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Nexus between Environmental Degradation, Clean Energy, Financial Inclusion, and Poverty: Evidence with DSUR, CUP-FM, and CUP-BC Estimation

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Abstract: This research delves into the intricate interconnections among financial inclusion, the adoption of renewable energy, environmental resilience, and poverty reduction in low-income countries (LICs), lower-middle-income countries (LMICs), and sub-Saharan Africa (SSA), in light of complex issues such as poverty, environmental degradation, and sustainable development. This work comprehensively understands the interaction between these crucial factors by utilizing a dynamic panel model, specifically Dynamic Seemingly Unrelated Regression (DSUR), CUP-FM, and CUP-BC. The empirical analysis conducted in our study has produced findings that are both significant and noteworthy. Financial inclusion pertains to facilitating formal financial services for demographic segments that have historically been marginalized or excluded. A negative relationship between financial inclusion and poverty levels in low-income countries (LICs), lower-middle-income countries (LMICs), and sub-Saharan Africa (SSA) has been observed. Moreover, there is an inverse correlation between the utilization of renewable energy sources and poverty, indicating that the utilization of renewable energy sources possesses the potential to catalyze the enhancement of economic conditions and overall welfare. However, it is important to note that the correlation between environmental deterioration and poverty underscores the urgent necessity for implementing comprehensive policies that address sustainability and poverty reduction. The results above shed light on the potential for governmental interventions to promote positive transformations. Improving endeavors to achieve financial inclusion holds the capacity to empower individuals and businesses alike, fostering economic progress and alleviating poverty. Renewable energy technology is progressively acknowledged as a viable strategy to promote economic advancement and tackle environmental issues simultaneously. It is of utmost importance to establish comprehensive policy frameworks that effectively tackle the intricate interplay between environmental degradation and poverty to create a future that is both sustainable and egalitarian.

Keywords: financial inclusion; clean energy; environmental degradation; poverty; dynamic SUR

Citation: Li, Z.; Qamruzzaman, M. Nexus between Environmental Degradation, Clean Energy, Financial Inclusion, and Poverty: Evidence with DSUR, CUP-FM, and CUP-BC Estimation. *Sustainability* **2023**, *15*, 14161. https://doi.org/10.3390/su151914161

Academic Editors: George Banias, Sotiris Patsios, Konstantinos N. Kontogiannopoulos and Kleoniki Pouikli

Received: 30 August 2023
Revised: 19 September 2023
Accepted: 21 September 2023
Published: 25 September 2023

1. Introduction

Poverty has a staggering effect on the entire economy. It has been estimated that the cost of poverty to the global economy is over USD 1 trillion per year. This tremendous burden affects countries worldwide, leading to diminished economic growth, increased social and economic disparities, and a heightened risk of widespread economic crisis. At an individual level, poverty has a direct economic impact on households, employers, and communities [1,2]. People in poverty often struggle to access basic services or to meet their basic needs, such as food, clothing, and housing. This can cause a considerable amount of stress and have a direct impact on mental and physical well-being [3,4]. As a result, people in poverty often struggle to access quality healthcare and education, entrapping them in a cycle of poverty. At a national level, poverty has a range of economic impacts.

Poor countries tend to have an increased investment risk and lack access to capital. This can lead to a decrease in economic growth, an increase in unemployment, and a decrease in the overall standard of living. The risk of poverty can also lead to increased crime rates, as people turn to crime to survive. Apart from these economic impacts, poverty also leads to inequality. People living in poverty are often denied access to opportunities and resources, further exacerbating their economic disparities. This impacts the overall economic performance of a country, with the country's most vulnerable citizens bearing the brunt of the consequences [5,6].

Poverty has a profound impact on the economy, both in terms of short-term costs and long-term implications. In the short term, poverty can lead to decreased consumer spending, reduced labor productivity, and higher unemployment [7]. These can, in turn, lead to decreased investment in businesses, lower economic growth, and a rise in inequality. In the long term, poverty can cause persistent underinvestment in infrastructure, education, and healthcare, leading to further economic disparities and slower economic growth. Furthermore, poverty profoundly affects economic growth, income distribution, and the labor market. Poor individuals often cannot save, invest, and build a better future for themselves, their families, and their communities. Furthermore, poverty can lead to poor access to basic healthcare, education, and safe drinking water. These issues have a ripple effect throughout the overall economy, leading to slower economic growth and higher levels of inequality [7–10]. Overall, poverty affects the economy in numerous ways. It affects economic growth, income distribution, and labor markets. It also creates a ripple effect, leading to slower economic growth and higher levels of inequality.

The determinants of poverty are complex and multifaceted. They include economic, environmental, political, and social factors. For example, economic determinants include income, wealth, and employment opportunities. Environmental determinants include access to land, water, energy, and natural resources. Political determinants include the legal and regulatory environment and the quality of governance. Social determinants include the quality of education and health services, access to basic services, and the presence of social inequality. Moreover, the determinants of poverty can vary from country to country but typically include factors such as low wages and weak labor markets, inadequate access to financial services, and a lack of government resources. Poverty is often linked to a lack of education, social capital, and gender, racial, and ethnic disparities. By understanding the impact of poverty on the economy and its determinants, policymakers can address the issue more effectively, helping to reduce poverty and promote economic growth [1,11–18].

The study considered energy consumption, financial inclusion, and environmental degradation in the equation of poverty reduction in LICs, LMICs, and SSA for 2000–2018. Regarding financial inclusion's role in poverty reduction, the literature advocates that financial inclusion is a key component of poverty reduction. Financial inclusion can help people access basic services, such as healthcare, education, and housing. It also can help them manage their money better, which helps them save and invest in themselves [19–22]. Financial inclusion is important because it ensures that everyone has an opportunity to participate in society and have a stake in its growth. It also helps poor people become more prosperous by giving them access to financial services such as banking, insurance, and microfinance institutions. In many countries worldwide, people who are financially excluded from mainstream markets cannot save money or make investments that would allow them to improve their lives [23,24]. The relationship between environmental degradation and poverty is not a straightforward one. This is because poverty can be caused by environmental degradation. However, it can also be caused by economic factors that are beyond the control of a country's government or people [13,25,26]. For example, suppose a country has an agriculture-based economy and no suitable land for growing crops. In that case, it will not be able to feed its population properly, which will cause them to become dependent on food imports from other countries and, therefore, increase their vulnerability to economic shocks like weather-related crop failures or disease outbreaks [8,27,28]. On the other hand, if you have an economy based on industry or services such as construction or tourism,

then you may find that pollution causes your business profits to decrease over time due to increased costs associated with cleaning up after industrial accidents or containing health hazards such as wastewater spills [29–33]. The potential to substantially alleviate poverty lies in the increasing accessibility of dependable, affordable, and ecologically sustainable energy sources. Low-income families have the potential to achieve significant cost savings on their energy bills through the adoption of renewable energy sources such as solar and wind power. Households have the potential to enhance their energy independence and reduce reliance on expensive fossil-fuel-derived energy sources through the installation of solar panels or wind turbines [34]. The clean energy transition presents numerous opportunities for industries such as renewable energy installation, production, and maintenance to thrive. The openings above possess the inherent capacity to facilitate the acquisition of gainful employment and subsequent attainment of financial autonomy for individuals belonging to the low-income demographic [35,36]. In low-income areas, the accessibility of clean energy can enhance both health outcomes and academic performance [11]. The mitigation of indoor air pollution and respiratory problems can be achieved by using clean cooking alternatives, such as efficient stoves or biogas systems. Access to consistent energy enhances the quality of study lighting and facilitates greater access to information and communication technologies (ICTs) [37]. The utilization of clean energy has the potential to significantly enhance economic growth and generate employment opportunities in underdeveloped regions. Access to reliable electricity is essential for advancing commercial enterprises, agricultural pursuits, and cottage industries, which play a significant role in poverty alleviation. Low-carbon energy sources effectively mitigate the harmful impacts of global warming. The transition to sustainable energy has the potential to effectively mitigate the adverse effects of climate change on vulnerable populations within communities [2]. It is important to acknowledge that varying energy policies can yield distinct impacts on the capacity of renewable energy to alleviate poverty. To attain a "triple win" scenario that effectively addresses environmental, social, and economic concerns, governments and organizations must prioritize energy policies that mitigate climate change and alleviate poverty.

The motivation of the study is to gauge the potential impact of clean energy, financial inclusion, and environmental quality on poverty level through the implementation of panel data estimation techniques, including a cross-sectional dependency test [16,38], a panel cointegration test following [39], dynamic SUR, and a causality assessment.

The study's contribution to the existing literature can be documented in the following ways: First, the potential effects of energy consumption on poverty have been investigated in the literature. However, the literature support is not extensive and conclusive. Furthermore, the energy transition's effects, that is, clean energy inclusion in the economy and its potential effects on poverty, are still barely investigated in the literature. This paper presents an innovative empirical model that examines the intricate interplay among environmental degradation, the adoption of clean and renewable energy sources, financial inclusion, and their collective impact on poverty reduction. The research aims to comprehensively understand the interaction between sustainable development efforts and their influence on poverty alleviation by integrating multiple components into a unified equation. The holistic model presented in this study offers valuable insights into the complex interplay and potential synergistic effects among environmental, economic, and social factors. By doing so, a deeper understanding of innovative approaches can be employed to effectively develop methods to reduce poverty. Second, this study utilizes a thorough comparative analysis to ascertain the nuanced distinctions and commonalities among low-income countries (LICs), lower-middle-income countries (LMICs), and sub-Saharan Africa (SSA). By conducting a thorough analysis of multiple locations, this research not only highlights the distinct challenges and opportunities specific to each region but also reveals overarching trends and patterns that can provide valuable insights for policymakers and stakeholders in developing focused interventions that cater to the specific needs of each respective region. Incorporating a comparative technique in this research enhances its applicability and relevance to diverse global contexts, ensuring that the findings resonate

beyond particular geographical settings. Third, the research employs a rigorous panel estimation approach, specifically utilizing the Dynamic Seemingly Unrelated Regression (SUR) framework. This advanced methodology enables the analysis to incorporate the variables' dynamic connections and potential interdependencies throughout the research. By employing this methodology, the research examines the dynamic characteristics of the investigated phenomena, resulting in a more accurate and comprehensive understanding of the intricate interplay between environmental degradation, adopting sustainable energy sources, advancing financial inclusivity, and alleviating poverty. Using the Dynamic Seemingly Unrelated Regression (SUR) methodology enhances the statistical robustness of the analysis, reinforcing the credibility and reliability of the study's conclusions.

2. Literature Survey

2.1. Energy Consumption Impacts Poverty Reduction

Energy consumption is a major contributor to global warming and an important factor in poverty reduction. We must ensure our energy is sustainable, affordable, and available to reduce poverty. Energy consumption impacts poverty reduction because it helps us maintain our standard of living and improve our quality of life. Suppose you want to live in a home with electricity and running water. In that case, you need electricity from somewhere, which means burning fossil fuels like coal or oil. But suppose we burn those fuels instead of using solar panels or wind farms. In that case, all those benefits go out the window. Another way poverty reduction is affected by energy consumption is through pollution control measures such as pollution taxes or emissions caps on factories or power plants (which would help reduce air pollution). Pollution taxes would increase prices for consumers who produce more waste than others; emissions caps would limit how much carbon dioxide can be released into the atmosphere by certain companies or industries—again affecting prices paid by companies based on how much waste they produce.

