Does Renewable Energy Consumption and Health Expenditures Decrease Carbon Dioxide Emissions? Evidence for sub-Saharan Africa Countries

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Abstract: This paper employs panel methodological approaches to explore the link between per capita carbon dioxide (CO_2) emissions, per capita real gross domestic product (GDP), renewable energy consumption, and health expenditures as health indicator for a panel of 42 sub-Saharan Africa countries, spanning the period 1995-2011. Empirical results support a long-term relationship between variables. In the short-run, Granger causality reveals the presence of unidirectional causalities running from real GDP to CO_2 emissions, to renewable energy consumption, and to heath expenditures, and bidirectional causality between renewable energy consumption and CO_2 emissions. In the long-run, there is a unidirectional causality running from renewable energy consumption to health expenditures, and bidirectional causality between health expenditures and CO_2 emissions. Our long-run elasticity estimates document that both renewable energy consumption and health expenditures contribute to the reduction of carbon emissions, while real GDP leads to the increase of emissions. We recommend these countries to pursue their economic growth and invest in health care and renewable energy projects, which will enable them to benefit from their abundant wealth in renewable energy resources, improve the health conditions of their citizens, and fight climate change.

Keywords: Carbon dioxide emissions; renewable energy consumption; health expenditures; panel econometrics; sub-Saharan Africa.

JEL classification: C33; I15; Q42; Q54; O55.

1. Introduction

The World Health Organization (WHO, 2015) argues that 18% of global carbon dioxide (CO_2) emissions are attributed to energy and to the fuel used by the residential sector. The expansion of greenhouse gas emissions is a serious danger on the environment and on human health. Is it estimated that the adoption of cleaner technologies for renewable energy production (solar, wind, geothermal, biogas, etc.) can substantially reduce emissions of climate change pollutants by about 0.4-0.9 billion tons of CO_2 emissions between 2010 and 2020.

Moreover, there is much consideration that health care facilities play an important role in combating climate change. In fact, health care facilities have been estimated to represent between 3% and 8% of the climate change footprints in developed countries (WHO, 2011). However, there are no health sector estimates on a national level across South-East Asian and Sub-Sahara African countries. Both electricity access and hospital electricity consumption data in countries of South-East Asia and sub-Saharan Africa reflect far lower energy use rates compared to developed countries (USAID ECO-III Project, 2009). In addition, it has been estimated that between 200.000 and 400.000 hospitals and health clinics in developing countries have no electricity or have unreliable electric supplies (WHO, 2015).

Sub-Saharan Africa countries are rich in renewable resources, while investment projects in renewable technologies are crucially needed for the development of their economies. The installation of photovoltaic solar panels or wind turbines could be a good idea to feed health facilities in electricity. Moreover, encouraging developing countries to adopt clean technologies turns out to be a good policy to stimulate higher health quality and decreases carbon emissions levels to combat global warming.

This paper considers the dynamic causal links between carbon dioxide emissions, economic growth, renewable energy consumption, and health expenditures as health indicator in the case of a panel framework. We will discuss the interactions that might exist between renewable energy consumption and health expenditures and their environmental impact by considering a sample of sub-Saharan Africa countries. We firmly believe that there is no panel empirical study that has considered the dynamic links between renewable energy consumption and a health indicator. This study has the objective to fill this gap, particularly on focusing on sub-Saharan Africa countries which have low health indicators compared to developed countries, and have insufficient investments in renewable energy projects while being rich in renewable energy resources.

The remaining of the paper is organized as follows. Section 2 is about literature review. Section 3 describes the used data set and the empirical methodology. Section 4 presents the empirical results, and Section 5 provides a discussion of the obtained findings. Finally, Section 6 concludes the paper with policy recommendations.

2. Literature review

Our research is related to the literature dealing with renewable energy consumption, economic growth, and CO_2 emissions, and that dealing with health indicators and pollutant emissions. Earlier empirical analysis discuss the interdependence between renewable energy consumption and economic growth (e.g., Sadorsky, 2009; Apergis and Payne, 2010a, 2010b, 2011; among others) or between renewable energy consumption and CO_2 emissions (e.g., Apergis et al., 2010; Menyah and Rufael, 2010; Ben Jebli et al., 2015a; Ben Jebli et al., 2016; Ben Jebli and Ben Youssef, 2015; among others). These previous empirical studies document that the presence of Granger causality as well as the direction of causality between output, renewable energy consumption and carbon emissions depends on the selected data, the considered period, and the used econometric method. Nevertheless, most of these studies agree on the causality between renewable energy consumption and economic growth and the positive impact of renewable energies on both economic growth and the environment.

