the productivity of energy consumption and shows the degree of decoupling of energy use from GDP growth. The GDP/Enco is positively correlated with energy efficiency level. (2) The quantity of energy consumption per unit production; the Enco/GDP can also be applied to express energy efficiency. The Enco/GDP is negatively correlated with energy efficiency level.

Similar to (Li, M. et al., 2019) the study on hand adapted energy efficiency used as a proxy of energy security, which is measured by energy productivity- GDP/Enco

$Ense_{it} = GDP_{it}/Econ_{it}$………………………………………………………………………… (1)

Different methods have been developed in the literature to measure the effect of one against the other, who lacks market value. The STIRPAT (stochastic impacts by regression on population, affluence, and technology) model has been used for evaluation of environmental effects to investigate the influences of urbanization and industrialization rates, affluence, and population factor on energy security during urbanization. The STIRPAT model was improved based on IPAT model and widely applied mainly in environmental economics (Lu, M. et al 2019).

According to (Poumanyvong et al., 2012), The STIRPAT model specified as follow:

$I = aP^bA^cT^de$ ……………………………………………………………………………… (2)

Where, I donate environmental assessment variable that has to be studied. P, A, T indicate population, Affluence and technology respectively, b, c, and d indicate the indices of population, Affluence and technology respectively, a is the coefficient of STIRPAT model and e is the error term. By taking the logarithm on both sides the STIRPAT model can be transformed as follow:

$LnI = lna + blnP + clnA + dlnT + lne$…………………………………………………………… (3)

Based on the previous literature, the study choice urban population size as the index of population (P), consumption expenditure, and per capita income and GDP growth as the index of Affluence (A), and urbanization as well as industrialization used as index of technology (T). Therefore equation (3) transformed in to eq. 4:

$LnEnse_{it} = \beta_0 + \beta_1 lnIndu_{it} + \beta_2 \, lnUrb_{it} + \beta_3 lnGdpg_{it} + \beta_5 lnPci_{it} + u_{it} + \acute{\varepsilon}_{it}$…………… (4)

Where Ense is the explained variable indicate for energy security measured by energy productivity, GDP/Enco. Indu, Urb, GDPg, Psi and Pci are explanatory variable donated Industrialization, Urbanization, GDP growth rate, Population size and Per capita income respectively. The change in energy security (Ense) as the result of change in one explanatory variable expressed as $\beta_i$% while i and t represent country and time respectively. $\beta_0$ is the intercept term, while $u_{it}$ is a random variable that cannot be observed and presents heterogeneity of different provinces. $\acute{\varepsilon}_{it}$ is the disturbing term, which changes with individuals and time. Owing to provincial heterogeneity, it further reflects the influences of other random factors that cannot be observed in different provinces on energy security. Here, $\acute{\varepsilon}_{it}$ is assumed independently identical in distribution and is unrelated with $u_{it}$: Cov ($u_{it}$, $\acute{\varepsilon}_{it}$) = 0.

### 3.2 Data Source and Variable Description

In this study we employed the panel data for 30 African countries for the period of 2000 -2018. The sample countries choose entirely based on the availability of data. The data set which were used in model analysis were obtained from the database of the World Development Indicators (WDI). In the analysis, the panel regression model that was used as In STIRPAT model specified above. The dependent and dependent variables used in this study described in table below:

Table 2: Variable description

| Abbreviation | Variable name | Explanation | Expected sign |
|---|---|---|---|
| Ense | Energy security | Energy efficiency used as proxy for energy security which is obtained by the ratio of between GDP and total energy consumption, which is expressed by a logarithmic form in the analysis. Total energy consumption measured based on unit: 10,000 tons of standard Coal | |
| Indu | Industrialization | Rate of industrialization which is obtained by the ratio of industrial value added to the GDP, and the ratio converted to the logarithmic form used for this study. | +ve |
| Urb | Urbanization | Percentages of population live in urban area, obtained by the ratio of urban population to the total population. The logarithmic form used for this study. | -ve |
| Gdpg | GDP growth rate | Growth of GDP, the logarithmic form used for this study. | -ve |
| Pci | Per capita income | The variable used to express the effect of income energy security, the logarithmic form used for this study. | -ve |

**Source: (**Own construction, 2019)

### 4. RESULT AND DISCUSSIONS

According to the objective of the study, the effects of urbanization on energy security using STRIPAT model was estimated with panel regression technique. Before analysis the overall credibility of the model was tested. Since $R^2$ is not accurate measurement of the quality of the model, $\chi^2$statistic for Wald test on the null hypothesis that all the slope coefficients were equal to zero, the value of $\chi^2$ statistics were highly significant, confirming that the overall fitness of the equations was quite satisfactory.