The study by Ogbeide-Osaretin [7] established energy consumption's role in poverty in the Nigerian economy from 1990 to 2017. Using the ARDL model, the study documented that modern energy consumption, including electricity energy, was positively correlated with reducing poverty. In contrast, some non-modern energy was not statistically significant. For this reason, this paper recommended encouraging modern energy supplies to accelerate women's employment and family planning to eradicate the poverty problem. Moreover, Khobai [30] has examined the association between renewable energy consumption, poverty alleviation, and economic growth quarterly for the period 1990–2018 in the South African economy. The study used the ARDL model and VECM, and its findings suggest that renewable energy consumption and economic growth are statistically significant and positively eliminate poverty. The study results suggest that policies encouraging clean technology reduce poverty in such nations. Thiam [40] explored how escalating energy consumption can catalyze shrinking poverty in Sahelian, a developing region of Senegal, from 2008 to 2012. The study concludes that modern energy supply, especially in remote rural areas, unavailability of grid connection, and photovoltaic renewable technology can be a great source, so this study encourages policies for adopting clean technology to diminish poverty. The study of Nnaji et al. [41] documented that improved policy to conserve energy and implement visible industrialization would make employment economically significant in minimizing poverty. Okwanya and Abah [42] unveiled the extension of energy consumption and other factors, such as capital stock and political stability, to alleviate poverty. For Pakistan, Ali et al. [43] suggested that financial development negatively affects the environment, thus controlling carbon emissions and boosting economic growth while alleviating poverty problems. Moreover, aligned findings can be found in Kousar and Shabbir [29]. Using a household energy survey, Openshaw [44] found that wood energy consumption in sub-Saharan Africa is implemented, and around 13 million people can obtain job opportunities, assisting in poverty reduction.

In the study of Tsaurai [6], documented energy consumption and poverty reduction are positively and linearly linked. If proper policies ensure energy consumption, poverty can be reduced significantly. Additionally, Alhassan [45] observes that if households adopt clean fuel energy for their cooking activities, Ghana can be wealthier, so clean energy should be available at the household level to eradicate poverty. In the case of developed and developing nations [8], institutes, expenditures, and electricity consumption have major negative influences on poverty. For data ranging from 1980 to 2010 in the Middle East and North Africa, ref [33] concluded that the energy poverty problem arises mainly from net exports rather than from the domestic scarcity of energy resources. The article also recommends many helpful policies to implement to solve this issue. With a global sample of 51 countries from 2002 to 2014, ref [46] explored an intense causal relationship between energy poverty and earning variation, and the greater the range in earning distribution, the greater the energy poverty problem. The study shares some crucial implications of policies for all the stakeholders to mitigate this issue. Particular evidence is also available in [47–49].

2.2. Nexus between Financial Inclusion and Poverty

Financial inclusion can help poor people access financial services, which means they can start building up savings and investments that will allow them to buy things like food, housing, and education for their children. When people have this kind of wealth, they can improve their lives in many ways—and it is also good for the economy as a whole. The World Bank estimates that if all countries could reach full financial inclusion by 2024 (the date they have set as their goal), it would reduce poverty by half! That means there would be fewer people living in extreme poverty around the world—and those people would not be able to spend all their money on drugs or alcohol instead of buying food for their families. Additionally, financial inclusion is vital to decreasing poverty and inequality by connecting those previously shut out from the formal financial sector to financial services such as savings, credit, payments, and insurance. It helps those impoverished to accrue assets, acquire credit and insurance, and access more affordable goods and services. In addition, it reduces disparities by offering economic opportunities to those who would otherwise be deprived of participating in the financial system. Moreover, it boosts financial literacy and capabilities so people can make more informed financial decisions. Finally, financial inclusion stimulates economic growth by giving people access to capital that can be used to establish businesses and create jobs.

In terms of the nexus between financial inclusion and poverty reduction, the literature revealed the beneficial effects of FI in the process of poverty alleviation [50–55]. For instance, ref [56] studied the role of FI in reducing poverty using secondary data sources from 1992 to 2016 in the Nigerian economy. Studies documented that those not associated with the banking system are poor, and those who are somehow, even a little, linked are doing financially better than those who are not connected. This suggests that banks should be introduced and encouraged to involve people more and reduce poverty significantly. Further evidence can be found in the studies of [23,57], which researched poverty reduction through financial inclusion in sub-Saharan Africa; ref [24], considering 29 European countries; ref [27], considering 33 Indonesian provinces; and ref [19], considering 53 developing nations.

The research of [20] analyzed the impact of financial inclusion on intense poverty and income inequality using data from 2004 to 2017 for 53 developing nations. The study's results indicate that access to financial inclusion has a significant positive effect on minimizing poverty, and few EM countries can close the gap to 0%. Also, if proper measures are taken, poverty can be reduced significantly in some countries by 2030. The study [21] investigated the effect of financial inclusion on economic expansion, poverty rate, income inequality, and financial balance in 34 Asian nations from 1990 to 2017. Studies documented that financial inclusion positively affects these explanatory variables, and governments and policymakers should look into this matter and encourage enhancing financial inclusion in those countries. The paper [22] studied how financial inclusion affects the poverty rate

and economic growth with the help of two models from data from the World Bank's 2017 Global Findex survey in Nigeria. The findings indicate that financial inclusion positively reduces poverty levels in Nigerian households and should be encouraged and enhanced.

2.3. Environmental Degradation and Poverty Reduction

Environmental degradation is a double-edged sword. On the one hand, it allows us to live in a more comfortable environment with less stress, but on the other hand, it can harm our health and the environment. The impact of environmental degradation on poverty is that it makes living conditions more difficult for those already struggling with poverty. This means that people in developing countries have less access to clean water and sanitation facilities, which can lead to higher disease rates among these populations. Environmental degradation also affects food security because it reduces crop yields and makes land unusable for farming purposes due to erosion or soil loss caused by deforestation. This means that people will have less access to food sources like fruits or vegetables, which can lead to malnutrition among children under 5 years old (UNICEF).

Environmental degradation directly impacts economic poverty [58–61]. Poor environmental conditions can cause a lack of access to clean water, food, and other necessities, leading to an increased risk of disease, malnutrition, and other health problems. Furthermore, destroying natural resources can increase the cost of goods and services, thus reducing the purchasing power of individuals and families. In addition, air and water pollution caused by environmental degradation can lead to respiratory and other health problems and damage crops and other agricultural products. All of these factors can lead to increased poverty in the economy. The paper [62] analyzed the correlation between carbon dioxide emission and FDI with poverty with the usage of simultaneous-equation models (SMEs) for data ranging from 1995 to 2017 in 98 developing countries of Asia, Africa, and Latin America. Studies documented that, except for the African economy, there is a negative association between FDI and poverty but a negative correlation between FDI and carbon dioxide in African countries. Also, there is an inverted U-shaped linkage between FDI and carbon dioxide in Asia and a positive association between FDI and environmental quality in Latin America. For the case of SSA, ref [63] explored the environment poverty linkage for data from 1996 to 2014. The study's findings came with three major outcomes: Poverty minimization depends on the environment more than income, and environmental quality has a significant effect. Environmental quality improvements are mainly implemented more frequently in urban areas, which does not significantly reduce poverty. Further evidence is available in the study of [64] with the usage of panel data of 39 sub-Saharan African economies covering data from 1996 to 2018. The study documented that with household net consumption expenditure measurement, FDI and environment decline were not sufficient to control poverty, but with the human development index, they can reduce poverty; with life expectance measurement, FDI and carbon dioxide emission enhance poverty more, and lastly, with FDI and remaining variables, environment decline has no such effect on poverty reduction. The authors of [65] investigated the interrelation of how rising greenhouse gases can pollute the environment and eventually become a major threat to environmental quality but promote rapid economic growth from 1972 to 2014. The results show that energy is the primary pollution factor, and proper actions should be taken to control this while maintaining the economy and reducing poverty. Taking into account panel data, ref [66] studied the correspondence between poverty and the environment for 50 developing countries in Asia, Europe, Latin America, sub-Saharan Africa, and South Asia from 2001 to 2014. The research found poverty is the key factor of environmental hindrance, and extensive policies should be implemented to eradicate the poverty problem. The authors of [18] illustrated that poverty can hamper environmental quality, whereas environmental downfall was independent. The authors of [67] analyzed the causal association between poverty and environmental downfall for the 46 sub-Saharan African countries by taking data from 2010 to 2016. The study documented that electricity accessibility and an economic boost can reduce poverty, while easing environmental degeneration increases poverty. A similar

line of evidence can be found in the study of [28], which investigated the nexus between environmental degradation and poverty with the aid of 175 peer-reviewed articles from the Web of Science published between 1993 and 2020. The findings of the study show that there is an effect of environmental degradation on increasing poverty level in poor and developing economies of countries with four major thematic clusters. Similar findings can be found in the study of [9] in Nagaland; ref [68] for Malaysia, Singapore, Brunei, and the Philippines from 1995 to 2014; ref [69] for global panel data of 146 countries from 1996 to 2014; ref [70] for 2000 to 2013 in China; ref [71], which analyzed the multidimensional characteristics of poverty and how it impacts the environment and society using the 2009 National Health Interview Survey (NHIS) and the 2009 report of Department of Statistics in Taiwan; ref [31], which used time series of secondary data of 2012 to 2016 along with a cross-sector with 38 regencies in East Java, Indonesia; ref [32], considering the period from 1990 to 2015 in Nigeria; and ref [72], considering 33 provinces in Indonesia for 2012–2017.

3. Data and Methodology of the Study

3.1. Model Specification

The motivation of the study is to gauge the effects of renewable energy consumption, financial inclusion, and environmental quality on poverty reeducation in low-income countries and lower-middle-income countries for the period 2000–2019. Based on explained and explanatory variables, the generalized equation can be reported in the following manner:

$$\mathrm{POV} \int \mathrm{ED}, \mathrm{REC}, \mathrm{FI} \tag{1}$$

POV, EQ, REC, and FI denote poverty, environmental degradation, renewable energy consumption, and financial inclusion. After transformation into a natural log of all research variables, the above equation can be reproduced in the following way:

$$\mathrm{POV}_{i,t} = \alpha_{it} + \beta_1 \mathrm{ED}_{i,t} + \gamma_1 \mathrm{REC}_{i,t} + \delta_1 \mathrm{FI}_{i,t} \tag{2}$$

Poverty is defined as a state marked by a lack of crucial resources, such as income, financial means, and access to fundamental necessities for maintaining a minimal standard of living. In the context of this study, the abbreviation "POV" refers to the metric that assesses the level of poverty observed in different regions or countries. Poverty can manifest across multiple dimensions, encompassing economic, social, and human development indicators. The issue of inadequate access to education, healthcare, clean water, and sufficient nourishment is paramount. These deficiencies have led to a decline in overall well-being and limited opportunities for individuals and communities. Environmental degradation is defined as the deterioration in the quality and functionality of natural resources and ecosystems due to human activities. This phenomenon can lead to a decline in biodiversity, the introduction of pollutants, deforestation, soil erosion, and changes in climatic patterns [14,73,74]. In this research study, the term "ED" refers to the extent to which the environment is adversely affected by actions undermining its ability to sustain itself and remain viable in the long term. The ramifications of environmental degradation are far-reaching, affecting various facets, including ecosystems, biodiversity, and society's overall well-being. Consequently, these issues exacerbate the challenges associated with poverty and sustainability.

Renewable energy uses energy derived from naturally replenished sources, such as solar, wind, hydroelectric, and geothermal sources. The acronym "REC" utilized in this research pertains to how societies or regions rely on renewable energy sources to meet their energy needs. Renewable energy is paramount in mitigating greenhouse gas emissions, alleviating climate change, and facilitating a transition towards a more sustainable energy system. Ultimately, this contributes to economic development and the improvement of living conditions. Financial inclusion pertains to the accessibility and availability of formal financial services to all segments of society, with particular attention given to individuals and groups who have historically experienced exclusion or insufficient access. In the

context of this research, the term "FI" denotes the degree to which individuals and entities can access banking services, credit facilities, insurance coverage, and various other financial instruments. Financial inclusion initiatives aim to empower marginalized populations by allowing them to effectively save, invest, and manage their resources. A positive correlation exists between increased financial inclusion and various desirable outcomes, including economic development, poverty alleviation, and improved social well-being.

