THE IMPACT OF FINANCIAL DEVELOPMENT ON RENEWABLE ENENRGY CONSUMPTION IN MAURITIUS

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Abstract - This study examined the asymmetric impact of financial sector development on renewable energy in Mauritius, employing data from 1990 to 2022. The study was motivated by the growing call for countries to reduce their carbon footprint, which has been spearheaded by the United Nations. The study, therefore, aims to examine whether financial development in Mauritius plays a significant role in its renewable energy drive. The study used a financial institution index developed by the IMF to examine the link between the two variables. Using the NARLD (non-linear autoregressive distributed lag) model, the study found positive shocks on financial development to be positively associated with renewable energy consumption in Mauritius. However, negative shocks on financial development were found to have no impact on energy consumption from renewable sources, both in the short run and in the long run. The study, therefore, recommends that Mauritius continue to expand its financial sector to increase its renewable energy consumption and transform its renewable energy mix, as highlighted in its Renewable Energy Roadmap 2030.

Keywords: Renewable energy, Mauritius, NARDL, financial development; financial institution Index.
JEL: C2; G2' Q20

1. INTRODUCTION

The continuous build-up of carbon emissions over the years associated with anthropogenic and natural causes has resulted in climate change, which threatens the achievement of the Sustainable Development Goals, among other national development aspirations. Climate change has increased the frequency and intensity of natural disasters like cyclones, heavy rains, heat waves, drought, coastal erosion, and rising sea levels, among other negative developments.

The scale and severity of the disasters threaten economic growth and development, with governments being financially overwhelmed when trying to support the affected individuals and businesses. There has been a call from international organisations like the United Nations (UN) for each country to take steps to reduce its carbon footprint.

The major contribution to carbon emission is associated with fossil fuels that are used to generate electricity. To reduce carbon emissions and take care of the climate, the United Nations, through the SDGs and the Paris Agreement, calls for a concerted effort to minimise the adverse effects of economic activities on the environment. Mauritius is among the signatories to the SDGs and the Paris Agreement. Thus, the government is supposed to take intentional steps to reduce its carbon footprint.

Mauritius has not disappointed in its drive to increase renewable energy use. The renewable energy drive is ingrained in the legislation, which clearly spells to Mauritius businesses and people that the government fully supports alternative energy sources.

It is against this background that this study aims to investigate the extent to which financial development in Mauritius contributes to its renewable energy consumption. Several studies have been conducted on the link between financial sector development and renewable energy consumption.

Unfortunately, these studies do not fully account for the asymmetric effects of financial sector development on energy demand. There is a growing body of literature advocating for an asymmetric relationship since negative and positive shocks on financial sector development might not affect renewable energy demand in the same way.

This study examined the dynamic relationship between financial sector development and renewable energy consumption using a non-linear ARDL (NARDL) approach. The NARLD approach shows how negative and positive shocks on financial sector development affect renewable energy demand.

The results are important to policy makers in formulating appropriate policy response to financial development shocks in Mauritius. Mauritius is an interesting country selected for this study because it is one of the advanced countries classified previously as an upper-income country before COVID-19 and has made great strides in creating an environment that supports a move to cleaner energy.

The findings of this study will provide insights into the relationship between financial development and renewable energy consumption, especially in Africa, where many countries are still in the teething stage when it comes to the implementation of policies aimed at promoting renewable energy explorations.

The rest of the study is divided as follows: Section 2 covers a literature review, which is divided into country-based literature and empirical literature. Section 3 presents the methodology, while Section 4 covers empirical results. Section 5 offers concluding remarks.

2. LITERATURE REVIEW

2.1. Dynamics of financial development and renewable energy in Mauritius

The Bank of Mauritius was established in 1967 following the enactment of the Bank of Mauritius Act in 1966 [1]. Mauritius has established robust supervisory and regulatory flare, contributing to a sound financial sector [1]. The financial sector is supported by a robust legal framework, which includes the Financial Services Act of 2007, the Banking Act of 2004, and several laws that cover several banking services – insurance, anti-money laundering, pensions and securities [1, 2]. Since 2005 Mauritius has streamlined the banking licensing to one licence for both local and cross-border banking services [2]. The Financial Services Commission was established in 2001 and supported by the Private Pension Schemes Act, the Offering Services Act, the Captive Insurance Act, the Insurance Act, the Securities Act and the Financial Services Act [3]. The Commission monitors, regulates, and licenses businesses in the sector covered by the Acts highlight. The Financial Services Commission aims to suppress crime and malpractice, promote transparency and efficiency in the financial market, and ensure the soundness and stability of the financial sector [3]. The banking sector provides several services, such as corporate banking, private banking and wealth management, individual banking, investment management, and global business banking [2].