Several other determinants (i.e., trade, tourism) of carbon emissions have been taken into consideration in the recent literature. Trade is considered as an important factor of pollution emission that deserves more attention. For a panel of the organization of economic cooperation and development (OECD) countries, Ben Jebli et al. (2016) illustrate that increasing trade or renewable energy consumption reduces carbon emissions, recommending that more trade and more renewable energy consumption are efficient strategies to combat global warming in these countries. They explain this effect of trade by its positive effect on per capita GDP and by the inverted U-shaped environmental Kuznets curve (EKC) hypothesis verified by this panel of OECD countries. Other studies have considered that tourism might have an important impact on environmental conditions. Ben Jebli et al. (2015a) provide a model that investigates the dynamic causal links between CO_2 emissions, output, combustible renewables and waste consumption, and international tourism in the case of Tunisia. Their results highlight that both combustible renewables and waste consumption, and international tourism contribute to the increase of carbon emissions. They attribute this finding to the increase in food consumption, energy for transport, cooling, and heating, and that transforming wastes into energy generates CO_2 emissions.

Some of these studies on renewable energy have been of interest to sub-Saharan Africa. Ben Jebli et al. (2015b) examine the role that renewable energy consumption can play in the mitigation of emissions. These authors consider a panel of 24 sub-Saharan Africa countries and make use of panel cointegration methodologies in their analysis. They recommend that the benefits from technology transfers through trade exchanges are a good path to increase their renewable energy use and decrease carbon emissions levels.

Additionally, for a panel of 51 sub-Saharan Africa countries, Ozturk and Bilgili (2015) examine the long-run dynamics between GDP growth and biomass energy consumption. Their evidence shows a significant impact of biomass consumption on GDP growth.

The literature lacks of empirical studies investigating the relationship between health indicators and any other variable such as economic growth or carbon emissions. Jerrett et al. (2003) explore the relationship between health care expenditures and environmental factors in Canada (i.e., for 49 counties of Ontario) using a sequential two stage regression model to control for variables that may affect such expenditures. Their results document that both total toxic pollution emitted and per capita municipal environmental expenditures display significant relationships with health expenditures. In addition, these authors suggest that counties with higher pollution emission levels demonstrate higher per capita health expenditures, while those that spend more on defending environmental quality levels demonstrate lower expenditures on health care. Lu et al. (2017) investigate the dynamic relationship between environmental quality, economic development, and public health in China by considering a panel data from 30 Chinese provinces for the period 2002-2014. They show a negative effect of environmental pollution on public health. However, education and medical conditions participate significantly to economic growth and public health promotion.

3. Data and empirical methodology

3.1. Data

Annual data are obtained from the Word Bank (2015) online database for a panel of 42 sub-Saharan Africa countries[1], spanning the period 1995-2011. The variables used for the

[1] The selected countries are: Angola – Benin - Botswana – Burkina Faso - Burundi - Capo Verde - Cameroon – Central Africa - Chad - Comoros – Congo Dem – Congo Rep – Ivory Cost – Equatorial Guinea - Eritrea - Ethiopia - Gabon - Gambia - Ghana - Guinea – Guinea-Bissau - Kenya - Madagascar - Malawi - Mali -

empirical study are per capita carbon dioxide emissions (*CO_2*) measured in metric tons of oil equivalent, per capita real gross domestic product (*Y*) measured in constant 2005 prices, renewable energy consumption (*RE*) measured as a share of total final energy consumption, and health expenditures (*HE*) measured as a share of total GDP. Depending on data availability, our empirical analysis includes the maximum number of observations.

