



**UNIVERSITY of
RWANDA**

Dissertation Title: **RENEWABLE ENERGY CONSUMPTION AND ECONOMIC GROWTH
IN EAST AFRICA COMMUNITY**

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LIST OF ABBREVIATIONS AND ACRONYMS

1. **ARDL** : Auto Regressive Distributed lag
2. **EAC** : East Africa Communities
3. **DFE** : Dynamic Fixed Effects
4. **GDP** : Gross Domestic Product
5. **GDPPC** : Gross Domestic Per Capita
6. **MG** : Mean Group
7. **PMG** : Pooled Mean Group
8. **LAB** : Labor Participation Rate
9. **TRC** : Total Renewable Consumption

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DECLARATION

I certify that this project is entirely unique to me and has never before been used to get a degree from the college of Science and Technology.

According to my academic style, all sources of material included in the work have been appropriately cited.

A handwritten signature in blue ink, appearing to read "Nishimwe Niyonkuru Ange Christa", written in a cursive style.

NISHIMWE NIYONKURU Ange Christa

DEDICATION

TO

My Parents

Sisters and Brothers

My Friends

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I wish to show my sincere thanks to the Rwanda University and the African Center for Excellence in Energy for Sustainable Development (ACE-ESD) for providing me with a full scholarship to pursue an MSc.

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I owe a lot to **My Parents, Brothers, and Sisters** who supported me during every stage of my personal and academic life and wanted this achievement to be realized. I wish to thank all the people, who helped me with this effort in any way they could.

I also want to thank ACE-ESD for the economic, medical, and financial support they provided me with so that I could complete my master's degree in energy economics. Last but not least, those whose names did not appear on this website should be aware that they are still remembered. I appreciate each and every one of you genuinely.

APPROVAL

In my capacity as an academic advisor, I have given this thesis proposal the go-ahead to be evaluated.

Signature

A handwritten signature in blue ink, appearing to read 'Richard Kabanda', enclosed within a rectangular box.

Dr. Richard KABANDA

ABSTRACT

This research investigates the link between the use of renewable energy and economic growth in six East African nations from 2000 to 2022 using a multivariate panel data approach. After extensive discussion, Mohammad H. Pesaran, Yongcheol Shin, and Ron P. Smith (1999) created the pooled mean group (PMG) estimation model to evaluate the validity of the results. The PMG estimator enforces consistent long run connections across countries while allowing for variation in short run responses and intercepts, allowing for greater parameter heterogeneity than the conventional estimator procedures employed in empirical growth research.

The heterogeneous panel cointegration test indicates that real GDP, renewable energy consumption, real gross fixed capital formation, and labor force all show long-run equilibrium correlations. The results of the error correction models demonstrate a causal relationship between the use of renewable energy and economic expansion in both the short- and long-term. Thus, the empirical findings support the feedback hypothesis that the adoption of renewable energy sources and economic expansion are mutually dependent.

These findings indicate the effectiveness of government initiatives that promote the use of sources of renewable energy by developing markets for those sources, as well as renewable energy portfolio standards are favorable from both a macroeconomic and environmental perspective. This study does not suggest any new macroeconomic policies; it just provides evidence that measures in favor of renewable energy sources would, at the very least, not negatively affect the economies of the countries.

Key words: Economic Growth, Renewable Energy Consumption, Pooled Mean Estimator

1. INTRODUCTION

1.1. Background

A source of energy is a critical aspect in attaining long-term economic growth and development. As the number of fossil fuels diminishes and fails to fulfill demand, there has been a hunt for alternative energy sources resulting from the faster increase in usage of energy. (Apaydin, Gungor and Tagdogan, 2019).

An exceptional chance to achieve climate targets while promoting economic growth, creating new employment opportunities, and Accelerating the switch to a renewable energy system is one way of enhancing human health. The world's commitment to embracing this opportunity is evidenced by the inclusion of renewable energy objectives in 164 countries' energy plans as well as in the Nationally Determined Contributions (NDC) that will direct the execution a climate change treaty signed in Paris. Energy sector investment decisions taken today will have an extended impact on economic expansion and development. They will also determine our ability to decarbonize energy, which is essential for battling climate change. Switching to a renewable energy-based system may help reach this objective while also opening up new economic prospects, increasing incomes, adding employment, and improving the health and wellbeing of millions of people. (Can and Korkmaz 2019)

The energy industry contributes to economic growth in two different ways. First, since it obtains, processes, and the energy industry, a vital economic sector that delivers energy services and products across the economy (World Economic Forum, 2012). Next, remainder of the economy was impacted by the oil industry. Almost all commodities and services in the economy include energy, which also sustains economic activity throughout all of its sectors. Even though Africa has had sustained economic growth for almost 20 years, power outages, restricted access to electricity, and a reliance on biomass as fuel are impeding efforts to eradicate poverty. Africa now has a severe energy deficit, which is a major roadblock to its progress.

For long-term economic growth to be achieved and sustained, energy production and consumption are essential (Sebri 2015) . Both the production and use of energy have significantly impacted the environment, since non-renewable energy sources like the using hydrocarbons like coal, gas and petroleum tend to increase overall CO2 emissions while also gradually increasing energy costs. In many regions of the world, rising expenses have led to circumstances where a lack of energy has led to both economic issues and what appears to be an increase in poverty. (Terrapon-Pfaff et al. 2014) has brought to problems with climate change as a result of (Bilen et al. 2008).

The fact that renewable energy generally costs less than traditional, fossil fuel-based energy is one of its key advantages. Long-term cost savings from using green or alternative energy sources may be utilized to raise the average living standard of the population and free up government resources to solve environmental challenges.

Both developed and developing economies have recently lent their support to the global push to reduce reliance on energy derived from fossil fuels. The EU launched one such coordinated effort, aiming to replace 20% of its energy sources with renewable ones by the year 2020. National action plans for renewable energy were also approved by all of the participating nations. Around 19% of the world's electricity needs are presently satisfied by electricity generation., with a goal of 50% by 2050. 560 million Africans, or 43% of the continent's population, lack access to electricity. Around 80% of Africans rely on traditional biomass, primarily fuelwood and charcoal, for cooking. As a result, home air pollution causes around 600,000 deaths in the area each year, of whom almost half are children under the age of five.