The Mauritius International Financial Centre (MIFC) provides a well-regulated and transparent platform for cross-border investment and finance [2]. This has attracted international banks, legal firms, investment funds, and corporate services to Mauritius. To date, there are 19 banks, and the sector is projected to contribute 13.1% to GDP, consisting of 972 funds, 176 management companies 176, and employs 9449 employees [2]. Along with its advancement in digital assets, Mauritius has built an ecosystem able to facilitate virtual assets. It has also built a Fintech Hub, which provides a safe environment for crowdfunding and peer-to-peer lending [2]. Mauritius's financial sector also embraces the use of mobile banking, which offers a plethora of services. Thus, like in other developing countries, this step has provided access to many people, even in areas where physical banks are not available. The Bank of Mauritius launched a financial literacy strategy that focuses on protecting and educating customers about financial and banking sector services. Figure 1a illustrates the trends in financial development.

Figure 1a reports the dynamics in financial development in Mauritius captured by the Financial Development Index and broken down into bank-based and market-based measures captured by the Financial Market Index and Financial Institution Index, respectively. Mauritius has experienced a general improvement in financial development during the study period. The bank-based financial sector appears to be strong compared to market-based contribution. Although many studies in the literature have linked an increase in renewable energy consumption to financial development, for Mauritius, renewable energy consumption as a percentage of total energy consumption has declined over the study period, as reported in Figure 1b.

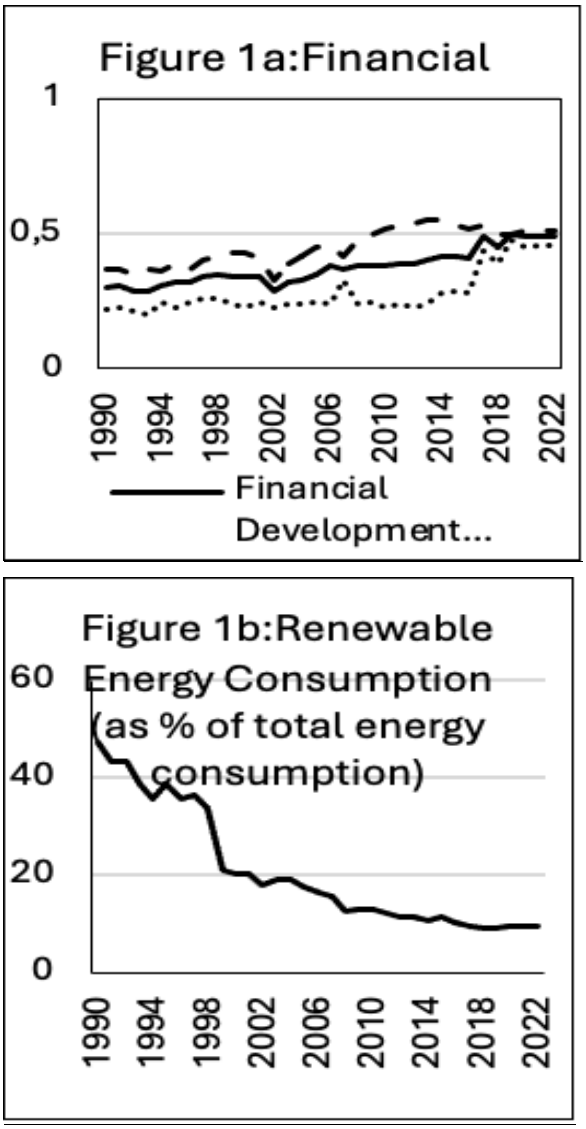

Fig. 1. Financial development from 1990-2022
Source: [4, 5]

Still, on the renewable energy front, Mauritius is a signatory to the SDGs (Sustainable Development Goals), the Paris Agreement, and the COP21 against climate change. This makes the reduction of carbon footprint important to the country on its journey to meet the SDG targets and contribute to the battle to reduce climate change emanating from anthropogenic activities. Mauritius' renewable energy stance is advanced through investment in infrastructure, policy support, and public engagement.