3.2. Empirical methodology

Our empirical analysis considers a model that examines the dynamic causalities between CO_2 emissions, real GDP, renewable energy consumption and health expenditures. Precisely, we consider that health expenditures can have an important impact on the environmental situation. Thus, our empirical model is developed as follows:

$$CO_{2it} = f(Y_{it}, RE_{it}, HE_{it}) \quad (1)$$

The natural logarithmic transformation of Eq. (1) yields the following equation:

$$LNCO_{2it} = \alpha_i + \beta_i t + \delta_{1i} LNY_{it} + \delta_{2i} LNRE_{it} + \delta_{3i} LNHE_{it} + \varepsilon_{it} \quad (2)$$

Where *LN* denotes logarithmic transformations, $i = 1, \ldots, N$ for each country in the panel, $t = 1, \ldots, T$ denotes the time period, and ε denotes the

Mauritania - Mauritius – Mozambique- Namibia - Niger - Nigeria - Rwanda - Seychelles – Senegal - Sierra Leone – South Africa - Sudan - Swaziland - Tanzania - Togo - Uganda – Zambia.

stochastic error term. The parameter α_i allows for the possibility of country-specific fixed effects.

Before testing the integration order of the studied time series, it is essential to proceed testing the degree of cross-sectional dependence (CD) through the statistic recommended by Pesaran (2004). The residual statistic test of Pesaran (2004) allows selecting which panel unit root tests can be chosen: either first-generation unit root tests (traditional panel unit root tests) or second-generation unit root tests. Traditional panel unit root tests of the first generation used in the present study are five: Breitung (2000), Levin et al. (2002), Im et al. (2003), Fisher Augmented Dickey and Fuller (ADF, 1979), and Phillips and Perron (1988). The employment of the second generation unit toot test developed by Pesaran (2007) is more suitable for testing the stationary proprieties of variables. The cross-sectional augmented IPS (CIPS) unit root test, developed by Pesaran (2007), supports the null hypothesis of a unit root, while the alternative hypothesis suggests that the variable is stationary. The Pesaran (2004) test is computed from the augmented Dickey and Fuller (1979) regression corresponding to each variable in the model. This statistic is measured as an average of all pair-wise correlation estimated coefficients. The null hypothesis of the CD test suggests that the residual cross-section is independent, while the alternative hypothesis reveals that the residual is dependent.

Next, to determine the integration order of the analysis variables, it is needed to examine the cointegration between them. If the variables are integrated of order one, we investigate the presence of a long-run association within a heterogeneous panel using Pedroni's (2004) panel cointegration approach. The null hypothesis is that there is no cointegration, while the alternative hypothesis is that variables are cointegrated. All the tests are running with individual intercept and deterministic trend. The deviation to the long-run relationship is determined by the residuals presented in equation (2).

If there is a long-run relationship between variable, then we estimate the long-run coefficients using both the fully modified ordinary least squares (FMOLS) approach proposed by Pedroni (2001, 2004), and the dynamic ordinary least squares (DOLS) methodological approach developed by Kao and Chiang (2001) and Mark and Sul (2003). Both of these methodologies are substantially effective because they take explicitly into account the endogeneity of regressors, and they correct for serial correlation.

The last step of the empirical analysis involves testing short- and long-run causalities between CO_2 emissions, real GDP, renewable energy consumption and health expenditures through the two steps procedure recommended by Engle and Granger (1987). The estimation of the dynamic vector error correction model (VECM) is given as follows:

$$\begin{bmatrix} \Delta LNCO_{2it} \\ \Delta LNY_{it} \\ \Delta LNRE_{it} \\ \Delta LNHE_{it} \end{bmatrix} = \begin{bmatrix} \chi_1 \\ \chi_2 \\ \chi_3 \\ \chi_4 \end{bmatrix} + \sum_{p-1}^{q} \begin{bmatrix} \theta_{11p} & \theta_{12p} & \theta_{13p} & \theta_{14p} \\ \theta_{21p} & \theta_{22p} & \theta_{23p} & \theta_{24p} \\ \theta_{31p} & \theta_{32p} & \theta_{33p} & \theta_{34p} \\ \theta_{41p} & \theta_{42p} & \theta_{43p} & \theta_{44p} \end{bmatrix}$$

(3)

$$\times \begin{bmatrix} \Delta LNCO_{2it-1} \\ \Delta LNY_{it-1} \\ \Delta LNRE_{it-1} \\ \Delta LNHE_{it-1} \end{bmatrix} + \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \end{bmatrix} ect_{it-1} + \begin{bmatrix} \mu_{1it} \\ \mu_{2it} \\ \mu_{3it} \\ \mu_{4it} \end{bmatrix}$$

Where Δ is the first difference operator; the autoregressive lag length, *q*, is determined by the Schwarz Information Criterion (SIC); μ is a random error term; *ect* is the error correction term derived from the long-run relationship of equation (2). We consider the pairwise Granger causalities tests for the short-run relationships. These tests are established by the significance of the F-statistics. Moreover, the computed t-statistics of the lagged *ect* corresponding to each equation presented in the VECM are designed to examine the significance of the long-run relationships.