The variables being investigated, namely EQ, REC, and FI, serve as indicators of fundamental elements within a complex and interconnected framework that greatly impacts the overall well-being of communities. Environmental degradation (EQ) is a concept that elucidates the adverse effects of human activities on natural resources and ecosystems, leading to long-lasting repercussions for both the environment and civilization. Renewable energy consumption (REC) is a feasible and enduring strategy for tackling society's energy needs, as it simultaneously promotes economic growth and mitigates detrimental environmental impacts. Integrating cleaner energy sources is an imperative component in the global transition towards sustainable energy, which is a pivotal factor in mitigating climate change and promoting long-term environmental stability.

Financial inclusion (FI) is fundamental for fostering economic growth and addressing disparities. The provision of financial services to individuals who have been excluded has the potential to unlock their capabilities, promote economic mobility, and empower them to make informed financial decisions. The three variables that have been identified, namely the density of commercial bank branches (per 100,000 adults), the number of depositors with commercial banks (per 1000 adults), and the availability of automated teller machines (ATMs) (per 100,000 adults), possess the potential to make a significant contribution towards poverty reduction. However, it is important to note that the impact of their actions is not direct and is influenced by various mediating factors.

One factor is the provision of financial services and individuals' and businesses' ability to acquire and utilize these services. A higher density of commercial bank branches per 100,000 individuals signifies an elevated level of physical access to banking services. This has the potential to enhance consumers' ability to establish savings accounts, apply for loans, and access other financial products. Financial inclusion pertains to the accessibility and availability of financial services to individuals and communities, specifically targeting those who have historically faced exclusion from the formal financial system. The establishment of bank branches has the potential to enhance financial inclusion by providing individuals, especially those living in marginalized areas, with access to the formal financial system. Incorporating this provision can serve as a proactive measure to safeguard against unforeseen financial burdens and unexpected expenditures.

Another factor is the process of collecting and amassing funds for future utilization. An elevated number of depositors within commercial banks signifies a higher prevalence of individuals choosing to deposit their funds within established financial institutions. The implementation of these measures may encourage a societal inclination towards saving and strengthening financial stability, thereby reducing the vulnerability of individuals and families to poverty during times of economic hardship. An expanded base of depositors can also enhance the overall pool of cash available for lending purposes. Increased deposits in banks have the potential to enhance their willingness to provide loans to individuals and companies, thereby stimulating economic activity that could contribute to poverty alleviation. One of the advantages of this financial service is the convenience it provides in accessing funds. Automated teller machines (ATMs) offer a convenient method of accessing cash and a variety of financial services. This convenience has the potential to assist individuals, especially those residing in remote areas, in accessing their financial resources as needed. As a result, it plays a crucial role in meeting their daily expenses and addressing unexpected situations. One of the advantages of this approach is the potential reduction in transaction costs. The utilization of automated teller machines (ATMs) has the potential to reduce the costs associated with accessing financial services. Reduced transaction costs possess the potential to motivate individuals to opt for formal

financial services rather than informal alternatives, which typically incur higher costs. It is imperative to recognize that although these factors have the potential to contribute to poverty alleviation, their impacts are not guaranteed and may vary depending on the broader economic and policy context. The potential influence of these variables on the mitigation of poverty may depend on factors such as the level of financial literacy, prevailing interest rates, regulatory framework, and the overall economic advancement of a specific region or country.

Furthermore, achieving a comprehensive resolution to poverty requires the implementation of a multifaceted strategy. This strategy should encompass improved access to financial services, along with investments in education, healthcare, infrastructure, and social safety nets. The integration of financial inclusion initiatives within comprehensive development plans holds the potential to enhance the efficacy of poverty alleviation measures.

The correlations among these variables demonstrate a complex and multidirectional nature. The phenomenon of environmental degradation can exacerbate poverty levels through the depletion of valuable resources and the constricting of economic prospects. On the contrary, poverty per se may contribute to adopting unsustainable behaviors that exacerbate environmental degradation [12,75]. The utilization of renewable energy sources possesses the potential to effectively mitigate environmental degradation, consequently leading to a reduction in poverty levels through the enhancement of energy accessibility. Furthermore, the active involvement of individuals in the financial system possesses the inherent capability to bolster their aptitude in efficiently managing their financial affairs, acquiring knowledge, and participating in investments in sustainable energy solutions, contributing to reducing poverty levels and advancing environmental sustainability. Table 1 displays the variables' definitions and proxy measures, and Table 2 presents descriptive statistics.

Table 1. Proxy measures of research variables.

Variable	Notation	Indicator Name	Expected Sign	Data Source
Renewable energy consumption	REC	Renewable energy consumption (% of total final energy)	–	WDI
Foreign direct investment	FDI	Foreign direct investment, net outflows (% of GDP)	–	PAT
Environmental degradation	ED	CO_2 emissions (metric tons per capita)	+	IEA
Gross savings	GS	Gross savings (% of GDP)	–	WDI
Financial inclusion		Commercial bank branches (per 100,000 adults)		
		Depositors with commercial banks (per 1000 adults)		
		Automated teller machines (ATMs) (per 100,000 adults)		
	FI	Financial inclusion index	–	
Financial development	FD	Domestic credit to private sector by banks (% of GDP)		
Remittance	PERM	Personal remittances received (% of GDP)	–	WDI
Poverty		Poverty gap at USD 2.15 a day (2017 PPP) (%)		
		Poverty gap at USD 3.65 a day (2017 PPP) (%)		
		Poverty gap at USD 6.85 a day (2017 PPP) (%)		
	Poverty index	Applying PCA		

Table 2. Descriptive statistics of research variables.

Variables	REC	FDI	Poverty	GS	FI	FD	PREM	ED
Panel A: For LIC								
Mean	71.68455	1.202444	0.316466	14.69041	2.601948	109.9289	0.09688	10.29654
Standard Error	1.267755	0.36445	0.025957	0.53861	0.086527	5.006162	53358941	0.602185
Median	82.11	0.034907	0.142565	14.43907	2.340239	85.7577	0.58908	8.821958
Standard Deviation	28.17727	6.895726	0.58273	9.421826	1.71969	85.39873	1.2109	7.25127
Sample Variance	793.9587	47.55103	0.339574	88.7708	2.957334	7292.943	1.4718	52.58091
Kurtosis	1.087984	57.03484	12.34709	0.845973	1.277117	2.901946	26.04551	6.572764
Skewness	−1.56698	7.014976	3.535821	0.297307	1.126601	1.318262	4.096243	2.160716
Maximum	98.27	75.99954	3.25717	45.21787	8.742912	541.4732	1.1210	49.90132
Panel A: For LIMC								
Mean	56.85747	0.682861	0.861261	20.20926	6.449957	235.1353	1.6909	10.35821
Standard Error	1.282785	0.20516	0.054575	0.906527	0.478418	32.20273	1.6608	2.146184
Median	61.61	0.049026	0.381722	18.06008	2.985161	84.07117	6.4908	7.245775
Standard Deviation	30.1659	4.24934	1.284537	17.41382	8.886219	424.7832	3.7609	13.57366
Sample Variance	909.9815	18.05689	1.650035	303.2411	78.9649	180440.8	1.4219	184.2443
Kurtosis	−0.98216	72.26644	8.28317	60.80915	8.895758	24.3561	38.76588	8.3769
Skewness	−0.50558	8.112707	2.805702	5.75558	2.771703	4.515502	5.789541	2.982606
Range	97.97	52.57597	7.113652	243.8569	57.18544	3010.98	3.2810	58.24945
Maximum	98.27	46.03203	7.133953	223.9539	57.22822	3010.98	3.2810	59.75663
Panel A: For SSA								
Mean	66.78781	1.013551	0.904386	17.77325	5.709007	227.9994	8.6108	10.10609
Standard Error	1.113333	0.28188	0.075083	0.625733	0.370123	17.06912	45681512	0.728864
Median	78.07	0.082719	0.252086	16.28583	3.039129	106.1145	4.3908	4.005809
Standard Deviation	26.1574	5.899304	1.776786	12.67012	8.391272	326.9974	1.0409	14.77636
Sample Variance	684.2098	34.80179	3.156967	160.5319	70.41344	106927.3	1.0718	218.3408
Kurtosis	−0.07032	82.97196	10.83826	0.817894	11.50146	9.742464	3.895175	2.755835
Skewness	−1.01881	8.335612	3.28425	0.277237	3.261311	2.934073	1.963424	1.921692
Range	97.17	85.27023	10.32851	77.75315	54.00243	1956.04	5.7809	66.84207
Maximum	97.88	75.99954	10.34881	57.85018	54.04252	1956.04	5.7809	66.84207

3.2. Justification of the Empirical Model

The regression equation's primary aim is to estimate the influence that carbon dioxide emissions, renewable energy consumption, and financial inclusion have on poverty levels. Each variable's coefficient represents the magnitude and direction of its effect on poverty levels. A positive coefficient signifies that an increase in the variable is correlated with an elevation in poverty, while a negative coefficient indicates the opposite. Financial inclusion

is incorporated into the regression equation due to its positive impact on mitigating energy poverty [76]. That is, the sign of FI on poverty is negative; alternatively, $1 < \delta_1 = \frac{POV_{i,t}}{FI_{i,t}}$. Individuals have the opportunity to invest in renewable energy technologies and enhance their energy efficiency, provided they have increased access to financial services. This, in turn, will lead to a reduction in their energy costs and an improvement in their overall economic situation [77]. Hence, it can be argued that the promotion of financial inclusion has the potential to indirectly mitigate poverty through the facilitation of enhanced access to renewable energy resources. Access to financial services enables a broader range of individuals to allocate funds towards essential objectives such as retirement planning, funding a child's education, and other significant goals. It may assist individuals in avoiding falling into poverty in the event of an unexpected disaster, such as the loss of a job or a serious illness. Enhanced access to credit facilities and financial inclusion enhances individuals' capacity to secure loans for significant life investments, such as initiating or expanding a business, pursuing higher education, or acquiring valuable skills for the job market. Consequently, individuals may have the opportunity to augment their income and productivity, thereby enabling them to transcend the confines of poverty. The cost of money transfers, both sending and receiving, can be reduced by implementing financial inclusion strategies. This would enable more individuals to actively participate in the economy. This can potentially expand the range of opportunities for achieving financial success. Enhancing financial literacy enables individuals to make informed decisions regarding their finances. This feat can be accomplished by promoting financial inclusion, which may assist individuals in recognizing and mitigating instances of financial fraud and optimizing their financial resources. Including individuals in the financial system can potentially assist them in both preparing for and managing unforeseen circumstances that may adversely affect their financial stability, such as unemployment or significant health issues. This may help individuals avoid falling into poverty in an unforeseen financial setback [36,78]. Financial inclusion has the potential to significantly mitigate poverty. Financial inclusion has the potential to facilitate individuals in effecting positive transformations in their lives, accumulating assets, and ensuring a more promising future for themselves and their families by broadening their reach to appropriate and easily accessible financial services.