The model was based on the assumption of the error term so as to predict the relationship between variables. Pooled OLS, fixed effects and random effects were appropriate for panel data. The technique for choosing the appropriate method was tested using LM test which tests the homogeneity of the country effects. The null hypothesis in which random effect model turns into pooled regression model was tested and the variance of the unit effects was found as zero through LM test.

***H0: Pooled Regression, σ2 α = 0***
***H1: Random Effect, σ2 α > 0***

The study run these test and found rejection of the null hypothesis, indicate the model cannot be predicated with pooled regression (the statistics of tests related with the models are shown in Appendix).

The study was predicted through fixed effects first, and then tested through Hausman test, in deciding between fixed effects or random effects. The Hausman test find out whether the error term in the model related with independent variable in order to use more accurate method. According to (Gujarati ,2004) if the individual error component $\varepsilon_i$ and one or more repressors are correlated, then the Random Effect model estimators are biased, whereas those obtained from fixed effects model are unbiased. If the null hypothesis is rejected, the conclusion is that Random Effect Model is not appropriate. According to the results of these two tests, fixed effects model provides the most reliable predictions.

### 4.1 Result Analysis

Three regression analyses conducted simultaneously to choose the appropriate estimation model. In order to eliminate the problem of heteroscedasticity problem on the disturbance the cluster robust standard error was applied. Finally the appropriate estimation model was chosen based on reasonable judgments. The regression result presented in table 3 as follow:

Table 3: estimation result for three regression model

| | Explained variable: energy security(lnense) | | |
|---|---|---|---|
| | Pooled OLS | Random effect | Fixed effects |
| **Lnurb** | 0.07*<br>( 0.07) | 0.31***<br>( 0.11) | 0.455***<br>(0.127) |
| **Lnindu** | 0.09<br>(0 .07) | .014<br>(0.05) | 0.043*<br>(0.006) |
| **Lngdpg** | -0.04<br>(0.03) | (-.01)<br>(0 .01) | -0.013<br>(0 .009) |
| **Lnpci** | 0.42***<br>( 0.04) | (0.75)***<br>(0 .04) | 0.745***<br>(0 .041) |
| **Cons** | 8.35***<br>(0.20) | 5.06***<br>(0 .31) | 4.536***<br>(0.320) |
| **Rho** | | 0.92 | 0.95 |
| **P** | | | 0.000 |
| **N** | 527 | 527 | 527 |
| **F** | 111.4 | | 186.34 |
| **$R^2$** | 0.48 | 0.474 | 0.472 |

Note: *, **, and *** are significant at 10%, 5%, and 1% levels, respectively. Number in parentheses is standard error. Cons is a constant term.

Source: (Own results, 2019)

Table 3 present the panel data regression for three models i.e pooled OLS, Random effect and fixed effect model. Here the study used the fixed effect model for the analysis based on reasonable judgment described above. Energy security is addressed in terms of energy efficiency, which is measured as the ratio of GDP to total energy consumption. Even though the number of observation (N) is 570, the study used 527 observations. Some country GDP growth was negative for particular year and the logarithm of negative number is not possible. Therefore this study had been dropped 43 observations from regression analysis.

According to column three the overall model is statistically significant (F= 186.34 and p value= 0.000). The coefficient of determination ($R^2$) is 0.472, which implies 47.2% of the variation in the energy security is explained by the variation in the explanatory variable. Moreover, rho = 0.953 for fixed effect model and rho= 0.92 for random effect model, which indicate fixed effect is better estimate than random effect.

The fixed effect regression model showed that lnurb and lnpci positively and significantly affect energy security at 1% level of significant. The coefficient of industrialization (lnindu) also affects energy security positively at 10% level of significance.

According to the regression result in column three the coefficient of lnurb is significant at 1% and its elasticity coefficient is 0.455. Other things remaining constant, as urbanization increase by 1%, on average energy security increase by 45%. In contrary to the expectation, the result indicates that urbanization can improve energy security. The result confirm with the finding of (Li, M., 2019) and (Bellouini et al., 2016). Even though, the fixed effect models indicate the coefficient of lnurb is 0.455, random effect regression and between estimator regressions (not presented) shows that the coefficient in to 0.31 and 0.026 respectively. This variation implies urbanization level can improve energy security, although the overall effect declines to some extent.