4. Empirical analysis

The results of the CD test are reported in Table 1 and indicate the rejection of the null hypothesis of no cross-section dependence in the panel.

Table 1. Pesaran (2004) Covariate Augmented Dickey-Fuller (CADF) tests

Variables	t-bar	cv10	cv5	cv1	Z[t-bar]	P-value
$LNCO_2$	-2.028	-2.030	-2.110	-2.250	-1.893	0.029**
LNGDP	-2.158	-2.030	-2.110	-2.250	-2.720	0.003***
LNRE	-1.993	-2.030	-2.110	-2.250	-1.673	0.047**
LNHE	-2.073	-2.030	-2.110	-2.250	-2.176	0.015**

Notes: "**", "***" indicate statistical signficance at the 5% and 1%, respectively. The estimates include both a constant and a trend. t-bar test indicates the truncated values of student statistic, N,T = (42,17), with "N" denoting the number of countries and "T" indicating the time span. Number of observations = 630. Under the null hypothesis of cross-sectional residual independence, the Pesaran (2004) test is augmented by one lag. "cv" denotes the critical value provided by Pesaran (2004) at the 10%, 5% and 1% significance levels.

Thus, the traditional unit root tests (first-generation) provide bias of estimation. So, it is desirable to use the second generation unit root tests to check for the order of integration of each analysis variable. The panel unit root tests results of the first and the second generation are reported in Table 2. These findings indicate that all the variables under investigation are integrated of order one.

Table 2. Panel unit root tests

Variables	LLC	Breitung	IPS-Wstat	ADF-Fisher	PP-Fisher	CIPS
$LNCO_2$	-4.78529***	0.18632	-0.997	112.097**	124.921***	-0.941
$\Delta LNCO_2$	-18.3929***	-8.82959***	-15.0842***	339.582***	406.300***	-1.893**
LNGDP	-0.97333	3.65085	3.67476	95.6005	330.571	-1.375
ΔLNGDP	-15.8750***	-5.34773***	-12.3034***	283.222***	395.982***	-2.720***
LNRE	-1.92367**	2.11714	1.89343	80.5532	112.239**	-0.890
ΔLNRE	-16.3697***	-6.58400***	-12.9784***	300.337***	423.476***	-1.673**
LNHE	-0.97333	3.65085	0.12066	96.4758	77.0851	-2.176**
ΔLNHE	-15.8750***	-5.34773***	-12.3034***	283.222***	395.982***	-3.816***

Notes: "**", "***" denote statistical significance at the 5% and 1%, respectively. Δ denotes first differences.

Next, the long-run cointegration properties are explored through the cointegration tests of Pedroni (2004). Table 3 reports the results of seven tests. They illustrate and confirm the presence of cointegration across the variables under study.

Table 3. Pedroni panel cointegration tests

Alternative hypothesis: common AR coefs. (within-dimension)				
			Weighted	
	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	0.690224	0.2450	-1.181825	0.8814
Panel rho-Statistic	0.816451	0.7929	1.007946	0.8433
Panel PP-Statistic	-5.592538	0.0000***	-5.743409	0.0000***
Panel ADF-Statistic	-6.243037	0.0000***	-6.244811	0.0000***
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	3.563427	0.9998		
Group PP-Statistic	-6.673381	0.0000***		
Group ADF-Statistic	-6.068990	0.0000***		

Notes: "***" indicates statistical significance at the 1% level.

In the following stage of the empirical analysis, the long-run elasticities are computed using both FMOLS and DOLS methodologies. The estimations include both an intercept and a deterministic trend. The results are reported in Table 4 and they document that all coefficients are statistically significant at the 1% level. In addition, the results of the two methodologies are very close. According to these elasticity estimates, real GDP is positively associated with increased pollution levels caused by carbon emissions, while both renewable energy consumption and health expenditures contribute to lower levels of emissions in the long-run. In particular, the FMOLS long-run estimates highlight that a 1% increase in real GDP leads to increases in carbon emissions by 1.09%, while a 1% increase in renewable energy consumption and in health expenditures leads to lower carbon emissions by 0.29% and 0.21%, respectively.