The inclusion of renewable energy consumption in the regression equation is justified because it can directly contribute to poverty alleviation by providing affordable and reliable energy sources [79]. By increasing the utilization of renewable energy sources, households have the potential to diminish their reliance on expensive and environmentally detrimental fossil fuels. Consequently, this transition can lead to enhancements in both their economic circumstances and overall well-being. Thus, it is expected that the sign of REC on poverty will be negative; alternatively, $1 < \gamma_1 = \frac{POV_{i,t}}{REC_{i,t}}$. The utilization of pristine energy sources possesses the inherent capability to bestow advantageous consequences in poverty alleviation. Numerous mechanisms exist through which the utilization of renewable energy sources may contribute to the mitigation of poverty [80]. The utilization of pristine energy sources can bestow economically feasible methods of attaining power, thereby augmenting the overall quality of life for those enduring poverty. A research study has revealed that providing affordable access to electricity can mitigate poverty in emerging economies [81]. Energy efficiency methods can alleviate the affliction of energy poverty by proficiently diminishing energy expenditures. These solutions require significant and long-lasting investments, yet they offer beneficial externalities such as decreased energy consumption and lowered energy costs [82]. Community energy initiatives can assuage energy poverty by facilitating accessible and reliable energy provision at a reasonable and equitable expense. These programs can incorporate indigenous communities in policymaking, mitigating detrimental social repercussions [1,28]. The allocation of monetary resources for sustainable energy endeavors through green financing possesses the capability to alleviate the issue of energy poverty. Based on scholarly research, green financing has been recognized as a viable strategy to address energy poverty, offering effective solutions in both the immediate and prolonged periods [83,84].

The inclusion of carbon dioxide emissions in the regression equation is warranted due to their substantial impact on climate change, posing detrimental consequences for vulnerable populations, particularly those economically disadvantaged [85]. Thus, it is anticipated the sign of the coefficient representing the magnitude of ED will be positive and that excessive CO_2 emission aggravates the present state of the poverty level; i.e., $\beta_1 = \frac{POV_{i,t}}{ED_{i,t}} > 1$. Communities possess the capacity to effectively mitigate the adverse impacts of climate change and enhance the resilience of susceptible populations through reducing carbon dioxide emissions. The degradation of the environment, particularly the excessive emission of carbon dioxide (CO_2), greatly impedes our endeavors to alleviate poverty. Greenhouse gas profoundly influences the intricate tapestry of natural ecosystems and the holistic state of human well-being. First and foremost, the emissions of CO_2 have a profound impact on the delicate balance of our climate, ultimately resulting in the manifestation of unpredictable weather patterns, such as droughts and floods [76,84–86]. These climatic disturbances disproportionately burden impoverished communities, who often lack the necessary resources to adapt or recover from such adversities. These tumultuous weather phenomena disrupt the sacred agricultural practices, leading to diminished harvests and a scarcity of sustenance, thus intensifying poverty levels in the impacted territories.

Furthermore, the emissions of CO_2 originating from various industries have a detrimental impact on the quality of the air we inhale. This, in turn, leads to respiratory ailments, which disproportionately affect marginalized communities residing in economically disadvantaged regions with restricted availability of healthcare resources. Moreover, the relentless deterioration of our natural surroundings, propelled by the emissions of CO_2, sustains a relentless cycle of impoverishment by inflicting detrimental consequences upon the loss of biodiversity and the destruction of our precious ecosystems [34,83]. Indigenous communities, frequently burdened by economic hardships, heavily rely upon the bountiful gifts of Mother Earth for their sustenance. These invaluable resources, such as the abundant fisheries or the lush forests that provide fuelwood and non-timber forest products, serve as the lifeblood of their existence. However, the elevation of CO_2 levels plays a significant role in the augmentation of temperatures, thereby causing disturbances within marine ecosystems and coral reefs that hold the utmost importance for the sustenance of fish populations [87]. Simultaneously, this phenomenon also expedites the pace of deforestation, owing to alterations in precipitation patterns and heightened vulnerability to wildfires. The waning of these essential ecosystems deprives impoverished individuals of crucial income-generating opportunities, exacerbating their profound financial hardships. Moreover, the diminishment of biodiversity resulting from the degradation of our natural surroundings undermines vital ecosystem services, such as pollination and soil fertility regulation, which are crucial for the sustenance of agriculture. This, in turn, directly affects the livelihoods of small-scale farmers who predominantly rely on subsistence farming techniques [1,79].

3.3. The Slope Heterogeneity and Cross-Sectional Dependency Tests

The slope heterogeneity test (SHT) and the cross-sectional dependency (CSD) test are essential tools in statistical analysis. The primary aim of the SHT is to ascertain the presence of heterogeneity in the gradients of discrete categories or variables within a given dataset. Through careful analysis of this heterogeneity, researchers can gain valuable insights into the influence of different factors on their intended outcomes. CSD, however, enables us to ascertain the interdependence of cross-sectional observations. It is of utmost importance to consider the potential violation of one of the fundamental assumptions of independence when working with data. These assumptions are crucial for ensuring the validity of statistical inference. Both tests play pivotal roles in identifying subtleties within datasets and ensuring the robustness of our analyses by accounting for potential variations and dependencies that may have a substantial impact on our results. Therefore, utilizing these tests enhances the validity and reliability of research findings and contributes to the progression of scientific knowledge in an ever-evolving milieu. The present study has implemented several CSD tests following the framework offered by the CD test [88], the

bias-correction LM test from [89], the scale LM test [90], and the LM test [91]. The following equation is to be implemented to derive the test statistics for the CD test:

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{IJ}\underset{d}{\rightarrow}X^2N(N+1)2 \tag{3}$$

$$CD_{lm} = \sqrt{\frac{N}{N(N-1)}}\sum_{I=1}^{N-1}\sum_{J=i+1}^{N}(T\hat{\rho}_{ij}-1) \tag{4}$$

$$CD_{lm} = \sqrt{\frac{2T}{N(N-1)}}\sum_{I=1}^{N-1}\sum_{J=i+1}^{N}(\hat{\rho}_{ij}) \tag{5}$$

$$CD_{lm} = \sqrt{\frac{2}{N(N-1)}}\sum_{I=1}^{N-1}\sum_{J=i+1}^{N}\left(\frac{(T-K)\hat{\rho}_{ij}^2-u_{Tij}}{v_{Tij}^2}\right)\vec{d}\,(N,0) \tag{6}$$

3.4. Second-Generation Panel Unit Root Test

The augmented Dickey–Fuller (ADF) test is an example of a first-generation panel unit root test, which assumes that the cross-sectional units in a panel dataset are independent. However, this assumption is often broken, leading to skewed and untrustworthy results. At the same time, second-generation panel data unit root analyses are designed to withstand the influence of cross-sectional factors. Two of the most popular second-generation panel unit root tests are the CIPS and CADF tests. The CIPS test uses a common factor analysis. This component is then used to adjust for the impact of cross-sectional correlation. The CADF test is a variant of the ADF immune to the effects of cross-sectional dependency. The CIPS and CADF tests are more resilient than first-generation panel unit root tests when the cross-sectional dependency is present. They are, therefore, often favored over first-generation tests when examining panel datasets that may be vulnerable to cross-sectional dependency. The following equation is to be implemented in deriving the test statistics for the stationary test:

$$\Delta Y_{it} = \mu_i + \theta_i y_{i,t-1} + \gamma_i \overline{y}_{t-1} + \vartheta_i \overline{y}_t + \tau_{it} \tag{7}$$

$$\Delta Y_{it} = \mu_i + \theta_i y_{i,t-1} + \gamma_i \overline{y}_{t-1} + \sum_{k=1}^{p}\gamma_{ik}\Delta y_{i,k-1} + \sum_{k=0}^{p}\gamma_{ik}\overline{\Delta y}_{i,k-0} + \tau_{it} \tag{8}$$

$$CIPS = N^{-1}\sum_{i-1}^{N}\partial_i(N,T) \tag{9}$$

$$CIPS = N^{-1}\sum_{i-1}^{N}CADF \tag{10}$$

3.5. Panel Cointegration Test

The Westerlund–Edgerton cointegration test is a statistical technique used to measure the long-term relationship between two or more time-series variables. This cointegration test is based on the Engle–Granger two-step approach. It uses a combination of regressions and unit root tests to assess whether or not there is a long-term relationship between two or more time-series variables. It has been widely used in finance, economics, and other fields for its ability to detect cointegrating relationships. The main advantage of this test is that it allows researchers to identify cointegration relationships quickly and easily without manually calculating various regression parameters. This technique can also be part of an advanced portfolio analysis process as it helps determine optimal portfolio allocation strategies.

The error correction techniques for long-run cointegration assessment are as follows:

$$\Delta Z_{it} = \partial_i' d_i + \varnothing_i\left(Z_{i,t-1} - \delta_i' W_{i,t-1}\right) + \sum_{r=1}^{p}\varnothing_{i,r}\Delta Z_{i,t-r} + \sum_{r=0}^{p}\gamma_{i,j}\Delta W_{i,t-r} + \epsilon_{i,t} \tag{11}$$

The results of group test statistics can be derived with Equations (12) and (13).

$$G_T = \frac{1}{N}\sum_{i-1}^{N} \frac{\varphi_i}{SE\varphi_i} \tag{12}$$

$$G_a = \frac{1}{N}\sum_{i-1}^{N} \frac{T\varphi_i}{\varphi_i(1)} \tag{13}$$

The test statistics for panel cointegration can be extracted by implementing the following Equations (14) and (15):

$$P_T = \frac{\varphi_i}{SE\varphi_i} \tag{14}$$

$$P_a = T\varphi_i \tag{15}$$

3.6. Long-Run Coefficient Estimation: DSUR, CUP-FM, and CUP-BC

Dynamic SUR, offered by Mark et al. [92], was implemented to document the explanatory variables' effects on poverty in the selected panel. Dynamic Seemingly Unrelated Regression (DSUR) is a statistical model that can be used to estimate the parameters of a dynamic system. It considers the correlation between different variables over time and allows us to estimate the parameters more accurately than other estimators. DSUR estimator has become increasingly popular due to its ability to estimate parameters efficiently and accurately, even in dynamic systems with nonlinear relationships. Furthermore, it can be used for forecasting purposes, making it an invaluable tool for researchers in various fields. The following equation is to be implemented in exporting the coefficients of explanatory variables:

$$q_{it} = \alpha_i + \beta_i\left(S_{it,k} - s^*_{it,k}\right) + \sum_{I=1}^{N}\sum_{h=-p}^{P} \omega_{ij\Delta Z_{it-h}} + \mu_{it} \tag{16}$$

Further, this study employed the continuously updated and fully modified (CUP-FM) estimation method as well as the continuously updated and bias-corrected (CUP-BC) estimation method, which was proposed by Bai et al. [93]. These methods were used in an effort to ensure the reliability and validity of our findings. We derived inspiration from recent studies conducted by the authors of [15] and Ulucak and Bilgili [94] that utilized these techniques. The research sample is distinguished by its substantial size and high power values, which strongly support the Cup-FM and Cup-BC estimation methods. The methods above have proven their capability to produce precise outcomes, even when confronted with cross-sectional dependence (CD), endogeneity, and autocorrelation. As a result, they are considered highly effective for conducting panel data analysis compared to alternative estimation methods. One of the primary advantages of these estimation methods is their capacity to generate unbiased and dependable results, especially in the presence of exogenous regressors.

Additionally, they can handle mixed I(1)/I(0) factors and produce reliable outcomes. Even when endogeneity is absent, these methods consistently offer dependable predictions. The Cup-FM estimation method effectively manages a consistent and restricted distribution of model parameters. The parameters are updated continuously over time through simulations until convergence is achieved. This approach assumes the error term adheres to the factor model, as the existing literature outlines.