In particular, regions in East Africa without access to energy are primed for renewable energy. In 70% of Kenya's undeveloped areas, solar potential is great. In these regions, 4.3 million people reside. In Tanzania, 67% of the population currently lives without access to electricity, yet 25% of those areas have a high potential for clean energy, which may provide power to 2.9 million people. The nation of 6.8 million people in Uganda has a tremendous potential for all renewable energy sources, including sun, wind, and small-scale hydropower.

1.2. Statement of the Problem

When renewable power sources are developed, environmental quality, sustainability, industrial output, transportation, rural development, and health protection are all boosted (Hostettler, 2015). However, as regulations, markets, and enterprises related to renewable energy grow, they run into more challenging issues with a number of facets. Fossil fuel reserves are abundant, which makes it difficult to prioritize alternative energy sources. In comparison to alternative energy sources, fossil fuels receive six times greater subsidies (Tugcu, Ozturk, and Aslan 2012a).

Two significant barriers, particularly for poor countries, are costs and a lack of solid legislation. Investment in renewables is discouraged by startup costs, a lack of policies to balance price discrepancies between renewables and fossil fuels, and overarching structural barriers like the centralized energy sector, which prevents more regionalized methods of supplying electricity. Inequality is a significant issue raised by the expansion of renewable energy. The problem is that policy implementation, financial accessibility, and technological diffusion differ significantly inside and beyond national boundaries. Additionally, while renewable energy has one of the fastest rates of development today, expanding by 2.5% yearly, it hasn't been enough to keep up with the effects of the rapidly increasing demand for energy (Report 2019).

One of the main barriers that might threaten the feasibility of developing renewable project is the absence of a supporting legal framework, even in the midst of plentiful resources and favorable technical advances. Investigation has to be taken methodically in so as to better understand obstacles to the deployment and growth of renewable energy in various nations. Local circumstances, the dynamics of the global system, and the movements of information and resources all have an impact on the unique issues that different countries confront. Finding workable answers to a global problem that crosses generations is challenging. For developing countries, this challenge is compounded by the fact that they must simultaneously enhance access to essential energy services while achieving a number of objectives, including environmental objectives as well as social and economic development objectives(Apergis and Payne 2010).

1.3. Objectives

This study has two research objectives; key goals and precise targets

1.3.1. Major Objective

The study's main goal is to establish the usage of renewable energy affects nations in East Africa's economic growth.

1.3.2. *Specific Objectives*

The stated research goal is to evaluate the:

- 1) Determinants of consumption of renewable energy
- 2) Effect of renewable energy consumption on economic growth in East Africa Region

1.3.3. Research questions

In this research, the researcher is going to attempt providing answers to the following questions:

- 1) What are the indicators affecting renewable energy consumption?
- 2) Is there any causal relationship between the renewable energy consumption on economic growth?

1.4. Scope of the study

The analysis is restricted to secondary data on the following variables: Between 2000 and 2020, data on each of the six East African countries' Real GDP, GDP per capita, labor force, gross capital creation also employee numbers are provided.

1.5. Expected Outcomes and Significance of the Study

Both scholars and policy officials in East African nations may find value in the study's findings. These research's intended beneficiaries will utilize its results to advance expansion of clean sources accordingly.

1.5.1. Expected Outcome from Study

Results from the research will provide preservation of the country's natural resources, the reduction of the demand for imported goods, the electricity generation specialization and a lesser reliance on foreign sources. employment and economic development in fabrication and erection.

1.5.2. Significant of the Study

Determining whether utilization of renewable energy affects economic expansion is the main objective of the research. The findings will help to enhance national policies to enable an increase in economy's energy sustainability.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This part summarizes some of the both conceptual and quantitative studies on how using renewable energy affects economic growth.

2.1 Definition of Key Concepts

2.1.1 Economic Growth

Economic growth is defined as an increase in the production of goods and services used by the economy. It can be calculated in actual (inflation-adjusted) numbers or monetary values. Different methods are occasionally employed, Despite the fact that gdp growth and gross domestic income (GNP) are frequently employed to estimate total growth in the economy. significant improvement in an economy's entire production is the most basic definition of economic growth. Generally speaking, but not always, gains in average marginal productivity are connected with increases in total output. Spending more money by consumers leads to an improvement in the standard of living or material quality of life, which increases income and boosts consumer confidence.

2.1.2 Sustainable Energy

Despite having naturally finite flow, renewable sources of energy may regenerate. Although they have a nearly limitless lifespan, renewable resources only have a limited quantity of energy available at any given moment. In addition, energy that is endless or renewable energy that comes from sources like the sun. When the term "alternative energy" is used, renewable energy sources are commonly included.

2.2 Theories about Economic Growth

Economically speaking, the labor force, technology, human capital, and physical capital are commonly viewed as factors in growth. Simply put, higher economic output will result from improvements in the amount or quality of the working-age population, their access to resources, and their ability to combine Ingenious uses of labor, money, and raw resources. There are several ways to stimulate economic growth. The expansion of the country's economic inventory of tangible durable goods is the first component. Since the amount of capital in the economy increases, labor productivity often rises.

Workers can create more in less time if they have access to more, better, and more equipment(Sheya and Mushi n.d.)

For instance, a fisherman will use a net rather than a pointed pole to catch more fish per hour. But two things in particular are crucial to this process. Someone in the economy first has to save money in order to obtain the funds needed to create additional currency (following functions some of their current consumption). For workers to truly make good use of extra funds, it must also be the exact type, in the right location, at the right time.

Another method for fostering economic expansion is the advancement of technology. An illustration of this is the development of gasoline; previous to gasoline's ability to provide energy, Oil had a very poor economic value. Fuel became a better and more efficient means to transport raw materials as well as completed products. By integrating capital goods in new, more efficient ways, improved technology enables employees to increase production while using the same amount of resources. The rates of capital growth and technical growth are intimately associated since investments and savings are required to fund research and development(Sheya and J.S. Mushi 2000)

Increased labor force participation is another strategy for boosting the economy. assuming that all different things are the same, more employees create extra affordable goods and services. United States saw rapid economic expansion in the 19th century thanks in large part to a massive influx of labor from low-cost, hardworking immigrants. Similar to capital-driven expansion, this process is nonetheless dependent on a few crucial factors. Additional labor must at least be productive enough to offset this and avoid net consumption. This is because an increase in the labor market will inevitably lead to an increase in production that must be consumed to meet the basic nutritional needs of new employees. Additionally, it's critical that the correct kind of labor move to the right industries, much like new capital investments. To reach their full potential for productivity, businesses must have the proper kinds of complementary jobs in the correct locations.(Tugcu, Ozturk, and Aslan 2012b)

The ultimate plan is to increase skill development. This implies that individuals grow their skills, learn from mistakes, or just practice more, which leads to increased productivity and proficiency at work. The strategies of specializing, investing, and conserving are the most dependable and controllable. Behavior inclinations toward more social reciprocity and trust, as well as political or economic

improvements like enhanced property rights protection, are examples of human capital that can increase economic output.(Sadorsky 2009)

2.3 Theories on Renewable Energy and Economic Growth

Numerous national and international researchers have looked at how energy use and economic growth are related. In his well-known work on the "economic growth-energy" nexus, Ozturk (2010) reviews the many causal hypotheses that have been advanced to explain the state of study link among the usage of renewable energy and economic growth.