Table 4. Long-run panel estimates

Variables	***LNGDP***	***LNRE***	***LNHE***
FMOLS	1.091937 (0.0000)***	-0.289687 (0.0000)***	-0.210902 (0.0000)***
DOLS	1.047998 (0.0000)***	-0.321844 (0.0000)***	-0.174733 (0.0003)***

Notes: "***" indicates statistical significance at the 1% level. P-values are in parentheses.

Next, the results of the causality tests for both the short- and the long-run relationships are reported in Table 5. According to the significance of the F-statistics of the pairwise Granger causality results, in the short-run, there is bidirectional causality between carbon emissions and renewable energy consumption. There are also unidirectional causalities running from real GDP to CO_2 emissions, health expenditures, and renewable energy consumption. In the long-run, the error correction terms for the carbon emissions and health expenditures equations are statistically significant at the 1% level, indicating that there is bidirectional causality between these two variables. In addition, there are long-run unidirectional causalities running from: *i)* economic growth and renewable energy consumption to CO_2 emissions; *ii)* economic growth and renewable energy consumption to health expenditures.

Table 5. Granger causality results

Dependent variable	**Short-run**				**Long-run**
	ΔLNCO₂	*ΔLNGDP*	*ΔLNRE*	*ΔLNHE*	*ECT*
ΔLNCO₂	-	14.0653	2.33007	0.75342	-0.022163
		(0.000)***	(0.0981)*	(0.4712)	[-2.60600]***
ΔLNGDP	0.33763	-	0.28296	1.07810	0.004517
	(0.7136)		(0.7536)	(0.3409)	[1.35238]
ΔLNRE	3.72682	6.33115	-	0.68090	0.007282
	(0.0246)**	(0.0019)***		(0.5065)	[3.60173]
ΔLNHE	1.02720	2.30900	0.67698	-	-0.011391
	(0.3586)	(0.1000)*	(0.5085)		[-2.54914]***

Notes: "***", "**", "*" indicate statistical significance at the 1%, 5% and 10%, respectively. p-values are in parentheses. Statistics are computed for the case where both an intercept and a deterministic trend are included. Lag length selection is based on the SIC criterion with a max lag of 2.

5. Discussion

In this section we discuss the results earlier reached by our empirical study. The dynamic causal linkages between carbon emissions, real GDP, renewable energy consumption, and health expenditures have been investigated for a panel of sub-Saharan Africa countries. The causalities results are summarized in Figure 1.

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Fig.1. Short-(continuous line) and long-run (discontinuous line) Granger causalities

They point out the presence of a unidirectional short-run causality running from real GDP to carbon emissions which is consistent with the results reached by Ben Jebli and Ben Youssef (2015) for the case of Tunisia, and Jalil and Mahmud (2009) study on China. Indeed, economic growth needs energy (fossil or renewable) that has an immediate impact on CO_2 emissions. Our long-run parameter estimates show that per capita GDP has a positive impact on per capita carbon dioxide emissions. This result is consistent given that the majority of sub-Saharan Africa countries have not yet reached the required level of per capita real GDP that allows reduced per capita emissions levels.

Causality results also reveal a bidirectional short-run causality between renewable energy consumption and carbon emissions, meaning that any increase in the share of renewable energy consumption affects the emission of pollution, and this latter has an impact on renewable energy consumption even in the short-term. This finding is consistent with that reached by Apergis et al. (2010) for the case of a panel of 19 developed and developing countries, but is not in line with that presented by Menyah and Rufael (2010) who find the absence of causality between carbon emissions and renewable energy consumption in the case of the United States. Moreover, and as shown by the majority of the literature, an increase in the share of renewable energy consumption reduces carbon emissions in the long-run.

There is a short-run unidirectional causality, without feedback, running from economic growth to renewable energy consumption, which is consistent with the conservation hypothesis. Furthermore, causality results illustrate the presence of a short-run unidirectional causality running from real GDP to health expenditures, indicating that, in the short-run, economic growth can cause health expenditures, while the reverse does not hold. Any augmentation in the economic activities added values in this area shortly contributes to increases in expenditures reserved to health care. This also means that these countries don't spend sufficiently in health care because of budgetary constraints. Our result is consistent with that of Erdil and Yetkiner (2009) for most low- and middle-income countries. However, it is not similar to the result of Amiri and Ventelou (2012) who find that bidirectional causality between health expenditures and GDP is predominant for OECD countries.