On the policy front, the National Energy Policy launched in 2007 places emphasis on renewable energy and energy efficiency in the country. To facilitate and promote innovation in renewable energy, the Mauritius Renewable Energy Agency was created through Act 11 of 2015 to promote and oversee the exploration of renewable energy in Mauritius. Some of the functions of the agency include, amongst others, outlining a renewable energy

strategic plan every five years; encouraging and supporting studies and research on renewable energy; compiling data on renewable energy use and benefits; contributing to the funding strategy for renewable energy projects; sharing information and knowledge on renewable energy technology; and assessing skills required to explore renewable energy projects [6]. The mandate of the agency is to promote and create a conducive environment for renewable energy development in Mauritius. The Ministry of Energy and Public Utilities plays a big role in shaping policies and driving the transition from non-renewable to renewable energy in the country. The Central Electricity Board (CEB), which falls under the Ministry of Energy and Public Utilities, is responsible for the transmission, distribution, and sale of electricity throughout the country [7]. The CEB produces 37% of its energy requirement from thermal power, and part of the energy requirement is met by independent power producers, mainly through the generation of biogas energy from sugar cane [7].

Mauritius has made strides to reduce carbon emissions and has moved towards cleaner energy sources. The Renewable Energy Roadmap 2030, which was launched in 2019, initially targeted a 35 percent renewable energy mix by 2025 with a scenario of up to 40 percent [8]. However, this was revised to 60 percent by 2030 [8]. The revision reveals the position and commitment the country has taken to reduce the carbon footprints and a shift from the use of fossils in electricity generation. Further, the government offers incentives to companies that invest in renewable energy [7]. Some of the incentives include a full annual allowance of 100 percent on capital expenditures for acquiring green technology, and an eight-year tax holiday for companies investing in deep ocean water air conditioning technology, among other concessions [7]. Figure 1b reports the trends in renewable energy consumption in Mauritius. The trends in renewable energy consumption seem to conflict with the groundwork that has been made to support cleaner energy consumption, necessitating another study for Mauritius.

2.2. Empirical literature

Studies that investigated the effect of financial sector development on renewable energy consumption are inconclusive, and most of them assume a linear relationship between the two. Some studies found a positive relationship between financial sector development and renewable energy, others found no impact between the two, and yet some confirmed a negative relationship.

[9] analysed the impact of economic growth and financial sector development on renewable energy consumption for 13 major oil-exporting countries using data from 1990 to 2020. The study found that financial development has a positive impact on renewable energy in the long run. [10], while employing the ARDL approach and using data from South Africa between 1990 and 2021, found similar results. The study found that there is a positive relationship between financial development and renewable energy supply in both the short and long run. [11] examined the relationship between financial development shocks and renewable energy in Saudi Arabia from 1990 to 2021. Using the Basic Vector Autoregressive model (VAR) and forecasted-error variance decomposition (FEVD), the study found that renewable energy responds positively to shocks in financial development.

[12] studied the relationship between Islamic finances and renewable energy production in 10 Islamic countries during the period between 2013 and 2021. The study found that countries with well-developed Islamic banking systems have high renewable energy production. [14] found that financial sector development to have a significant positive impact on renewable energy in Turkey using data from 1980 to 2019. The study found a 1% increase in financial sector development tends to increase renewable energy consumption by 0.21%. [14] analysed the impact of financial development on non-renewable and renewable energy using data from 37 OECD countries during the period from 2002-2015. Using the GMM, the study found consistent results like [9, 12]. [15], using the ARDL approach and data from 1998 to 2018 for ASEAN +3, found that financial development does not play a role in renewable energy consumption. [16] examined the relationship between renewable energy and financial development in Azerbaijan. The study also found that there is a positive link between financial sector development and renewable energy in the studied country. [17], while assessing the energy revolution in China, found financial sector development to contribute 42.42 percent to variations in renewable energy growth. Capital markets and foreign investment were found to be important sources of renewable energy growth. [18], while examining the relationship between stock market development and renewable energy consumption using data from China, India, South Africa and Brazil during the period from 1990 to 2012, found stock market development to promote renewable energy consumption. [19], in a study on Malaysia using the VECM (Vector Error Correction Model), found that there is a positive and significant relationship between financial sector development and energy consumption in Malaysia.

[20] explored the impact of financial development on renewable energy consumption in emerging markets using data from 1996 to 2015. Using GMM, the study found financial development to contribute positively to the transition to renewable energy consumption. [21] used data from 1997 to 2017 and the ARDL-PMG model to examine the link between renewable energy, financial sector development and economic growth. The study found that financial development has a negative impact on renewable energy consumption in the long run, but a positive impact in the short run. [22], in a panel of 28 countries in the European Union (EU) using data from 1990 to 2015, found that there is a positive relationship between bond market and banking sector and the share of renewable energy consumption. However, capital market development was found to have no significant impact on renewable energy in the studied countries.