We aim to improve the accuracy and reliability of our findings by utilizing the Cup-FM and Cup-BC estimation methods. These methods take into consideration potential biases and endogeneity issues. These advanced techniques enable us to extract valuable insights from our panel data analysis, establishing a robust basis for drawing meaningful conclusions. Finally, the following factor model has been finalized:

$$\begin{gathered}\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(\hat{y}_{it} + \hat{\gamma}_{CUP})\left(x_{it} - \overline{X_i}\right)' - T\left(\mu_i'(\hat{\gamma}_{cup})\Delta_{F\varepsilon i}(\hat{\gamma}_{CUP}) + \right.\right.\right. \\ \left.\left.\left.\Delta_{u\varepsilon i}(\hat{\gamma}_{CUP})\right)\right)\right] \times \left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{it} - \overline{X_i}\right)\left(x_{it} - \overline{X_i}\right)'\right]\end{gathered} \tag{17}$$

Figure 1 displays the flows of methodological estimation for the study.

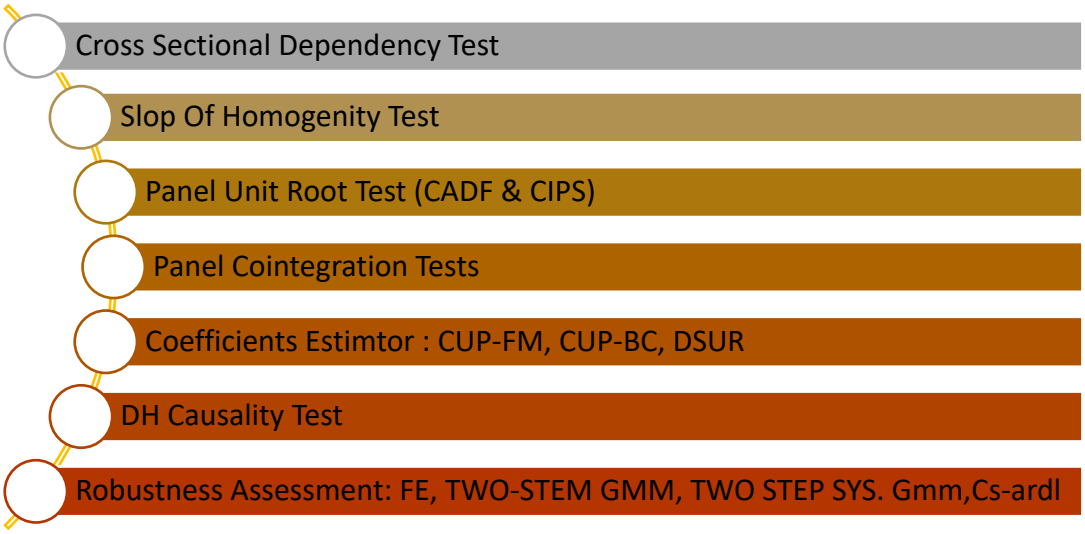

Figure 1. Flows of econometric estimation strategies.

4. Model Estimation and Interpretation

4.1. Cross-Sectional Dependency, Homogeneity Test, and Panel Unit Root Test

Table 3 displays the results of CSD tests with a null hypothesis of cross-sectional independence and the slope heterogeneity test with a null hypothesis of homogeneity. The test statistics of the CSD test established statistical significance at a 1% level, confirming the rejection of the null hypothesis and revealing that all the research units share common dynamics. Moreover, the SHT results revealed the selected variables' heterogeneous properties.

Table 3. Result of cross-sectional dependency and slope of heterogeneity.

	LM_{BP}	LM_{PS}	LM_{adj}	CD_{PS}	Δ	Adj.Δ
Panel A: for LICs						
POV	237.005 ***	40.13 ***	107.391 ***	43.821 ***	20.383 ***	106.367 ***
FI	233.646 ***	28.977 ***	181.097 ***	18.262 ***	66.87 ***	124.362 ***
REC	198.268 ***	34.089 ***	141.099 ***	37.438 ***	30.99 ***	128.666 ***
EQ	158.292 ***	29.32 ***	227.529 ***	52.274 ***	29.971 ***	89.244 ***
FDI	398.911 ***	44.552 ***	174.575 ***	47.943 ***	74.37 ***	123.721 ***
PREM	342.954 ***	26.418 ***	152.069 ***	25.21 ***	81.596 ***	94.121 ***
FD	214.18 ***	34.228 ***	219.804 ***	10.367 ***	94.53 ***	150.702 ***
GS	357.063 ***	20.911 ***	246.672 ***	33.338 ***	79.314 ***	63.513 ***
Panel B: for LMICs						
POV	400.362 ***	25.023 ***	187.104 ***	31.306 ***	22.169 ***	57.386 ***
FII	171.096 ***	35.061 ***	234.745 ***	26.791 ***	50.411 ***	149.847 ***
REC	284.785 ***	25.602 ***	153.787 ***	33.473 ***	91.122 ***	115.071 ***
EQ	433.877 ***	30.821 ***	219.232 ***	51.678 ***	58.78 ***	57.612 ***
FDI	177.166 ***	25.384 ***	236.504 ***	25.707 ***	51.627 ***	76.68 ***
PREM	380.401 ***	28.579 ***	212.971 ***	29.906 ***	70.643 ***	146.842 ***
FD	313.286 ***	26.593 ***	179.361 ***	13.643 ***	83.049 ***	142.79 ***
GS	206.993 ***	39.495 ***	108.149 ***	17.368 ***	29.703 ***	79.941 ***

Table 3. *Cont.*

	LM_{BP}	LM_{PS}	LM_{adj}	CD_{PS}	Δ	Adj.Δ
Panel C: for SSA						
POV	346.68 ***	45.6 ***	160.149 ***	46.436 ***	80.239 ***	136.183 ***
FII	215 ***	17.879 ***	192.689 ***	41.559 ***	50.568 ***	137.467 ***
REC	380.453 ***	21.545 ***	175.53 ***	41.469 ***	49.876 ***	116.169 ***
EQ	369.417 ***	31.5 ***	104.176 ***	40.402 ***	22.771 ***	101.927 ***
FDI	281.82 ***	19.976 ***	226.374 ***	21.909 ***	42.782 ***	141.512 ***
PREM	279.551 ***	37.792 ***	153.634 ***	5.616 ***	65.716 ***	58.03 ***
FD	237.728 ***	37.081 ***	203.02 ***	24.45 ***	44.178 ***	124.707 ***
GS	270.701 ***	34.042 ***	236.829 ***	49.992 ***	91.321 ***	90.768 ***

Note: the superscript of *** explained the level of significant at a 1%.

In the following section, the study implemented the second-generation panel unit root tests, commonly known as CIPS and CADF, offered by Pesaran Pesaran [95]. Panel unit root test results are displayed in Table 4. Referring to the test statistics derived from CIPS and CADF at the level and after the first difference, it is found that all the variables become stationary after the first difference, I (1).

Table 4. Second-generation panel unit root test.

	At Level		Δ	
	CIPS	**CADF**	**CIPS**	**CADF**
Panel A: for LICs				
POV	−1.814	−1.7	−7.596 ***	−7.778 ***
FII	−1.174	−1.163	−7.82 ***	−2.823 ***
REC	−1.001	−1.904	−3.036 ***	−2.586 ***
EQ	−1.22	−1.728	−3.236 ***	−2.497 ***
FDI	−2.884 ***	−2.914	−2.069 ***	−5.81 ***
PREM	−2.38	−1.861	−6.322 ***	−5.369 ***
FD	−1.385	−1.03	−6.43 ***	−6.583 ***
GS	−2.958 ***	−2.143	−3.535 ***	−6.223 ***
Panel B: for LMICs				
POV	−1.47	−1.916	−4.505 ***	−5.354 ***
FII	−1.35	−2.788	−4.493 ***	−6.868 ***
REC	−1.774	−2.388	−5.979 ***	−4.46 ***
EQ	−2.384	−1.318	−6.159 ***	−6.715 ***
FDI	−2.642	−1.358	−4.625 ***	−4.78 ***
PREM	−2.928 ***	−2.143	−5.251 ***	−2.678 ***
FD	−1.129	−1.257	−2.815 ***	−2.855 ***
GS	−2.83	−2.068	−6.572 ***	−4.359 ***

Table 4. *Cont.*

	At Level		Δ	
	CIPS	**CADF**	**CIPS**	**CADF**
Panel C: for SSA				
POV	−2.918 ***	−1.42	−2.954 ***	−6.406 ***
FII	−2.013	−1.367	−3.915 ***	−4.89 ***
REC	−2.524	−2.079	−2.582 ***	−3.071 ***
EQ	−1.245	−2.02	−7.624 ***	−5.615 ***
FDI	−1.132	−2.461	−6.324 ***	−3.144 ***
PREM	−2.185	−1.3	−7.025 ***	−5.186 ***
FD	−1.241	−2.473	−6.792 ***	−3.443 ***
GS	−1.377	−1.948	−5.709 ***	−7.993 ***

Note: the superscript of *** explained the level of significant at a 1%.

The study implemented a panel cointegration test following Westerlund [39], Kao [96], and Pedroni [97,98], and the results are displayed in Table 5, which includes three panels of reporting. The study ascertains a long-run association between poverty, financial inclusion, renewable energy consumption, and environmental degradation.

Table 5. Results of panel cointegration test.

Model	**LICs**	**LMICs**	**SSA**
Panel A: Westerlund PCT			
Gt	−13.706 ***	−14.026 ***	−13.992 ***
Ga	−11.232 ***	−14.33 ***	−12.96 ***
Pt	−13.355 ***	−8.178 ***	−5.483 ***
Pa	−13.897 ***	−11.262 ***	−10.375 ***
Panel B: KRCPT			
MDF	15.85 ***	−0.067 ***	17.948 ***
DF	8.747 ***	13.004 ***	15.56 ***
ADF	4.752 ***	11.391 ***	10.375 ***
UMDF	13.308 ***	−6.741 ***	−1.349 ***
UDF	−9.586 ***	21.383 ***	20.11 ***
Panel C: Padroni PCT			
MDF	−8.863 ***	13.468 ***	10.561 ***
PP	−1.846 ***	6.321 ***	−5.681 ***
ADF	12.728 ***	11.564 ***	15.633 ***

Note: the superscript of *** explained the level of significant at a 1%.

The impact of financial inclusion on poverty has been shown to be negative and statistically significant at a 1% level available in all three panel estimations, suggesting the contracting effect of access to financial services and benefits assisting in overcoming the poverty level (see Table 6). Additionally, the negative coefficients within renewable energy consumption (REC) suggest a correlation between the heightened utilization of renewable energy sources and the diminished prevalence of poverty rates. The potential reasons for this phenomenon may be attributed to various factors, including reduced energy costs and improved energy availability. These factors can yield positive outcomes regarding living standards and economic opportunities. Specifically, for every additional 1% increase in

REC, there is an estimated decrease of 0.163% in the poverty level in LICs, 0.293% in the poverty level in LMICs, and 0.113% in the poverty level in SSA.

The existence of a positive coefficient of CO_2 emissions implies a positive correlation between higher levels of carbon dioxide emissions and increasing poverty levels, suggesting that environmental factors could impact the amelioration of poverty and that giving priority to the mitigation of CO_2 emissions may potentially yield advantageous results in terms of reducing poverty in these particular regions. The negative coefficients of FDI suggest higher levels of FDI offer a lower level of poverty rates. This indicates that an increase in FDI is associated with poverty reduction. That is, FDI possesses the potential to facilitate economic development, offer employment prospects, and bolster infrastructure, thereby playing a substantial role in mitigating poverty. The existence of negative coefficients of remittance indicates an inverse correlation between higher remittance inflows and levels of poverty. Remittances transmitted by migrant workers employed abroad can function as a vital source of income for families residing in these regions, thereby playing a substantial role in alleviating poverty. The existence of negative coefficients concerning financial development suggests the presence of an inverse correlation between the level of financial sector development and poverty rates. A well-functioning financial system can optimize the allocation of funds, facilitate investment endeavors, and foster economic growth, thereby assisting in eradicating poverty. The negative coefficients of gross savings indicate an inverse correlation between savings levels and poverty rates. This implies that higher savings are associated with lower poverty levels. This statement suggests that the promotion of a savings culture and the increase in savings rates could potentially lead to positive results in terms of poverty alleviation.