In the long-run, the interdependence between carbon emissions and health expenditures is found to be bidirectional, indicating a strong correlation between pollution and health expenditures. It is evident that less CO_2 emissions, which means a better quality of the air that we breathe, has a beneficial impact on health. This is what found Lu et al. (2017) for a panel of Chinese provinces by showing a negative effect of environmental pollution on public health. In addition, our long-run elasticity estimates show that an increase in health care expenditures as a share of total GDP reduces carbon emissions. This is probably due to the less polluting health care sector with respect to the other economic sectors in these considered countries because it is more efficient in fossil energy use and/or uses more renewable energy.

Our study highlights the presence of a long-run unidirectional causality running from renewable energy consumption to health care expenditures. This constitutes an interesting result because the relationship between a health indicator and renewable energy has not been previously investigated by the literature. This finding points out the role that renewable energy can play in the health care of sub-Saharan population, given that the region is characterized by a wealth of unexploited renewable resources. Moreover, access to health care can be improved and turn to be more reliable through renewable energy systems. If countries of this area exploit their renewable resources efficiently, they will gain at least on two sides: their fossil energy bills and air pollution levels will be considerably reduced. This will enables them to save money for health care expenditures and improve the quality of the health conditions of their citizens. Thus, these countries should encourage the installation of modern renewable energy projects (solar, wind, geothermal) in the health care sector for many uses as heating, air conditioner, electricity generation, etc. These projects are extremely important for poor countries in this region, as access to conventional electricity by health facilities is not always easy, especially when the health facility is far from the big cities.

6. Conclusions and policy implications

This paper investigates the dynamic causal links between carbon dioxide emissions, real GDP, renewable energy consumption, and health expenditures as an indicator of health for a panel of 42 sub-Saharan Africa countries, spanning the period 1995-2011. Our empirical analysis uses a number of methodologies in relevance to panel data, including 2^{nd} generation panel unit root tests, panel cointegration approaches, panel long-run estimates, and panel causality tests to check out for the interaction between the considered variables.

Empirical findings document that the variables under consideration are cointegrated. The FMOLS and DOLS long-run parameter estimates highlight that both renewable energy consumption and health expenditures contribute to lower carbon emissions levels, while economic growth increases CO_2 emissions. Short-run Granger causality tests suggest the presence of bidirectional causality between renewable energy and carbon emissions, and a unidirectional causality running from economic growth to health expenditures, renewable energy consumption, and CO_2 emissions. The presence of long-run bidirectional causality between health expenditures and carbon emissions is detected. In addition, the existence of a long-run unidirectional causality running from renewable energy consumption to health care expenditures is established. This is a worth considering result as the relationship between a health indicator and renewable energy has not been previously investigated by the literature.

Given the above mentioned econometric results and the specificities of the considered panel of countries in terms of socio-economic development and wealth in renewable energy resources, we propose the following policy recommendations: *i)* Economic growth is the royal road to combat global warming, to ameliorate the health of citizens, and to encourage renewable energy use. Indeed, the inverted U-shaped EKC hypothesis, enables us to think that with a continuous economic growth these countries will reach a certain level of per capita GDP leading to a decrease in their per capita CO_2 emissions. In addition, such economic growth provides money for investing in health care and in renewable energy projects, which are expected to ameliorate the health of citizens and reduce carbon emissions; *ii)* Encouraging renewable energy use has a considerable and beneficial impact on the health of citizens and on climate change. Indeed, most of these considered countries are rich in unexploited renewable energy resources. So, if they exploit their renewable energy resources efficiently, they will gain at many sides: their fossil energy bills will be considerably shortened enabling them to save money for health care expenditures and improve the quality of the health conditions of their citizens. In addition, more renewable energy consumption leads to a reduction in carbon dioxide emissions with its beneficial impact on the health of citizens. The realization of renewable energy projects is extremely important for the poor countries of this region, because the access to conventional electricity by health facilities is not always possible, especially when the health facility is far from the big cities.

Although the easy recommendation is the expansion of renewable energy projects, this is not highly viable for these countries, because of cash constraints and lack of supply infrastructure. Therefore, it would be a very good opportunity for further research to explore potential financing mechanisms that will promote renewable energy expansion, without jeopardizing the growth path of those countries in the sub-Saharan Africa region. Indeed, these projects will allow the further stimulation of their production growth, advancing their health quality, and eliminating pollution levels caused by carbon emissions.

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