2.3.1 The neutrality hypothesis

The neutrality hypothesis states that there is either no link at all, or a very weak relationship, between energy usage and economic development. Because of this, energy and growth are unrelated. This idea is supported by an empirical investigation done by Assa et al.

2.3.2 The growth hypothesis

Energy, in accordance with the growth theory, is a prerequisite for economic expansion. It suggests that growth and energy follow a single path of causality. This is an example of a situation where an economy depends on energy to drive economic growth. Therefore, a limited supply of energy may limit or hinder growth. Economic growth and energy consumption are causally resembling in only one direction, according to Odhiambo.

2.3.3 The conservation hypothesis

According to the conservation hypothesis, energy is not necessary for economic growth. It suggests that growth and energy follow a single path of causality. As a result, the economy uses less energy to drive growth, allowing for the implementation of energy-saving initiatives without negatively affecting that development. Salim & Rafiq's research is an illustration of one that backs up this claim.

2.3.4 The feedback hypothesis

The above demonstrates a direct causal link between economic expansion and energies in both directions. The hypothesis of feedback states that energy and economic growth go hand in hand extremely nicely. Evidence from Apergis and Payne lends credence to this argument.

2.4 EMPIRICAL LITERATURE REVIEW

Importance of renewable energy in relation to economy of various nations has been demonstrated by a number of studies. For instance, Inglesi-Lotz (2015) found that over the long run, Real GDP or real Real gross fixed capital creation, GDP per person, total renewable energy consumption, or the percentage of total renewable energy consumption, employment, and global R&D spending all have an equilibrium connection. The estimates reveal that for every 1% rise in renewable energy consumption, a country's GDP will expand by 0.105percentage points and its GDP per capita by 0.100%, while for every 1% increase in the proportion of renewable energy in a country's energy mix, the GDP will increase by 0.089% and 0.090%, respectively.

In his research, Sadorsky (2009) found a relationship between per capita renewable energy use and real per capita income. We demonstrated the existence of a long-term equilibrium for real GDP, renewable energy consumption, real gross fixed capital creation, and the labor force. Apergis & Payne (2010) conducted a panel data analysis to examine the similar link for the OECD countries. environment. Their study backs up this result. They also discovered that for every 1% increase in real gross fixed investment and the usage of renewable energy, the real GDP rises by 0.76 % respectively. Panel data for 20 OECD nations from 1985 to 2005 were used to evaluate growth using a multivariate technique.

In single-country and multi-country research, transition economies generally (54%) agree with concept of feedback hypothesis, which contends that energy usage and economic development are connected. (23%) keeping with the conservation concept, which states that economic development has an influence on energy usage. (9%) supports the neutrality hypothesis, which contends that there is no link between energy consumption and economic growth, while (14%) supports the evidence for the growth hypothesis, which holds that energy consumption promotes economic growth. Frondel et al. focused their 2010 analysis on how renewable energy use affects Germany's capacity to grow its economy and operate effective markets. According to Sari and Soyotas (2004), a decomposition exercise led them to the conclusion that the consumption of garbage About 31.5% of the volatility in Turkey's real GDP may be attributed to wood, hydraulic steering, and other factors.

Based on expanded production function estimations of causative links, the use of eco-friendly energy and financial progress in France, Italy, Canada, and the United States, according to Can Tansel (2012), are not causally related. Renewable energy and the environment are interdependent, according to the conservation hypothesis on usage and economic expansion, which the research of Germany's instance showed. Along with Japan and England, the United States supports the feedback concept.

From 1980 to 2008, Assa proven the relationships among production of sustainable power, commerce, and consumption for a panel of 11 African nations. They discovered no proof of a causal link between commerce and the usage of renewable energy or between production and it in their short-term findings. Utilizing renewable energy has no long-term correlation and production or commerce. Sales and usage of renewable energy have a statistically significant beneficial impact on output.

Between 1990 and 2011, Attiaoui et al. examined the effects of per capita GDP, per capita CO2 emissions, and per capita nonrenewable energy consumption on per capita renewable energy consumption. 22 African countries were used as a panel to accomplish this. Based on the authors' research using a 'Pooled Mean Group' model with autoregressive distributed lag, the per capita GDP has very little to no impact on the adoption of renewable energy. Unlike the advantages of using non-renewable energy, the usage of renewable energy is significantly impacted by per-person CO2 emissions.

In their other panel analysis, Ackah and Kizys analyzed factors between 1985 and 2010 that affected the demand for renewable energy in African countries that produced oil. The researchers found a relationship between increasing per capita use of renewable energy and increasing per capita capital stock, GDP, and population. While per capita CO2 emissions and energy costs are lowering it, human capital has minimal effect on per capita energy use.

DaSilva et al. employed an autoregressive distributed lags panel model to investigate the variables influencing the growth of clean resources in Sub-Saharan Africa during 1990 to 2014. The utilization of renewable energy, according to the authors, was positively and significantly impacted by real income per person and per-person energy use. The utilization of renewable energy is, however, negatively impacted by variables including energy costs, population, CO2 emissions per person, power

import, and Kyoto Protocol ratification. The findings of Ackah and Kizys are corroborated by those of da Silva et al.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

The techniques and processes used to collect data are covered in this section, create models, and display the results. The dataset is also described in this section. The methodologies and tools used in the processing and analysis as well as descriptions of the data.

3.1 Research design

The study outlines broad strategy for addressing the research questions. (2007) Saunders, Lewis, and Thornhill. The research project is held together by the plan, which is used to frame the study and demonstrate how all of the key components cooperate to try to answer the primary research questions (2006) William Trochim. The adoption of a survey study methodology allowed for the uniform and systematic collection of the same type of data from a sizable population (Mugenda, 1999). The study is descriptive in nature, and it investigated and detailed the properties of many factors. The study also incorporated a few elements of a correlational research design, in which the correlation was employed to determine the link between Independent dependent and factors.