Apart from the above-mentioned studies, there are a few studies that used a nonlinear ARDL approach to examine the nexus between financial development and renewable energy. For example, [23] examined the link between financial sector development and renewable energy consumption in the United States using 1975-2019

quarterly data. Using the nonlinear NARDL approach and bank-based and stock-based financial development proxies, the study found that both positive and negative changes in financial development influence renewable energy in the USA.

3. ESTIMATION TECHNIQUES

In this study, the NARDL approach is used to investigate the nexus between financial sector development and renewable energy consumption in Mauritius. The advantage of the NARDL is that it captures the negative and positive shocks. Thus, the approach, in comparison to a simple ARDL, relaxes the assumption of a linear impact of the independent variable on the dependent variable. Following [12] with a modification of some variables, the study uses economic growth, trade openness, CPI and carbon emission as control variables.

Data and definition of variables

The study used an annual dataset spanning from 1990 to 2022. The data was obtained from different sources. Table 1 provides a summary of the definitions of variables, data sources, and the expected sign for each variable.

Table 1. Variable definition

Variable	Description	Source	Expected Sign
REW	Renewable energy consumption as a percentage of total energy consumption	WDI	-
FII	Financial Institution Index – an index of bank-based financial development measures	IMF	FD^+ - +ve impact FD^- - -ve impact
TRADE	Trade openness - a sum of export and imports as a percentage of GDP	WDI	+ve
GDPPC	Gross Domestic Product per Capita	WDI	+ve
CPI	Price level expressed as Consumer Price Index	WDI	-ve

WDI = World Bank Development Indicators
IMF- IMF Financial Statistics Database

Model specification and data.

The study used the following general model.

$$REW = f(FII, TRADE, GDPPC, CPI) \quad \ldots\ldots (1)$$

Where:
REW = Renewable energy consumption
FII=financial development
TRADE = Trade openness
GDPPC = Gross Domestic Product Per capita
CPI = inflation

The financial development variable in Equation 1 can be decomposed into negative and positive partial sums as follows:

$$FII_t = \beta_0 + FII_t^+ + FII_t^- \quad \ldots\ldots (2)$$

Where:

$$FII_t^+ = \sum_{j=1}^{t} \Delta FII_t^+ = \sum_{j=1}^{t} \max(\Delta FII_j; 0) \quad \ldots\ldots (3)$$

$$FII_t^- = \sum_{j=1}^{t} \Delta FII_t^- = \sum_{j=1}^{t} \min(\Delta FII_j; 0) \quad \ldots\ldots (4)$$

Based on the equations above, the NARDL model can be expressed as:

$$\Delta REW_t = \pi_0 + \sum_{i=1}^{p} \pi_{1i} \Delta REW_{t-i} + \sum_{i=0}^{q1} \pi_{2i}^{+} \Delta FII_{t-i}^{+} + \sum_{i=0}^{q1} \pi_{2i}^{-} \Delta FII_{t-i}^{-} + \sum_{i=0}^{q3} \pi_{3i} \Delta TRADE_{t-i} + \sum_{i=0}^{q4} \pi_{4i} \Delta GDPPC_{t-i} + \sum_{i=0}^{q5} \pi_{5i} \Delta CPI_{t-i} + \rho_1 REW_{t-1} + \rho_2^{+} FII_{t-1}^{+} + \rho_3^{-} FII_{t-1}^{-} + \rho_4 TRADE_{t-1} + \rho_5 GDPPC_{t-1} + \rho_6 CPI_{t-1} + \mu_{1t} \quad \ldots\ldots (5)$$

Where:
π_{0i} =constant; $\pi_1 - \pi_5$= short-run coefficients; $\rho_1 - \rho_5$ = long-run coefficients; and μ_{1t}= error term.
The NARDL error correction representation of Equation 5 is given in Equation 6.

$$\Delta REW_t = \pi_0 + \sum_{i=1}^{p} \pi_{1i} \Delta REW_{t-i} + \sum_{i=0}^{q1} \pi_{2i}^{+} \Delta FII_{t-i}^{+} + \sum_{i=0}^{q2} \pi_{2i}^{-} \Delta FII_{t-i}^{-} + \sum_{i=0}^{q3} \pi_{3i} \Delta TRADE_{t-i} + \sum_{i=0}^{q4} \pi_{4i} \Delta GDPPC_{t-i} + \sum_{i=0}^{q5} \pi_{5i} \Delta CPI_{t-i} + \lambda ECM_{t-1} + \mu_{2t} \quad \ldots\ldots (6)$$

Where:
ECM = Error correction term,

In this analysis, the Wald test will be used to test the long-run and short-run asymmetries, while the asymmetric cumulative dynamic multiplier will be used to assess how the dependent variable, i.e., renewable energy consumption, responds to negative and positive changes in financial sector development [24].