In a nutshell, the study findings suggest that financial inclusion, renewable energy consumption, foreign direct investment, remittances, financial development, and gross savings positively impact poverty reduction in low-income countries, lower-middle-income countries, and sub-Saharan Africa. On the other hand, environmental degradation aggravates the present poverty level. Therefore, it can be suggested that addressing environmental concerns could contribute to efforts to reduce poverty.

Table 6. Baseline estimation with fixed effects.

	LICs	**LMICs**	**SSA**
FII	−0.201 (0.0157) [−12.695]	0.081 (0.0096) [8.379]	−0.302 (0.0505) [−5.973]
REC	−0.163 (0.0245) [−6.629]	0.293 (0.031) [−9.447]	0.113 (0.016) [−7.047]
EQ	0.326 (0.0415) [−7.853]	0.109 (0.0166) [6.534]	0.301 (0.0232) [12.918]
FDI	−0.114 (0.013) [8.711]	−0.314 (0.0305) [10.285]	−0.192 (0.0166) [11.542]
PREM	−0.54 (0.0463) [11.657]	−0.045 (0.0064) [7.012]	−0.531 (0.045) [11.784]
FD	−0.333 (0.0433) [−7.676]	−0.121 (0.0191) [−6.322]	0.166 (0.0145) [11.392]
GS	−0.426 (0.1065) [−4.011]	−0.131 (0.0111) [−11.754]	−0.207 (0.0161) [−12.79]
Constant	−1.518 (0.2951) [−5.143]	−0.715 (0.0844) [−8.467]	−1.44 (0.1283) [−11.222]
Control	YES	YES	YES
Year	YES	YES	YES
Region	YES	YES	YES
R2	0.8077	0.8592	0.8317

4.2. Dynamic SUR Estimation

Financial inclusion has a beneficial role in alleviating the level of poverty in LICs (a coefficient of −0.1101), LMICs (a coefficient of −0.1058), and SSA (a coefficient of −0.118). Negative coefficients (−0.1101, −0.1058, and −0.118) imply an inverse relationship between financial inclusion and poverty (see Table 7). As financial inclusion increases, there is a

tendency for the incidence of poverty to decline [6,7,20,44,48,51,67]. This proposition is inherently logical, as the provision of financial services and resources to marginalized populations can effectively enhance their economic empowerment by enabling them to effectively manage their finances, make investments, and cultivate assets [6,8,47,72]. The coefficients for the three regions, namely LICs, LMICs, and SSA, exhibit only marginal variations. This statement implies that the effects of financial inclusion on poverty alleviation may vary based on the economic and social context of different regions. When formulating policies and implementing interventions for financial inclusion, it is imperative to duly consider the distinct challenges and opportunities inherent to each specific region [60,67,69,71]. The findings underscore the importance of promoting financial inclusion as a strategic approach to poverty reduction. Individuals and families residing in low-income and developing regions have the potential to enhance their economic prospects, bolster their ability to withstand disruptions, and allocate resources towards education and healthcare, which can be achieved through formal financial services, including banking facilities, credit options, insurance coverage, and savings mechanisms.

The coefficient of clean energy on poverty alleviation has been revealed to be negative and statistically significant at the 1% level in LICs (a coefficient of −0.09878), in LMICs (a coefficient of −0.17267), and in SSA (a coefficient of −0.10039), which is an indication of the controlling effects of clean energy consumption in the process of poverty alleviation through uplifting the standard of living. The presence of negative coefficients (−0.09878 for LICs, −0.17267 for LMICs, and −0.10039 for SSA) suggests that an increase in renewable energy consumption is associated with a decrease in poverty levels, ultimately resulting in an enhancement of the overall standard of living. Our study finding is supported by the findings offered by [2,35–37]. Study findings suggest that promoting and investing in renewable energy initiatives can greatly enhance the economic circumstances of vulnerable populations in these regions. Access to pure energy sources, such as renewable energy technologies, can benefit communities [34]. These advantages include enhanced economic opportunities, reduced energy expenditures, and improved living conditions. Moreover, by reducing their dependence on conventional fossil fuels and shifting towards sustainable energy alternatives, these regions have the potential to alleviate environmental degradation and mitigate the impacts of climate change. Consequently, this would foster a more robust and sustainable economic future. When formulating strategies for poverty reduction and sustainable economic development, policymakers should consider these findings. These findings emphasize the significance of incorporating renewable energy solutions into their agendas to promote inclusive growth and environmental stewardship [34]. The LIC, LMIC, and SSA panels exhibit a notable correlation between environmental degradation and heightened poverty levels. This is supported by positive coefficients, specifically 0.09552 in the LIC, 0.09595 in the LMIC, and 0.175 in the SSA category. A positive coefficient signifies a direct correlation between environmental degradation and poverty, implying that as environmental degradation escalates, poverty levels also rise.

In the context of LICs, the observed positive coefficient of 0.09552 suggests a direct correlation between ED and poverty levels. This proposition posits that as the degradation of the environment intensifies, there is a probable correlation with an increase in poverty levels. Low-income countries (LICs) often encounter challenges when effectively and sustainably managing their natural resources. The primary causes of these problems are rapid population growth, limited resource availability, and the absence of comprehensive environmental legislation. Environmental degradation can adversely impact agricultural production, the accessibility of natural resources, and overall economic activity. Consequently, economically disadvantaged populations may encounter a decrease in income and a rise in susceptibility due to these circumstances. Furthermore, it is worth noting that environmental degradation has the potential to significantly contribute to the occurrence of climate-related catastrophes. These disasters, in turn, have a disproportionate impact on vulnerable populations and exacerbate levels of poverty. In the LMIC model, a coefficient of 0.09595 suggests a positive correlation between environmental degradation and

poverty levels, which suggests that as environmental degradation deteriorates, there is an increased probability of an escalation in destitution within these nations. In numerous instances, lower-middle-income countries (LMICs) experience significant industrialization and urbanization processes, which may lead to heightened pollution levels, deforestation, and resource depletion. Environmental challenges can hinder economic development and intensify poverty by affecting various factors, including livelihoods, food security, and access to clean water and sanitation facilities. Furthermore, it is crucial to acknowledge that the adverse consequences stemming from environmental degradation possess the capacity to hinder endeavors focused on achieving sustainable development and mitigating poverty.

A positive coefficient of 0.175 in sub-Saharan Africa indicates a notable and distinguishable impact of environmental degradation on poverty levels within the region. Sub-Saharan Africa (SSA) is widely recognized for its copious natural resource reserves. However, it encounters noteworthy environmental challenges, including deforestation, land degradation, and the adverse impacts of climate change. The presence of environmental degradation possesses the capacity to disrupt agricultural endeavors, leading to a decrease in productivity and consequently exacerbating the problem of food insecurity. This concern is particularly pronounced among the rural impoverished, who heavily rely on agriculture as their main source of sustenance. Furthermore, it is imperative to acknowledge that a significant sub-Saharan Africa (SSA) populace is actively involved in subsistence agriculture, rendering these people particularly vulnerable to environmental disruptions and disturbances.

Table 7. Results from the DSUR estimation approach.

	Variable	**Coeff**	**Std. Error**	**t-Statistic**	**Coeff**	**Std. Error**	**t-Statistic**	**Coeff**	**Std. Error**	**t-Statistic**
			DSUR			**CUP-FM**			**CUP-BC**	
Low-Income Countries	FII	−0.1101	0.0399	−2.7593	0.1616	0.0175	9.2342	0.1296	0.0397	3.2654
	REC	−0.09878	0.0423	−2.3352	−0.1422	0.0425	−3.348	−0.0952	0.04	−2.3805
	EQ	0.09552	0.0357	2.6756	0.1090	0.038	2.8702	0.0983	0.0372	2.6427
	FDI	−0.14082	0.0365	−3.8580	0.1316	0.0458	2.8733	0.1630	0.0364	4.4802
	PREM	−0.1827	0.0201	−9.0895	0.17323	0.0424	4.0856	0.1218	0.025	4.8728
	FD	−0.14612	0.0353	−4.1393	0.0803	0.015	5.3573	0.0878	0.0242	3.6309
	GS	−0.15638	0.0269	−5.8133	0.0944	0.0438	2.155479	0.1615	0.0417	3.8745
	C	11.295	0.24013	47.037	9.747	0.24013	40.59051	11.817	0.2401	49.2108
Lower-Middle-Income Countries	FI	0.10518	0.0172	6.11511	0.0847	0.0463	1.8304	0.12545	0.0183	6.8551
	REC	−0.17267	0.0309	−5.5880	−0.1308	0.0139	−9.4143	−0.1033	0.0423	−2.4432
	EQ	0.09595	0.035	2.7414	0.15591	0.0226	6.8986	0.10775	0.0268	4.0205
	FDI	0.1112	0.0192	5.7885	0.08043	0.0371	2.1679	0.10327	0.019	5.4352
	PREM	0.0832	0.031	2.6854	0.16649	0.0341	4.8824	0.10154	0.0453	2.2415
	FD	0.10109	0.0327	3.0914	0.10301	0.0208	4.9524	0.11887	0.0434	2.7389
	GS	0.1421	0.032	4.4421	0.12235	0.0246	4.9735	0.09781	0.0212	4.6136
	C	17.036	0.2401	70.9449	9.624	0.24013	40.0782	15.869	0.24013	66.0850

Table 7. *Cont.*

	Variable	Coeff	Std. Error	t-Statistic	Coeff	Std. Error	t-Statistic	Coeff	Std. Error	t-Statistic
			DSUR			**CUP-FM**			**CUP-BC**	
Sub-Saharan African Countries	FII	−0.118	0.0468	−2.5213	0.12135	0.0284	4.2728	0.1197	0.0426	2.8110
	REC	−0.1003	0.0265	−3.7883	−0.1635	0.0198	−8.2601	−0.1431	0.0253	−5.654
	EQ	0.175	0.0151	11.5894	0.07873	0.036	2.1869	0.1457	0.0443	3.2902
	FDI	0.0840	0.0405	2.0745	0.11032	0.0383	2.8804	0.0882	0.0342	2.5809
	PREM	0.1779	0.0339	5.2486	0.13366	0.026	5.1407	0.1338	0.0357	3.7481
	FD	0.1685	0.0327	5.1551	0.15162	0.0141	10.7531	0.1349	0.0243	5.5530
	GS	0.0920	0.0339	2.71504	0.12135	0.0284	4.2728	0.1197	0.0426	2.8113
	C	11.817	0.24013	49.2108	16.691	0.24013	69.5081	16.523	0.2401	68.8085

The empirical model's robustness output has been reassessed. Referring to the sign of the coefficients in MG, AMG, and CS-ARDL, it is apparent that the earlier established relations have been re-established with the robustness test, suggesting a similar vein for association has been unveiled with MG, AMG, and CS-ARDL estimation (see Table 8).

Table 8. Long-run coefficient robustness estimation: MG, AGM, and CCEE.