3.2 The population of the study

The people, things, and events that make up the research's population are those from which the study sample was drawn. The population of this research is made up of East African countries' annual gross domestic growth, total energy usage, per-person gross domestic product, and gross capital creation from 2000 to 2020. Due to the researcher's interest in the countries of East Africa, this was chosen as the first option.

3.3 Data collection and processing

In this investigation, secondary data were incorporated. Historical panel data were evaluated for 4 parameters in a research spanning the years 2000 to 2020 using data indicators from the World Bank.

3.4 Methods and Tools used in data processing and analysis

The following programming tools were utilized for efficient data processing:

- Stata
- MG,
- PMG, and
- DFE Model

3.5 Model specification

3.5.1 Theoretical model

The theoretical underpinning of this research topic is the basic economics of production, which Fang (2011) employed in his analysis on the effect on the Chinese economy of using renewable energy. The empirical research presented here represents the link between inputs and results using a Bennett functional form. The shape of this generic function is given Cobb-1928 Douglas's publication

$$Q = AL^{\alpha}K^{\beta}$$

where Q denotes the output's financial value., L and K represent the labor and capital inputs, respectively, and A represents the total factor productivity. Although the capital and labor variables may be simply quantified as the nation's gross fixed capital creation and the number of employed persons, respectively, the technical progress can be represented by a variety of variables(Rivera-Batiz and Romer 1991)

According to Fang (2011), The total amount of renewable energy used and gross capital formation will be used as measures of how much of an impact that uses green resources might have on economic expansion. As a result, the last Cobb-Douglas function to be calculated is: in its natural logarithmic form.

$$gdppc \text{ or } gdp = \alpha_0 + \alpha_1 trc + \alpha_2 cap + \alpha_3 lab + \mu$$

Where,

Trc: total renewable energy consumption

Gdp: gross domestic product

Gdppc: gross domestic product per capita

Lab: labor participation rate

α_0 to α_3 : parameters

μ : error term.

3.5.2 Econometric model

Panel data approaches will be used to estimate the aforementioned theoretical model. Dynamic panel data models have received a lot of interest recently since they feature many time series observations (T) generally of the exact magnitude order as the number of groupings (N). In cross-country investigations, such panels are frequently employed. The bulk of these kinds of applications are interested in the long-term effects and the speed of long-term adjustment. Let's say we have data on time periods (t = 1, 2,..., T) and groups (I = 1, 2,..., N) and we wish to predict an ARDL (p, q, q, q, q) model.

$$y_{it} = \sum_{j=1}^p \delta_i y_{i,t-j} + \sum_{j=0}^q \beta'_{ij} X_{i,t-j} + \varphi_i + e_{it} \quad (1)$$

Where y_{it} is the dependent variable, is a $k \times 1$ vector that may only be I(0) or I(1) or cointegrated, δ_i is the coefficient of the lag-adjusted dependent variable, also referred to as a scalar, β'_{ij} is a set of $k \times 1$ coefficient vectors, φ_i is a set of unit-specific fixed effects, and I_t , and p, q are optimal lag orders.

For the ARDL (p, q, q,..., q) error correcting model, the following details are supplied.:

$$\Delta y_{it} = \theta_i [y_{i,t-1} - \lambda'_i X_{i,t}] + \sum_{j=1}^{p-1} \xi_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \beta'_{ij} X_{i,t-j} + \varphi_i + e_{it} \quad (2)$$

Summary:

- $\theta_i = -(1 - \delta_i)$, group-specific speed of adjustment coefficient (expected that $\theta_i < 0$)
- λ'_i = vector of long run relationships
- $ECT = [y_{i,t-1} - \lambda'_i X_{i,t-1}]$, error correction term

- ξ_{ij}, β'_{ij} are the short-run dynamic coefficients

The model specification:

$$\Delta gdpgr_{it} = \theta_i [gdpgr_{i,t-1} - \lambda'_i X_{i,t}] + \sum_{j=1}^{p-1} \xi_{ij} \Delta gdpgr_{i,t-j} + \sum_{j=0}^{q-1} \beta'_{ij} X_{i,t-j} + \varphi_i + e_{it}$$

For effective data analysis pooled mean group model as below developed were used.

3.6 Panel unit root

Cointegration methods should be used beforehand ensuring that all components are integrated in the identical order is crucial. Im et al(2003, 's henceforth referred to as IPS) n our investigation, we employed Pesaran's test series and the first-generation test of the panel unit root (2005). These tests are less limited and more beneficial than those developed by Levin and Lin (1993), Levine et al. (2002), and Breusch (2000), which do not account for the variability of the autoregressive coefficient. In a dynamic panel framework, the tests proposed by IPS assume heterogeneity across units, which facilitates the solution of Levin and Lin's collinearity challenge. The following is the basic formula for IPS's panel unit root testing:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^p \phi_{ij} \Delta y_{i,t-j} + e_{i,t}; \quad i = 1, 2, \dots, N; t = 1, 2, \dots, T \quad (1)$$

Soles fixed effect demonstrates that each variable we are evaluating in our model, and p is used to give the residuals temporal independence. The alternative hypothesis, which contradicts the null hypothesis that for all I, is that for some $i=1, \dots, N1$ and for some $i=N1 + 1, \dots, N$.

The following is a representation of the IPS statistic, which is based on averaging individual augmented Dickey-Fuller (hereinafter ADF) statistics

$$t^- = \frac{1}{N} \sum_{i=1}^N t_{iT} \quad (2)$$

When using the nation-specific ADF regression, as in Eq., the ADF t-statistic for nation I is located (1). The critical values are provided by Im et al., who additionally demonstrate that the statistics is uniformly distributed under H_0 (2003).