4. EMPIRICAL RESULTS

4.1. Unit root test results

Before proceeding with the NARDL, ensuring that no variables included in this study is I (2) or higher is essential. For this purpose, two-unit root tests were used: Phillips-Perron (PP) and Dickey-Fuller Generalised Least Squares (DF-GLS). The results of unit root tests based on these two tests are reported in Table 2.

Table 2. Unit Root Test

	Dickey-Fuller Generalised Least Square (DF-GLS)		Phillips-Perron (PP)	
Variable	Level	Δ	Level	Δ
REW	-0.569	-5.225***	-2.489	-5.625***
FII	-0.957	-6.244**	-1.162	-6.426***
GDPPC	-4.494***	-	-9.519***	-
TRADE	-1.755	-3.941***	-2.330	-3.165***
CPI	1.241	2.249**	0.583	-8.724***

*Note: *, ** and *** denote statistical significance at 10%, 5% and 1% levels, respectively*

The unit root test results reported in Table 2 show that no variable is I (2) or higher. The results show that all the variables are stationary in levels or first difference. Thus, the variables pass the requirement to use the bounds test for cointegration. To proceed with the analysis, the bounds test is conducted to ascertain whether a cointegration relationship exists among the variables included in this study. The results of the bounds test are reported in Table 3.

Table 3. Cointegration Results

F-Statistic		Cointegration Status			
3.393*		Cointegrated			
Asymptotic critical values for					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
1.810	2.930	2.140	3.340	2.820	4.210

*Note: *, ** and *** denote statistical significance at 10%, 5% and 1% levels, respectively*

Results reported in Table 3 confirmed a cointegration relationship among the variables included in this study. The F-statistic (3.393) has been found to be above the upper bound critical value at 5%. Hence, there is cointegration among the variables.

The results of the long and short-run models are reported in Table 4.

Table 4. Empirical Results

Dependent Variable is URBGR		
Panel A: Long-Run Results		
Regressor	**Coefficient**	**T-ratio [p-value]**
$LFII^+$	3.054**	2.543[0.018]
$LFII^-$	0.963	0.937 [0.358]
$GDPPC$	2.031**	3.695[0.001]
$LTRADE$	0.465	1.092[0.285]
$LCPI$	-4.226***	-3.976 [0.000]
Panel B: Short-Run Results		
Regressor	**Coefficient**	**T-ratio [p-value]**
$\Delta LFII^+$	2.311**	3.158 [0.006]
$\Delta LFII^+(-1)$	1.906**	2.893 [0.010]
$\Delta LFII^-$	-0.890	-1.522 [0.145]
$\Delta LFII^-(-1)$	0.601	0.968[0.346]
$\Delta GDPPC$	-0.261	-0.489[0.631]
$\Delta GDPPC(-1)$	-1.277) *	-2.002[0.061]
$\Delta GDPPC(-2)$	-3.196**	-3.711[0.002]
$\Delta LTRADE$	-0.139	-0.393[0.699]
$ECM(-1)$	-0.624***	-5.101 [0.000]]
Panel C: Test statistics and diagnostics		
R- Squared	0.609	
R-Bar-Squared	0.507	
F-statistic [Prob]	5.976 [0.000]	
Panel D: Long- and short-run asymmetry results		
Test	**F-statistic**	**P-value**	**Decision**
W_{LR}	8.000	0.011**	Asymmetric
W_{SR}	10.763	0.004***	Asymmetric

1) *, ** and *** denote statistical significance at 10%, 5% and 1% levels, respectively
2) W_{LR} = long-run asymmetric test
3) W_{SR} = short-run asymmetric test
4) + and - denotes positive and negative shocks.

Results reported in Table 4 show that positive shocks in financial development measured by the financial institution index have a positive impact on renewable energy. This is confirmed by the coefficient of $LFII^{+}$ in the long run and $\Delta LFII^{+}$ and $\Delta LFII^{+}(-1)$ in the short run that are found to be statistically significant at the 5% level of significance. The result supports the notion that advancement in banking sector development leads to an increase in the consumption of renewable energy in Mauritius. This could be through green financing that opens opportunities for new investment by businesses and households in renewable energy sources, such as solar. However, the negative shocks on financial sector development have an insignificant impact on the consumption of renewable energy in Mauritius, irrespective of the time considered.