Urbanization has led to shift in production from agriculture to industry, which are more energy intensive. But the population in urban area have better living standard than their counterpart in many African countries. Urban population in Africa can afford more energy demand. Therefore, urban populations have to diversify the source of energy.

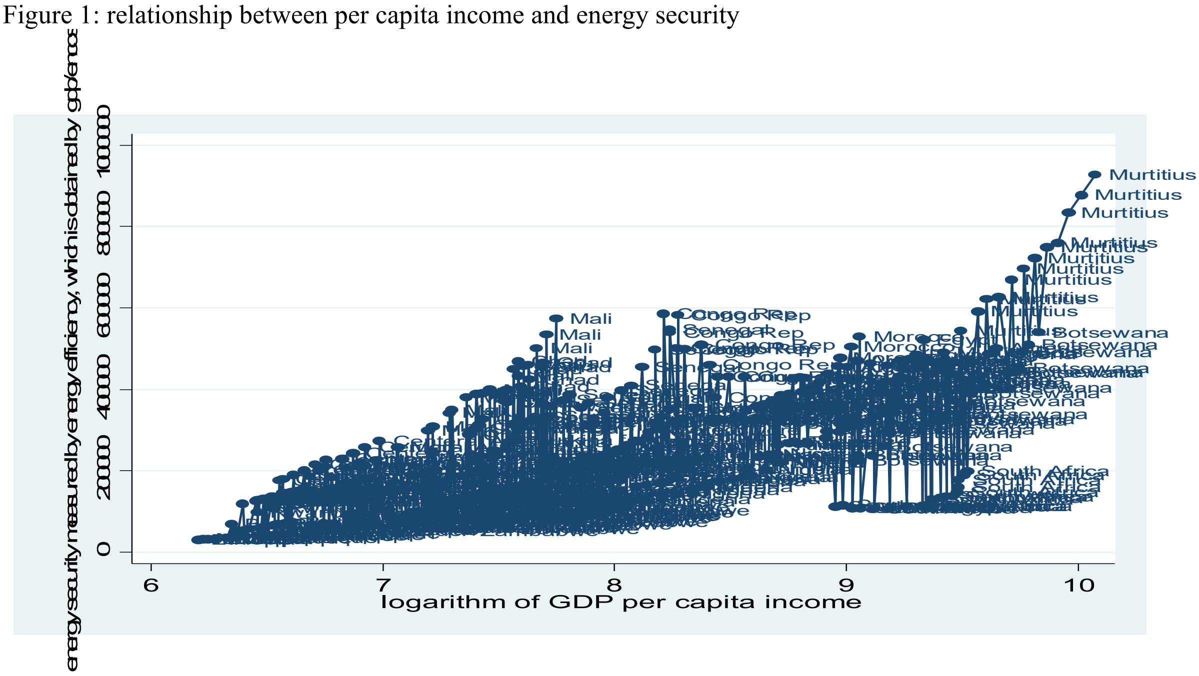
Similarly the coefficient of lnindu is significant at 10% and its elasticity coefficient 0.043. Sign of the coefficient are in line with the expectation and it indicates that for one percent increase in industrialization rate on average increase energy security by 4.3%, other things remaining constant. High industrialization improves energy efficiency and study confirms the finding of (Shahbaz et al., 2016). The reason might be industrialization resulted in economies of scale due to improved technology. Improved technology might be due energy saving leads to less energy consumption that will improve energy security.

Finally the coefficient of lnpci is statistically significant at 1% and its coefficient 0.745. in contrary to the expectation and (Trollip et al. ,2014; Opeyemi et al. ,2016) finding the coefficient of lnpci is positive and it indicate for one percent increase the per capita income of individual leads to increase in energy security by 74.5%

while keeping other things remaining constant. As per capita income increase the individual/household has a chance to diversify the source of energy and income represent major determinants in accessing different energy source. Diversifying the source of energy have been considering as a way of ensuring energy security. even though higher income increase the demand for more energy consumption, with higher income the population could have renewable energy source for their home energy consumption and used as substitution for non-renewable energy demand.