3.7 Pooled mean group estimator

Loayza and Ranciere argued that traditional static panel models—such as pooled OLS, fixed effects, or random effects do not discriminate between short- and long-run connections among variables. (Simões, 2011) Furthermore, As we will show in our specific sample, Campos and Kinoshita claim that the parameters might be affected when certain repressors are endogenous. The GMM-difference estimator and Arellano and Bond, as well as Arellano and Bover, developed the Regression approach., which focus on dynamic panel models, when the sample contains a substantial number of countries compared to the time period, which is not the case in our study, are quite useful.(Pesaran et al. 1999)

Additionally, short-run dynamics are of greater relevance to the GMM. These issues seem to be particularly well-compensated for by ARDL - Panel approach. key benefits from this technique, according to Pesaran and Shin (2000), is that it may be used to study variables whether they be $I(0)$, $I(1)$, or a mix of the two the two, levels of integrating. (Martorano, Sanfilippo, and Haraguchi 2017)

It is possible to determine the Panel ARDL Approach using MG, PMG and DFE. PMG claims that long-term slope parameters are uniform whereas short-run coefficients vary between nations. Pesaran and Smith's MG permits country-specificity both immediately and later on. This method, in particular, estimates separate regressions for each nation before calculating unweighted means(Pesaran and Smith 1995)

Despite the striking similarity between the DFE and PMG, the DFE additionally restricts both the short-term and long-term coefficients are expected to be identical. nations. The Hausman test is applied to determine if there are any important distinctions between the Pooled mean estimator, Mean group, and Dynamic fixed estimators. consistency of PMG and MG is widely known, however when long-term homogeneity is taken into consideration, PMG performs better. In order to rule out the null hypothesis (h_0 that the difference between PMG and MG is not significant and that the difference between PMG and DFE is the best one, we additionally test the null hypothesis that the difference between PMG and DFE is big. (Rafindadi 2013)

Panel data models are typically estimated using two estimation methods. The first step is to average the individual estimations for every panelist's group (mean group estimator). This calculation, according to Pesaran and Smith (1995), provides accurate estimates of the parameter's average values. Pirotte (1999) goes on to show that the mean group estimator provides accurate long-run estimates for high sample sizes. It allows the parameters to be completely independent of the groupings and disregards any potential group homogeneity. The second option makes use of the conventional panel strategy (random or fixed effects and GMM methods). These models' requirement for universal parameters could lead to misleading and inaccurate long-term coefficient (Bassanini and Scarpetta 2002)

The longer the interval, the more serious this possible problem might be. Pesaran and colleagues suggested an intermediary estimate (1999) that enforces long-term coefficient equality between nations while allowing short-term parameter differences between groups. The PMG has the advantage of demanding the same long-run coefficients while permitting varying short-run dynamic parameters for various nations.

3.8 Mean Group

The Mean Group (MG) technique is introduced by Pesaran, Shin, and Smith (1995) to lessen the bias brought on by heterogeneous slopes in dynamic panels. The long-run parameters for the panel are instead provided by the MG estimator, which averages the long-run values from ARDL models for several nations.

The aforementioned equations illustrate how the model forecasts various regressions for each country and determines the coefficients as the unadjusted mean of the anticipated coefficients for each country. All coefficients' heterogeneity and variation in the long- and short-runs are supported. For this method to be dependable and efficient, the time-series dimension of the data must be large enough. The method that should be used to analyze dynamic panels is the error-checking model utilizing Vector Autoregressive Lag (ARDL). (Asafu-Adjaye, Byrne, and Alvarez 2016)

The mean group (MG) of Pesaran and Smith is used as a reference point for the model's computation after that. Instead, the Pool Mean Group was used to look at the possibility of a possibly different dynamic issue across nations and to pinpoint both long- and short-term linkages between financial

development and economic growth (1999). The ARDL standard is formatted as follows, claim Loayza and Ranciere (2006):

Where y represents GDP growth, X is a group of independent variables, including a gauge of industrial development, and α stands for the relative short-run coefficients of the dependent and independent variables; β represents long-run coefficients; and ρ represents the coefficient of speed of long-run status adjustment. i and t represent, respectively, for the country and time. The statement included in square brackets refers to long-run growth regression. Three models, PMG, MG, and even DFE estimators, take into consideration long-run equilibrium as well as the unpredictability of the dynamic adjustment process. (Demetriades and Law, 2006).

Additionally, maximum likelihood estimations are used to compute these estimators. The main way that the first estimate (PMG) differs from the others is that it does not demand that the short-run coefficients, including such intercepts, the rate of readjustment to the long-run equilibrium values, be uniform across countries. The coefficient of the error correction term must be negative and greater than or equal to -2 in order for the interest elements to be linked across time. Among the prerequisites for the precision, reliability, and efficacy of this procedure is that. Second, the residual output of the error-correction model must be serially uncorrelated and the explanatory variables may be thought of as exogenous. This is a prerequisite for the consistency of the PMG estimates. We may meet these requirements by include the ARDL (p,q) delays for the dependent (p) and independent variables (q) in the error-correction form. Thirdly, when both are large, the dynamic panel approach may be used to address the issue of heterogeneity and prevent bias in the average estimators, thus the ratio of T to N is crucial.. Eberhardt and Teal (2010) contend that treating heterogeneity is essential to comprehending the development process in this instance. Additionally, when employing this method, the average estimators for small N are extremely sensitive to small model changes and errors. (see Favara, 2003).

Last but not least, and perhaps most importantly, This estimate is especially useful when there are reasons to believe that the long-run equilibrium correlations between variables will be similar across Sub-Saharan nations due to projected income level similarities , financial development or monetary structures, shared technologies, and the openness of the economies with a tendency toward

convergence. Due to the drastically varying effects of financial crises, outside shocks, stabilization efforts, monetary policy, and excessive lending on various nations, the slope coefficients and short-run adjustment relationships may vary by country. Because of this, the PMG estimator is unstable(Khan et al. 2020)

3.9 Dynamic Fixed Effect

The dynamic FE estimator only permits the coefficient of the co-integrating vector to be the same across all panels, despite the fact that it is near to the PMG estimator in the long run. The FE models further restrict the near-term components' ability to shift at a rapid rate to equality. Intercepts customized to a panel are possible using dynamic fixed effect models. The intragroup correlation is taken into account while calculating the standard error with DFE. the lagged dependent variable's endogenous endogeneity, as discussed in Baltagi, Grin, and Xiong's (2000) discussion, results in a simultaneous equation bias in FE models. The Hausman test makes it simple to gauge the degree of endogeneity(Simões 2011)

3.10 Choice between MG, PMG and DFE?

For our objectives, the PMG estimator outperforms mean group estimators in terms of estimate efficiency when long-run slope uniformity is assumed. (Pesaran et al., 1999). This is because, as Sub-Saharan countries, all of the countries under investigation have similar economic development and consumption patterns. As a result, we forecast increased long-term consistency in the use of renewable resources and expansion of the national economies of Sub-Saharan African countries. It is reasonable to assert that nation heterogeneity is particularly significant in the near term given that local regulations, prohibitions, and excessive finance have an impact on the immediate consequences of renewable energy consumption on economic activity.