The results in Figure 2 also confirm that positive shocks on financial sector development tend to have a deeper impact on renewable energy than negative shocks. The findings are consistent with the drive to cleaner energy sources to mitigate climate change that is spearheaded by the United Nations and embedded in the National Development Plans of most countries. The results do not come as a surprise, given the radical steps that have been taken by Mauritius to develop the financial sector and advance clean energy in the country.

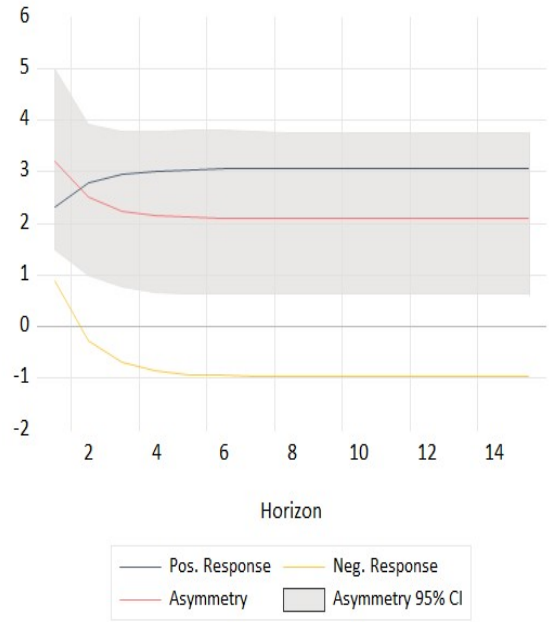

Fig. 2. Cumulative Dynamic Multiplier Graph

Other results presented in Table 4 confirm that economic growth positively affects renewable energy demand in the long run, but it has a negative impact on its consumption in the short run. This shows that although economic growth negatively impacts renewable energy consumption in the short run, in the long run, it contributes significantly to an increase in renewable energy consumption as economic agents accumulate high income to spend on renewable energy projects.

The results highlight the significance of sustained growth in the uptake of renewable energy. The study also found that inflation negatively affects the demand for renewable energy in the long run.

High price levels deter households from investing in renewable energy, which is normally associated with high initial costs. Trade openness was found to have an insignificant impact on renewable energy consumption in Mauritius.

The explanatory power of the model is 61%, with a rate of adjustment to the equilibrium when there is a disequilibrium in the economy of 62.4%. This is confirmed by a negative error correction term of 0.624, which is significant at 1%. Overall, the model was found to be generally stable, as confirmed by the cumulative sum of squares (CUSUMQ) and the cumulative sum (CUSUM) (results not reported here for brevity). Figure 2 reports the cumulative dynamic multiplier.

5. CONCLUSION

This study examines the non-linear relationship between financial sector development and renewable energy consumption in Mauritius using data from 1990 to 2022.

The growing call for countries to reduce their carbon footprint, which is spearheaded by the United Nations, motivated this study to find out whether financial development in Mauritius plays any significant role in its renewable energy drive.

The study used a financial institution index developed by the IMF to investigate the nature and the magnitude of the relationship between the two variables. Using the NARDL approach, the study found positive shocks in financial development to be positively associated with renewable energy consumption in the short and long run.

Thus, advancements in the financial sector have been found to boost renewable energy consumption. However, negative shocks on financial development were found to have an insignificant impact on renewable energy consumption.

The dynamic multiplier graph also confirmed the dominance of positive shocks on renewable energy consumption in Mauritius. Based on these findings, it can be concluded that bank-based financial development plays a positive role in influencing renewable energy consumption.

It is recommended, therefore, that Mauritius continue supporting financial development in its journey to expand renewable energy consumption and reach a 60% renewable energy mix by 2030.

Although scientific rigor was upheld in the analysis and reporting of this study, a few limitations were encountered.

Although it would have been desirable to use a larger sample, the current study period was limited by the availability of reliable annual times series data that was available at the time of the study.

Future studies may expand the study period when the data become available. Future studies may also benefit from market-based financial development measures and other renewable energy measures that have not been used in the current study.

The use of disaggregated renewable energy data may also provide a different insight into the nature of the relationship between financial sector development and renewable energy consumption.

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