	MG	AMG	CS-ARDL
Panel A: for low-income countries			
FI	−0.0803 (0.008) [−9.913]	−0.0209 (0.002) [−7.74]	−0.1355 (0.001) [−71.315]
REC	−0.0776 (0.009) [−8.344]	−0.1014 (0.005) [−20.28]	−0.0206 (0.005) [−4.12]
EQ	0.093 (0.008) [10.449]	0.0835 (0.006) [13.046]	0.1289 (0.011) [11.718]
FDI	−0.0731 (0.004) [−15.891]	−0.1005 (0.007) [−13.051]	−0.1081 (0.004) [−25.738]
PREM	−0.0719 (0.002) [−27.653]	−0.0592 (0.005) [−10.763]	−0.1386 (0.006) [−22.354]
FD	0.0297 (0.011) [2.538]	0.1086 (0.011) [9.61]	0.1151 (0.006) [16.681]
GS	−0.1016 (0.004) [−23.09]	−0.0996 (0.004) [−24.9]	−0.1779 (0.006) [−26.161]
Wald test	0.0043	0.0032	0.004
CD test	0.0109	0.0068	0.0033
Panel B: lower-middle-income countries			
FI	−0.0679 (0.009) [−7.461]	−0.0335 (0.004) [−7.79]	−0.0664 (0.006) [−9.764]
REC	−0.0281 (0.008) [−3.193]	0.0891 (0.006) [13.5]	−0.06 (0.002) [−22.222]
EQ	0.0607 (0.006) [9.484]	−0.0766 (0.003) [−23.212]	0.0208 (0.006) [3.25]
FDI	−0.0109 (0.007) [−1.513]	−0.0928 (0.006) [−14.5]	−0.1357 (0.002) [−64.619]
PREM	−0.0929 (0.004) [−22.658]	−0.0993 (0.003) [−27.583]	−0.1745 (0.005) [−31.727]
FD	−0.0447 (0.01) [−4.298]	−0.0679 (0.008) [−8.487]	−0.1377 (0.011) [−11.571]
GS	−0.0392 (0.004) [−9.56]	−0.0212 (0.01) [−2.099]	−0.0803 (0.004) [−16.387]
	0.0326 (0.003) [9.055]	0.0147 (0.006) [2.333]	0.1104 (0.004) [25.09]
Wald test	0.0066	0.0085	0.0067
CD test	0.0092	0.0113	0.0043

Table 8. *Cont.*

	MG	AMG	CS-ARDL
	Panel—C: sub-Saharan Africa		
FI	−0.0106 (0.004) [−2.585]	−0.1176 (0.001) [−61.894]	−0.0964 (0.004) [−20.956]
REC	−0.0219 (0.009) [−2.329]	0.0969 (0.009) [10.093]	0.0378 (0.006) [5.478]
EQ	0.0669 (0.002) [30.409]	−0.0823 (0.005) [−15.826]	−0.0794 (0.011) [−6.786]
FDI	−0.1029 (0.002) [−38.111]	−0.112 (0.007) [−15.774]	−0.1106 (0.008) [−13.654]
PREM	−0.0351 (0.002) [−16.714]	−0.041 (0.008) [−5.012]	−0.0786 (0.009) [−8.02]
FD	−0.0927 (0.003)-[28.09]	−0.1053 (0.004) [−23.931]	−0.0476 (0.004) [−10.818]
GS	−0.0431 (0.005) [−7.836]	−0.0402 (0.003) [−10.864]	−0.0687 (0.005) [−12.722]
	0.049 (0.007) [6.447]	0.0259 (0.011) [2.176]	0.176 (0.009) [17.777]
Wald test	0.0084	0.0106	0.0063
CD test	0.0114	0.008	0.0062

The directional association was investigated using the panel causality test and the results in Table 9. The study documented bidirectional associations between REC, ED, REM, and FD in low-income countries, specifically RECx←→PPV, ED←→POV, and REM←→POV, while unidirectional linkage was revealed between financial inclusion and poverty and between FDI and poverty. For LMICs, the feedback hypothesis holds for explaining causality for REC←→POV, FDI←→POV, and REM←→POV. On the other hand, unidirectional causality is available between financial inclusion, environmental degradation, and poverty. For SSA, the feedback hypothesis holds for explaining causality for REC←→POV, FDI←→POV, and FD←→POV. On the other hand, unidirectional causality is available between financial inclusion, environmental degradation, and poverty.

Table 9. Results of the D-H causality test.

	POV	FI	REC	CO_2	FDI	PREM	FD
				Panel A: for LICs			
POV		1.0329	(2.2731) *	(2.4463) *	1.1732	(2.5972) *	(5.3613) ***
		[1.0887]	[2.3958]	[2.5784]	[1.2365]	[2.7374]	[5.6508]
FII	(4.3421) **		1.577	1.3878	(2.4643) *	(6.0425) ***	(2.0998) *
	[4.5766]		[1.6622]	[1.4628]	[2.5974]	[6.3688]	[2.2132]
REC	(5.882) ***	(3.1498) **		(4.323) **	(4.1455) **	1.221	(5.4378) ***
	[6.1996]	[3.3199]		[4.5565]	[4.3694]	[1.2869]	[5.7314]
CO_2	(3.4888) **	(5.0998) ***	(5.6907) ***		(3.1062) **	(3.8204) **	(4.7236) **
	[3.6772]	[5.3752]	[5.998]		[3.274]	[4.0267]	[4.9787]
FDI	1.1785	(1.9224) *	1.5196	(3.9075) **		(4.7215) **	(3.5866) **
	[1.2421]	[2.0262]	[1.6017]	[4.1185]		[4.9765]	[3.7802]
PREM	(5.2306) ***	(3.832) **	(2.0818) *	1.1774	(4.0913) **		(2.5685) *
	[5.513]	[4.039]	[2.1942]	[1.241]	[4.3123]		[2.7072]
FD	(5.5122) ***	(5.5696) ***	(6.0403) ***	(4.1285) **	(1.9256) *	(3.7651) **	
	[5.8098]	[5.8703]	[6.3665]	[4.3515]	[2.0295]	[3.9684]	

Table 9. *Cont.*

	POV	FI	REC	CO_2	FDI	PREM	FD
Panel B: for LMICs							
POV		0.9022	(4.3889) **	0.849	(2.4505) *	(5.7173) ***	1.7194
		[0.9509]	[4.6259]	[0.8949]	[2.5829]	[6.026]	[1.8122]
FII	(2.6354) *		(2.2996) *	(3.7587) **	(3.5897) **	(5.9553) ***	(6.0743) ***
	[2.7778]		[2.4238]	[3.9617]	[3.7836]	[6.2769]	[6.4024]
REC	(4.7608) ***	(6.0403) ***		1.3698	(4.2709) **	(4.594) **	(2.7236) *
	[5.0179]	[6.3665]		[1.4437]	[4.5016]	[4.8421]	[2.8707]
CO_2	0.9181	(4.8076) ***	0.9585		(2.5366) *	(3.9001) **	1.6153
	[0.9677]	[5.0672]	[1.0103]		[2.6736]	[4.1107]	[1.7025]
FDI	(4.1562) **	(2.6163)*	(3.051) **	(3.6524) **		(4.2167) **	(4.7236) **
	[4.3806]	[2.7576]	[3.2157]	[3.8497]		[4.4444]	[4.9787]
PREM	(4.012) **	(3.0765) **	(4.3358) **	(5.2412) ***	(3.6769) **		(4.5504) **
	[4.216]	[3.2426]	[4.5699]	[5.5242]	[3.8754]		[4.7962]
FD	(3.2433) **	(3.8777) **	(3.7715) **	(5.5356) ***	1.8724	(1.9564) *	
	[3.4184]	[4.0871]	[3.9751]	[5.8345]	[1.9735]	[2.062]	
Panel C: for SSA							
POV		(4.1424) **	(2.5919) *	1.8034	(4.4548) **	1.1838	(3.56) **
		[4.366]	[2.7318]	[1.9007]	[4.6953]	[1.2477]	[3.7522]
FII	0.8342		(4.7396) **	1.4484	(2.8278) *	(5.6163) ***	1.2019
	[0.8792]		[4.9955]	[1.5266]	[2.9805]	[5.9196]	[1.2668]
REC	(5.7258) ***	(3.2146) **		(2.764) *	(3.2316) **	(3.2646) **	(2.814) *
	[6.035]	[3.3882]		[2.9133]	[3.4061]	[3.4409]	[2.9659]
CO_2	1.7683	(4.1891) **	(2.866) **		(5.7927) ***	1.7396	(2.4187) *
	[1.8638]	[4.4153]	[3.0208]		[6.1055]	[1.8335]	[2.5493]
FDI	(4.7343) **	1.0382	1.6471	(3.3421) **		(2.6397) *	(4.5621) **
	[4.9899]	[1.0943]	[1.7361]	[3.5226]		[2.7822]	[4.8085]
PREM	(2.78) *	(4.1679) **	1.6684	(5.3889) ***	(5.9043) ***		(4.4537) **
	[2.9301]	[4.3929]	[1.7585]	[5.6799]	[6.2231]		[4.6942]
FD	(3.6822) **	(4.2274) **	(4.7619) ***	(4.729) **	(6.017) ***	(4.2731) **	
	[3.881]	[4.4556]	[5.0191]	[4.9843]	[6.3419]	[4.5038]	

Note: the superscript of ***/**/* explained the level of significant at a 1%, 5%, and 10%, respectively.

5. Discussion

The study documented an advanced linkage between the level of financial inclusion and poverty level in all sub-sample panel estimations, indicating that financial services in the financial system offer households an expansion of consumption and earning possibilities, eventually playing a critical role in poverty level alleviation. Our study finding is supported by studies in the existing literature such as [50,51,99–101]. There are numerous advantages associated with financial inclusion. Individuals with the privilege of accessing formal financial services can securely store their funds, obtain credit for investment purposes and unforeseen circumstances, and engage in comprehensive financial planning. This empowerment can result in increased economic opportunities, improved quality of life, and reduced vulnerability to economic fluctuations. However, it is crucial to remember that the efficacy of financial inclusion methodologies varies depending upon the distinct

circumstances of each locale. Various factors, such as cultural, societal, and economic considerations, can significantly influence the adoption and utilization of financial services. In addition, it is important to consider the impact of financial services' quality and accessibility, as well as regulatory regimes, on the overall effectiveness of financial inclusion initiatives.

The potential for poverty reduction in developed and developing nations can be significantly enhanced by implementing financial inclusion. Financial inclusion pertains to the facilitation of access to formal financial services, encompassing savings accounts, credit, insurance, and payment systems, for communities that have been historically underserved. Throughout history, individuals with low income have encountered considerable obstacles in their attempts to access these services, primarily due to the absence of necessary documentation or the high costs of opening an account. Enhancing financial inclusion rates via mobile banking technologies or targeted initiatives offering microfinance loans or business training opportunities to underprivileged entrepreneurs could reduce global poverty levels. Enhanced financial literacy and accessibility can empower individuals and households with limited resources and economic instability to exercise greater authority over their finances, facilitating better management of household expenses and mitigating the risk of dire circumstances such as malnourishment or homelessness. Consequently, expanding upon this phenomenon has the potential to not only stimulate heightened economic expansion but also promote fair allocation of resources among the general population, thereby facilitating the establishment of parity in income distribution across societies. Despite persistent challenges, such as language barriers and cultural practices in certain regions, it is imperative to effectively prioritize enhancing inclusive finance mechanisms to combat global poverty trends.