Furthermore, the MG estimator doesn't have enough degrees of freedom because the study's time period is only 31 years. Therefore, PMG estimates are more pertinent to our research. The Hausman test can be used to detect whether there is a significant difference between the PMG and MG. The null hypothesis of the test states that there is no significant difference between PMG and MG estimates. If the null hypothesis is not disproven, they cannot be statistically distinguished, hence in this situation, the effective PMG estimator is used. The vast differences between PMG and MG can also be used to

explain this illness. In the event that the null hypothesis is false and the PMG and MG are found to be significantly different from one another, we will adopt the average estimate.(Sencer Atasoy 2017)

CHAPTER 4: DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

Using pooled mean group estimates, which will demonstrate the long-term projections and adjustment, this chapter provides and analyzes research findings on the relationship between East African nations' economic development from 2000 to 2020 and their level of renewable energy usage. The first section of this chapter provides data on the amount renewable energy is used as a proportion of the gross domestic product in the East African countries, and the second section looks into the relationship between the rates of economic development of these countries and the use of renewable energy.

4.1 Findings on Economic Growth and Renewable Energy Consumption in Eac countries

Findings will found after appendix page

4.2 Data presentation

To guarantee the reliability of the results, two distinct models are calculated:

Model 1

- Dependent variable: gdp
- Explanatory variable; trc,cap,lab

Model 2

- Dependent variable: gdppc
- Explanatory variable: trc, cap, lab

4.2.1 Descriptive statistics

Table 1 displays statistical descriptions for the key variables used in our investigation.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
gdp	126	24.43103	1.113341	22.38752	26.18046
gdppc	126	7.344976	.5425696	6.572918	8.402727
cap	126	21.81809	1.364761	19.42384	23.90757
trc	120	4.489212	.0801866	4.220684	4.588431
lab	120	4.342328	.1014356	4.159976	4.495913

Source: Elaborated by a researcher using Stata 15

4.2.2 correlation analysis

The table below demonstrates that the variables are not multicollinear.

Table 2: Correlation matrix

	gdp	gdppc	cap	trc	lab
gdp	1.0000				
gdppc	0.7582	1.0000			
cap	0.9666	0.7227	1.0000		
trc	-0.4602	-0.8048	-0.3764	1.0000	
lab	-0.4296	-0.0704	-0.3607	-0.0593	1.0000

Source: Elaborated by the researcher using Stata 15

4.2.3 Panel unit root

Table 3 summarizes the unit - root testing results. Total renewable consumption, gross capital formation, gross domestic growth, and labor participation were all stagnant at the first difference, as can be observed.

Table 3: Panel units roots results

IPS	LEVEL	DIFFERENCE
GDP	-0.7761 (0.2189)	-2.7460 (0.0030)
GDPPC	-0.7512 (0.2263)	-2.4608 (0.0069)
TRC	3.5851 (0.9998)	-2.0680 (0.0193)
CAP	-0.2894 (0.3862)	-4.5195 (0.0000)
LAB	-0.4583 (0.3234)	0.3762 (0.0066)

Numbers in parenthesis are p-values.

Source: Elaborated by the researcher using Stata 15

4.3 Pedroni cointegration

The two distinct models and associated Pedroni cointegration statistics are shown in Tables 4 and 5. According to Apergis and Payne, these data are based on the unit root analyses for each panel nation as well as the average values of the various autoregressive coefficients (2010). The normal standard is asymptotically followed by all statistical distributions. At the 1% level of significance, the group and group PP and ADF statistics refute the null hypothesis (h_0) that cointegration does not occur.

There are two responses to the evidence of cointegration in the two separate models. First off, the results are reliable since they are unaffected by changes in the proxies used to represent economic circumstances (gdp or gdppc) or renewable energy use (trc). Additionally, despite the inclusion of

several specifications, the results demonstrate a long-term relationship between a country's usage of renewable energy, including its production components, and its economic well-being.

Table 4: Model 1 panel cointegration

Pedroni test for cointegration			
Ho: No cointegration		Number of panels	= 6
Ha: All panels are cointegrated		Number of periods	= 17
Cointegrating vector: Panel specific			
Panel means:	Included	Kernel:	Bartlett
Time trend:	Not included	Lags:	1.00 (Newey-West)
AR parameter:	Panel specific	Augmented lags:	1
		Statistic	p-value
Modified Phillips-Perron t		-1.9375	0.0263
Phillips-Perron t		-7.1132	0.0000
Augmented Dickey-Fuller t		-6.6848	0.0000

Table 5: Model 2 panel cointegration

Pedroni test for cointegration			
Ho: No cointegration		Number of panels	= 6
Ha: All panels are cointegrated		Number of periods	= 17
Cointegrating vector: Panel specific			
Panel means:	Included	Kernel:	Bartlett
Time trend:	Not included	Lags:	1.00 (Newey-West)
AR parameter:	Panel specific	Augmented lags:	1
		Statistic	p-value
Modified Phillips-Perron t		-1.9123	0.0279
Phillips-Perron t		-7.1043	0.0000
Augmented Dickey-Fuller t		-6.7996	0.0000

4.4 Hausman test

To establish whether there is homogeneity, compare the estimators for the mean group (MG) and the pooled mean group, then do a Hausmann-type test on the results (PMG).

The null hypothesis must be rejected if the prob-value is less than 0.05

Table 6: Hausman test for MG and PMG

```
hausman mg pmg, sigmamore
```

	Coefficients		(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
	(b) mg	(B) pmg		
trc	-.0583202	-.0243168	-.0340034	.2326024
cap	-.0394659	-.0777462	.0382803	.1255546

b = consistent under Ho and Ha; obtained from xtpmg
 B = inconsistent under Ha, efficient under Ho; obtained from xtpmg

Test: Ho: difference in coefficients not systematic

chi2(2) = (b-B)' [(V_b-V_B)^(-1)] (b-B)
 = 0.11
 Prob>chi2 = 0.9451

The prob-value is 0.9451 because it is unable to completely exclude the null hypothesis(h0) of homogeneity. As a result, the model confirms the PMG estimate.

On the basis of a comparison of the estimators for dynamic fixed effects (DFE) and pooled mean group, the null hypothesis of homogeneity will also be tested using a Hausmann type test (PMG).

If the prob-value is lower than 0.05, the null hypothesis must be rejected.