The relationship between energy security and per capita income is positive implies as increase in per capita income improve energy security. The following figure described relationship between energy security and per capita income:

Figure 1: relationship between per capita income and energy security




Source: (Own results, 2019)

The above graphs indicate that the country with low per-capita income combined with low level of energy security. On the other hand, the countries with high per capita income have high energy security. Even though, the curve is not U-shape, the positive relationship between per capita income and energy security partially support U-shaped Kuznets curve.

## 5. CONCLUSIONS AND RECOMMENDATIONS

As the result indicates urbanization, industrialization and per capita income greatly affect energy security in African countries. The fixed effect regression indicates that urbanization, industrialization and per capita income can improve energy security in Africa. Industrialization improves energy security based on economies of scale mainly investing in energy saving technology. Similarly increased urban population can improve energy security during the process of urbanization in developing countries especially in Africa. In the view of overall effect, prompting research and technological development as well as innovation with high industrialization can improve energy security. Country with high urbanization and industrialization should pay great attention in technological development and innovation at the same time. These strategies can greatly improve energy security.

Moreover, the changes in per capita income also greatly improve energy security in Africa. Diversifying the source of energy has been considered as a way of ensuring energy sustainability. Higher in per capita income bring the developing countries to adopt renewable energy source for their growing demand. Currently World bank and other organization emphasize on renewable energy sector for maintaining sustainable energy access and development in developing countries. Therefore increased per capita income of the population in developing countries ensures the energy source from different direction.

The conclusion in this study can help the government of African countries to formulate policies and regulation and promote urbanization comprehensive consideration of local industrial structure and economic development. Government of African countries should optimize industrialization and urbanization while paying attention on improving the technology to reduce energy consumption, invest in energy saving technology to ensure energy security in their development process. Finally the government of African countries should promote the process of urbanization and promote supply system of renewable energy supply by increasing the per capita income the population to maintain sustainable energy security. Surly, the study has limitation. For instance, there are many indicators for measuring energy security but the study used energy efficiency as a proxy of energy security. Energy efficiency indicator do not fully address all important linked with energy security. Therefore, more comprehensive and appropriate energy security indicator should be design in the future research.

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**Appendix**

**Appendix 1:** Countries Examined in the Analysis

| | | | | |
|---|---|---|---|---|
| Angola | Cote d'ivore | Kenya | Tunisia | Uganda |
| Burundi | Cameroon | Morocco | Chad | South Africa |
| Benin | Algeria | Mali | Senegal | Zambia |
| Burkina faso | Congo Rep | Nambia | Rwanda | Zambabwe |
| Botsewana | Egypt | Mozambique | Nigeria | Togo |
| CenteralAfrica | Ethiopia | Murtitius | Niger | Tanzania |

**Appendix 2:** Descriptive statistics

| Variable | | Mean | St.dev | Min | Max | Observation |
|---|---|---|---|---|---|---|
| Lnense | Overall | 12.205 | 0.675 | 10.324 | 13.739 | N=570 |
| | Between | | 0.632 | 10.982 | 13.292 | n=30 |
| | Within | | 0.263 | 11.001 | 13.033 | T=19 |
| Lnurb | Overall | 3.566 | 0.485 | 2.109 | 4.285 | N=570 |
| | Between | | 0.486 | 2.339 | 4.197 | n=30 |
| | Within | | 0.082 | 3.286 | 3.799 | T=19 |
| Lnindu | Overall | 3.176 | 0.403 | 2.223 | 4.349 | N=570 |
| | Between | | 0.385 | 2.558 | 4.202 | n=30 |
| | Within | | 0.137 | 2.782 | 4.386 | T=19 |
| Lngdpg | Overall | 1.483 | 0.726 | -2.490 | 3.515 | N=527 |
| | Between | | 0.285 | 0.919 | 2.185 | n=30 |
| | Within | | 0.668 | -2.564 | 3.441 | T= 17.66 |
| Lnpci | Overall | 7.946 | 0.951 | 6.203 | 10.075 | N=570 |
| | Between | | 0.931 | 6.529 | 9.588 | N=30 |
| | Within | | 0.254 | 7.257 | 8.690 | T=19 |

**Appendix 3:** F, LM and Hausman Tests

| | | | |
|---|---|---|---|
| Model I | Wald F-test | 186.34*** | Fixed effects |
| | Breusch-Pagan | 2795.22** | Random effects |
| | Hausman | 47.25*** | Fixed effects/Random effects |

*** Significant at 1%, source: own result