This study highlights the positive effects of renewable energy consumption on poverty alleviation in low-income countries (LICs), lower-middle-income countries (LMICs), and sub-Saharan Africa (SSA). The existence of negative coefficients (-0.09878 for LICs, -0.17267 for LMICs, and -0.10039 for SSA) implies that an escalation in renewable energy consumption is linked to a decrease in poverty, thus facilitating an enhancement in the worldwide quality of life. This proposition posits that the promotion and investment in renewable energy initiatives possess the potential to considerably enhance the economic conditions of vulnerable populations in these regions [15,16,30,40,102]. Access to pure energy sources, specifically those obtained from renewable energy technologies, offers communities many advantages. Firstly, it facilitates the promotion of enhanced economic opportunities through its support of the development of new industries, the creation of new jobs, and the stimulation of increased economic activity. The proliferation of renewable energy initiatives has led to a commensurate rise in construction, maintenance, and operation employment opportunities. Furthermore, not only do these opportunities strengthen the local economy, but they also significantly contribute to its overall growth. Moreover, the utilization of renewable energy sources has the potential to effectively mitigate energy expenses for both individual households and commercial enterprises. It is widely acknowledged that conventional fossil fuels entail significant expenses, as their prices are susceptible to fluctuations in the global market. By adopting renewable energy sources, communities can diminish their dependence on expensive imported fuels and establish a more stable structure for energy costs. This would subsequently enable allocating resources to other indispensable requirements [13,26,36].

Moreover, the enhanced access to renewable energy can substantially enhance living conditions. Clean energy solutions in rural locations have the potential to power vital services, including schools and healthcare facilities. As a result, this has the potential to significantly enhance the quality of life for the occupants [13,22,26,28,36,83]. Furthermore, providing electricity catalyzes the enhancement of communication, education, and skill acquisition, thereby substantially contributing to endeavors focused on poverty reduction. In addition to the direct economic benefits, adopting renewable energy alternatives yields significant environmental consequences. Through a deliberate reduction in their depen-

dence on conventional fossil fuels, these regions possess the inherent capacity to effectively alleviate environmental degradation, curtail greenhouse gas emissions, and make substantial contributions to worldwide endeavors to combat the pressing issue of climate change. Adopting an environmentally sustainable approach not only confers advantages upon local communities but also safeguards natural resources and ecosystems for the benefit of future generations.

The impact of energy consumption on poverty reduction is a complex issue that requires a thorough understanding of the different factors at play. First, it is important to note that energy consumption does not cause poverty. The link between energy consumption and poverty is more about how people use their money and resources and their ability to produce goods or services that can be sold for money. For example, if you have access to electricity but no way to sell the electricity back into society (which is often the case in developing countries), you are still poor even if your house has electricity! The second thing we need to consider is whether or not energy consumption causes economic growth. Some studies have shown that as countries develop economically, they tend to use more energy, but others show that this is not always true; some countries have developed without experiencing an increase in their energy consumption rates.

For the case of the environmental degradation and poverty nexus, the research findings indicate a significant correlation between environmental degradation and heightened poverty levels in low-income countries (LICs), lower-middle-income countries (LMICs), and sub-Saharan Africa (SSA). This is demonstrated by the positive coefficients of 0.09552 in the low-income county (LIC) category, 0.09595 in the lower-middle-income country (LMIC) category, and 0.175 in the sub-Saharan Africa (SSA) category. A positive coefficient signifies a direct correlation between environmental degradation and poverty levels, suggesting that poverty levels also tend to rise as environmental degradation escalates. In the context of LICs, a positive coefficient of 0.09552 signifies a direct correlation between environmental degradation and poverty levels in low-income countries. This implies that poverty levels are anticipated to escalate as environmental degradation deteriorates. Low-income countries (LICs) frequently encounter challenges when efficiently and sustainably managing their natural resources. These issues primarily arise due to rapid population expansion, limited resource availability, and the lack of comprehensive environmental legislation. The detrimental consequences of environmental degradation may adversely affect agricultural output, natural resource availability, and overall economic activity [59,103,104].

As a consequence, such circumstances can lead to a decrease in earnings and an increase in vulnerability among impoverished populations. Furthermore, the degradation of the environment may potentially contribute to the occurrence of climate-related catastrophes. These catastrophes, in turn, disproportionately affect vulnerable populations and exacerbate poverty levels. A positive coefficient of 0.09595 in the LMIC model indicates a positive correlation between environmental degradation and poverty levels in lower-middle-income countries. This suggests that as environmental degradation deteriorates, there is an increased probability of escalating poverty levels within these nations. In many instances, lower-middle-income countries (LMICs) experience significant industrialization and urbanization processes, which can lead to increased pollution levels, deforestation, and resource depletion. Environmental challenges can hinder economic advancement and exacerbate poverty rates by affecting various facets, including livelihoods, food security, and the accessibility of clean water and sanitation facilities. Moreover, the adverse ramifications of environmental degradation possess the capacity to hinder efforts directed toward achieving sustainable development and mitigating poverty [17,26,103,104]. A positive coefficient of 0.175 in the SSA suggests a heightened and discernible impact of environmental degradation on poverty levels within the sub-Saharan Africa region. The sub-Saharan Africa (SSA) region is widely recognized for its plentiful natural resources. However, it is also confronted with significant environmental challenges, including deforestation, land degradation, and the adverse impacts of climate change. The occurrence of environmental degradation possesses the capacity to disrupt agricultural activities, thereby leading to

a decrease in output and ultimately contributing to the problem of food insecurity. This concern is particularly evident among the rural poor, who heavily rely on agriculture as their main source of sustenance. Furthermore, it is worth noting that the sub-Saharan Africa (SSA) region exhibits a considerable proportion of its population engaged in subsistence agricultural pursuits, thereby making them particularly vulnerable to environmental shocks and disturbances. Overall, the existence of positive coefficients in all three domains suggests a noteworthy correlation between the degradation of the environment and the intensification of poverty levels. The findings align with established research in environmental economics and substantiate the notion that a reciprocal correlation often exists between poverty and environmental degradation. The nature of this relationship can be described as a self-perpetuating cycle in which poverty serves as a driving force for the unsustainable exploitation of resources. Consequently, this leads to further degradation of the environment, subsequently exacerbating levels of poverty [17,102,104–107].

The mitigation of the adverse effects of environmental degradation on poverty requires the implementation of comprehensive and sustainable development initiatives. It is of utmost importance for policymakers to prioritize the preservation of the environment, allocate resources towards the sustainable management of resources, and actively advocate for the enhancement of climate resilience. The implementation of policies and activities that are specifically designed to address poverty alleviation and environmental sustainability simultaneously has the potential to significantly contribute to the promotion of a more equitable and sustainable development trajectory in nations with low and middle income levels [15,16,30,40,102,103]. Moreover, the importance of international collaboration and assistance cannot be overemphasized when addressing global environmental challenges. Environmental concerns frequently extend beyond national borders and require collective efforts to achieve significant and long-lasting results.

As nations continue to suffer from the effects of environmental degradation, poverty has become a more pressing issue. Deforestation, air and water pollution, soil erosion, and desertification all contribute to decreased quality of life for people in these areas. This is because the resources these people rely on for their livelihoods are depleted rapidly. As a result, their economic situation worsens, and they cannot secure the necessities of life. Moreover, environmental degradation can directly impact a country's economic development. Poor air and water quality can hinder the growth of industries, while soil erosion and desertification can reduce agricultural production and limit access to valuable resources. This, in turn, can lead to an increase in poverty levels, as people are unable to find adequate employment or sustain a decent standard of living.

6. Conclusions and Suggestions

The findings of this research underscore the intricate interdependencies between financial inclusion, utilization of renewable energy, environmental degradation, and the alleviation of poverty in low-income countries (LICs), lower-middle-income countries (LMICs), and sub-Saharan Africa (SSA). The present study has employed a dynamic panel model to yield significant findings that carry substantial implications for policy and practical implementation. The noteworthy inverse associations between financial inclusion and poverty in all three locations emphasize the critical significance of enabling individuals' access to formal financial systems to address poverty. The coefficients (-0.1101 for low-income countries (LICs), -0.1058 for lower-middle-income countries (LMICs), and -0.118 for sub-Saharan Africa (SSA)) highlight the importance of efforts focused on improving financial inclusion, as they possess the capacity to generate significant poverty alleviation outcomes. Financial inclusion is pivotal in enabling individuals and businesses to access banking, credit, insurance, and savings services. This accessibility facilitates pathways to achieving economic stability, increasing income levels, and improving the overall quality of life. However, it is crucial to recognize the contextual complexities that impact the effectiveness of these efforts, encompassing elements such as cultural sensitivities and regulatory frameworks. The research underscores the advantages of employing renewable

energy sources in alleviating poverty. The inclusion of negative coefficients (−0.09878 for low-income countries (LICs), −0.17267 for lower-middle-income countries (LMICs), and −0.10039 for sub-Saharan Africa (SSA)) provides valuable insight into the potential effects of clean energy adoption on enhancing economic conditions and overall well-being. The adoption of renewable energy technology catalyzes economic expansion and the generation of employment opportunities. Additionally, it alleviates energy expenses and enhances access to critical services such as healthcare and education. Moreover, incorporating renewable energy sources aligns with global initiatives to mitigate climate change and preserve natural resources, thereby contributing substantially to sustainable development. However, the research also highlights the correlation between environmental degradation and socioeconomic impoverishment. The positive correlations (0.09552 for low-income countries, 0.09595 for lower-middle-income countries, and 0.175 for sub-Saharan Africa) underscore the robust correlation between worsening environmental conditions and heightened poverty levels. Environmental problems can hurt economic activity, particularly in communities heavily dependent on natural resources. This may lead to a reduction in livelihood opportunities and an increase in vulnerability levels. This statement underscores the urgent need for comprehensive policies that address the dual challenges of environmental preservation and poverty alleviation.

To effectively address the issues above and maximize the opportunities highlighted in this research, policymakers and stakeholders should adopt the following strategies:

First, policymakers and stakeholders should implement strategic initiatives aimed at improving the accessibility of financial services, with a particular focus on marginalized individuals who face significant barriers to entry. There is a pressing need to advocate for the utilization of digital financial services as a means to effectively tackle regional disparities and mitigate the costs associated with transactions. Implementing financial literacy programs is paramount in providing individuals with the knowledge and abilities to make sound and informed financial decisions.

Second, a potential strategy for enhancing energy accessibility, particularly in rural regions, is allocating resources toward developing and implementing renewable energy infrastructure and technologies. Implementing incentives to foster private sector engagement in renewable energy projects may be viable and productive. Policymakers and stakeholders should facilitate the transfer of cutting-edge technology and effectively implement comprehensive capacity-building programs to promote and encourage the widespread adoption of sustainable energy solutions.

Third, a potential approach to addressing poverty and environmental degradation is integrating policies about poverty and the environment. By adopting this approach, policymakers can formulate comprehensive strategies that effectively address poverty alleviation and environmental sustainability. This integrated approach acknowledges the interconnectedness between poverty and environmental issues, recognizing that poverty frequently exacerbates such issues. We kindly propose a comprehensive array of solutions that adeptly address the intertwined challenges of poverty alleviation and environmental sustainability. We strongly advocate for the implementation of sustainable resource management methods, the establishment of afforestation initiatives, and the allocation of capital towards clean energy solutions. These measures should specifically focus on their direct positive impact on economically disadvantaged areas.

Author Contributions: Z.L.: conceptualization; investigation; writing—review and editing; M.Q.: conceptualization; investigation; data curation; validation; writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This paper was supported by the Institute of Advanced Research (IAR), United International University (UIU), Reference No. IAR-2023-Pub-046.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are openly available in WDI. These data can be found at https://databank.worldbank.org/source/world-development-indicators (accessed on 10 March 2023).

Conflicts of Interest: The authors declare no conflict of interest.

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