Table 7: Hausman test for DFE and PMG

```
hausman DFE pmg, sigmamore
```

	—— Coefficients ——		(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
	(b) DFE	(B) pmg		
trc	.1355606	-.0243168	.1598774	.0942651
cap	.0400519	-.0777462	.1177982	.0663748

b = consistent under Ho and Ha; obtained from xtprgm
 B = inconsistent under Ha, efficient under Ho; obtained from xtprgm

Test: Ho: difference in coefficients not systematic

$$\begin{aligned}
 \text{chi2(2)} &= (b-B)' [(V_b-V_B)^{-1}] (b-B) \\
 &= \quad \quad \quad 4.88 \\
 \text{Prob>chi2} &= \quad \quad \quad 0.0871
 \end{aligned}$$

Given that the prob-value is 0.0871, it is impossible to rule out the null hypothesis of homogeneity. As a result, estimations backs up the PMG estimate.

In conclusion, the Hausman test does not allow us to rule out the long-term validity of the homogeneity limitation. This demonstrates how effective the Pooled mean estimator is compared to the mean group. Additionally, when the PMG is compared to the Dynamic fixed effects, the null hypothesis is not rejected, demonstrates that the Pooled mean estimator is suggested to be more efficient. We concentrate our interpretation on the PMG since we can easily see that it is the most effective estimator. The PMG indicates that the link between these variables is currently sustainable in the short run, but that it is no longer so in the long term.

Since each country is different, the pooled mean Group estimator (PMG) assumes that all of the groups that make up the panels have the same long-run coefficients.

4.5 Pooled Mean Estimation

Table 8: Pooled Mean Estimation

	(1)	(1)	(2)	(2)
VARIABLES	gdp	gdp	gdppc	Gdppc
Error coefficients		-0.880***		-0.846***
		(0.157)		(0.151)
D.trc		0.383**		0.376**
		(0.170)		(0.160)
D.cap		0.236*		0.225*
		(0.141)		(0.135)
D.lab		0.333*		0.0620*
		(0.0234)		(0.0327)
Long run coefficients				
trc	0.0243**		0.0252**	
	(0.0421)		(0.0423)	
cap	0.0777***		0.0758***	
	(0.0263)		(0.0264)	
lab	0.107***		0.105***	
	(0.0410)		(0.0409)	
Constant		8.323***		8.007***
		(2.001)		(1.928)
Observations	102	102	102	102

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.5.1 Long-term outcomes

The results show, real gross domestic product and domestic gross output per capita are significantly boosted by total renewable energy use, per models one and two. Accordingly, a 1% increase in TRC will result in a 0.0243% rise in GDP and a 0.0252% rise in GDPPC.

Economic expansion and domestic gross output per capita both benefited from capital accumulation. Accordingly, a 1% increase in CAP will result in a 0.077% increase in GDP and a 0.0758 increase in GDPPC.

The GDP and GDP per capita will increase by 0.0234 and 0.0327, respectively, for every percentage point increase in labor participation.

4.5.2 Short run results

The short run coefficients demonstrated that total renewable consumption and capital formation had a considerable influence on economic growth as well as on gross domestic per capita. Accordingly, a 1% increase in TRC would result in a 0.383% increase in GDP and a 0.376% increase in GDPPPC.

Any deviation from the long-run equilibrium is corrected at an adjustment rate of 84.6%, which results in an annual delay of 7.02%. The significant error correction coefficient raises the possibility of cointegration among the variables in the sample.

CHAPTER FIVE: SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary

With the exception of South Sudan owing to a lack of data for the years 2002 to 2021, all of the EAC countries are included in this study's panel data framework with the aim of quantifying the relationship between economic conditions and the adoption of renewable energy. Results show that research will have a big impact on how future macroeconomic policies that support renewable energy sources are implemented. The exercise, which was carried out in a multidimensional structure based on the Bennett production function used yearly information for EAC members between 2002 and 2020.

Pedroni cointegration test displayed a long run relationship between the GDP Growth or GDP per capita of the countries, the total renewable energies usage, and the real gross fixed capital creation. The GDP and GDP per person are expected to rise by 0.0243% and 0.0252%, respectively, with every 1% rise in the use of renewable energies.

The findings demonstrate the effectiveness of government initiatives that encourage the use of renewable energy through developing energy markets and renewables grid standards are advantageous from a macroeconomic standpoint as well as from the standpoint of improving environmental conditions. This study just supports the idea that laws supporting sources of clean energy would, to say the minimum, not have an adverse effect on the economies of the nations; it makes no recommendations for new macroeconomic policies.

We understand that higher economic growth may affect the availability and usage of renewable energy, and we should make that clear. To help policymakers before implementing new laws, this research sought to ascertain the contribution of clean energy to the productivity expansion of the EAC economies. The results also suggest that rather than focusing only on renewable energy's expanding consumption, authorities should take into account their place and participation in the overall mix of energies.

5.2 Recommendations

- **To policy makers**

Economic policies that support the process of economic diversification and structural change should be created in order to promote economic growth. Second, changes need to be made to educational policy. To ensure a consistent supply of human capital, energy policies work hand in hand with demand matching throughout the growth path.

- **To researchers**

I propose future study to address unresolved elements of my research challenge, which can address the consequences of a particular event, the introduction of a new theory or body of evidence, and/or other current phenomena.

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Appendix

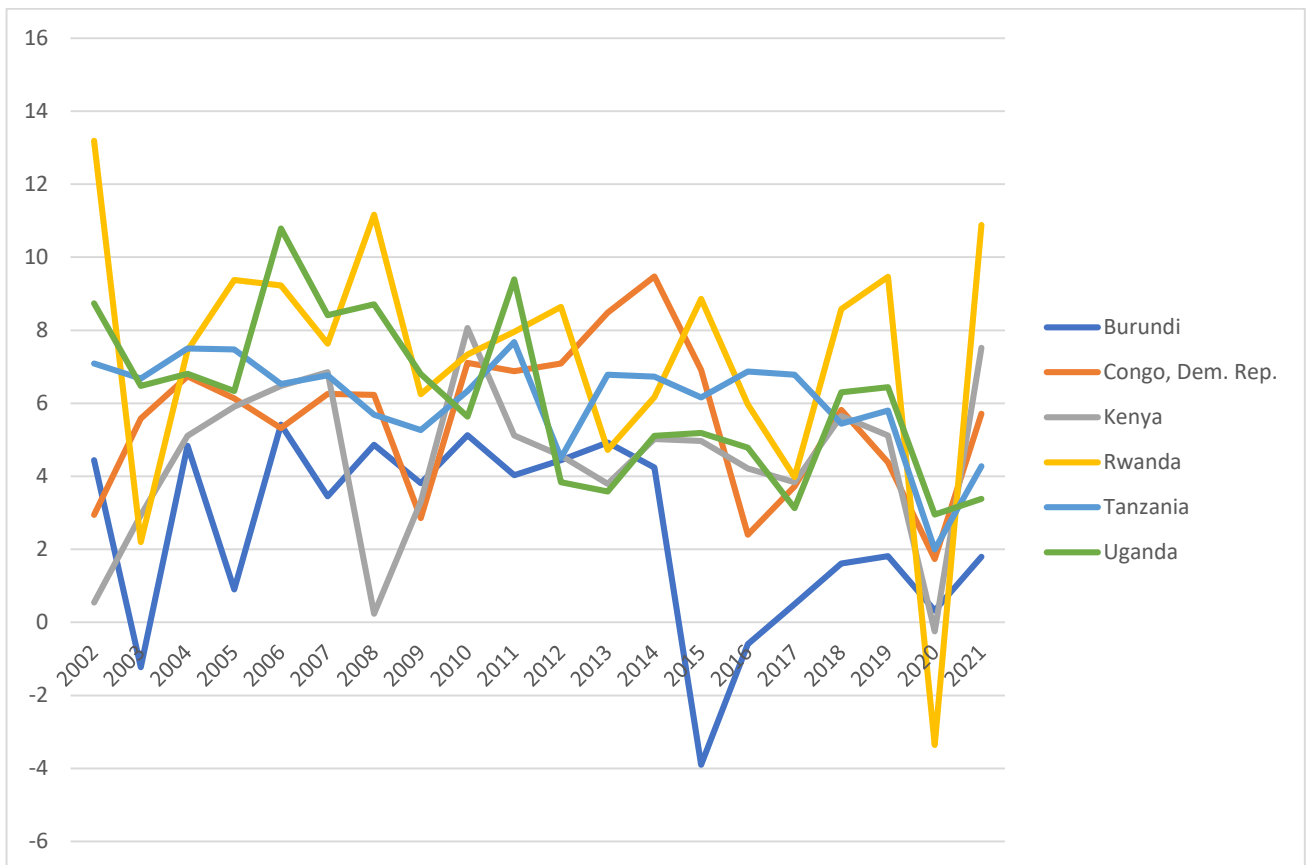


Figure 1: Evolution of Real gross domestic growth

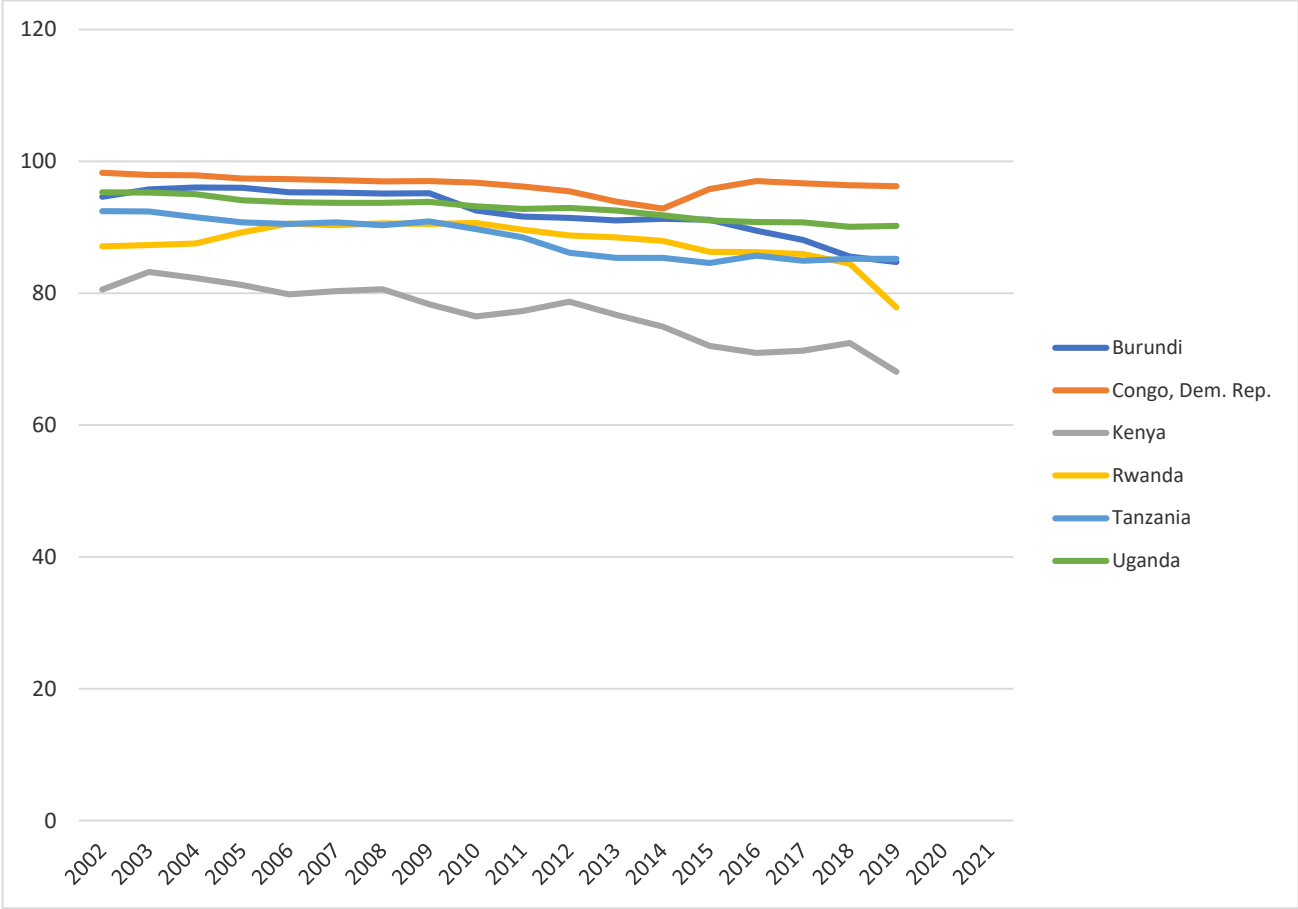


Figure 2: Evolution of Renewable Energy Consumption