“A meta-analysis of the economic impact of carbon emissions in Africa”

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A META-ANALYSIS OF THE ECONOMIC IMPACT OF CARBON EMISSIONS IN AFRICA

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Abstract

The economic impact of carbon emissions in Africa is gaining traction in the extant literature. This study adopted Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to concomitantly track data on carbon emissions versus economic growth in Africa from 2018 to 2022 providing evidence from a meta-analysis. Through database searches, 591 publications were identified. A machine learning algorithm called Latent Dirichlet Allocation (LDA) was used as a visualization technique for reporting trends in the eleven papers selected for the analysis. Identifying, evaluating, and summarizing the findings of all relevant individual studies conducted in Africa on the impact of economic growth on carbon emissions contributes to the existing body of knowledge. This study fills a critical gap by surveying the studies conducted in Africa in the last five years, implying that economic growth negatively and significantly triggers CO2 emissions in Africa. The debate on the economic impact of CO2 emissions in Africa, the most vulnerable continent to climate change, is elucidated. The findings tracked sources of data for carbon emissions in Africa. The results showed that although some studies reported a positive correlation (and some a negative correlation) between economic growth and carbon emissions, most studies concur that the economic impact of carbon emissions over a timeline can be explained by the Environmental Kuznets Curve (EKC) hypothesis. Therefore, there is a dire need for African countries to strengthen economic growth without deteriorating their environment or having ecological footprint. Future research must assess whether this trend on the economic impact of carbon emissions in Africa continues.

Keywords carbon emissions in Africa, economic impact, environmental Kuznets curve, financial growth in Africa, industrialization

JEL Classification O44, O55, P18, Q54

INTRODUCTION

The extant literature abounds with research on carbon emissions globally. The rapid economic growth in Africa owing to industrialization and manufacturing has led to a rise in energy consumption, which has contributed to an increase in carbon emissions (Ssali et al., 2018). Globally, policies are in place to control carbon emissions and protect the environment from pollution and degradation. Moreover, policies protect people from diseases such as lung cancer and skin cancer. Therefore, it is crucial to assess if economic growth in Africa is promoted without detrimental effects on people and the environment (Khobai & Sithole, 2021).

Several studies have found that the impact of economic growth on carbon emissions in Africa can be explained by the well-known Environmental Kuznets Curve (EKC) hypothesis. The inverted u-shaped curve postulates that, initially, economic growth increases carbon emissions until a certain level is reached. As economic growth increases, carbon emissions will decline (Ganda, 2019). Testing this hy-

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pothesis has been the interest of many studies conducted in Africa around carbon emissions (Olubusoye et al., 2020). This study tracks studies and data on carbon emissions versus economic growth in Africa in the last five years. Furthermore, it allows an understanding of the impact of economic growth on carbon emissions in Africa over a given timeline through a review of seminal studies.

1. LITERATURE REVIEW

Existing literature on the economic impact of carbon emissions in Africa has yielded two opposing arguments on the environmental issues not only in Africa but also globally (Bélaïd & Youssef, 2017). Furthermore, the literature showed that empirical findings and theoretical arguments on the economic impact of carbon emissions in Africa are unclear and contradictory (Mesagan, 2015). There are mixed results on whether economic growth positively or negatively influences carbon emissions (CO_2) (Chaudhry et al., 2020). Chaudhry et al. (2020) found that supporting economic advancement and development and not compromising the environment remain a dual challenge facing both developed and emerging countries. The United States of America, Russia, China, Germany, and the United Kingdom were found to be the countries with the highest emissions of CO_2 (Lee, 2019; Liu et al., 2018; Mohmmed et al., 2019). The harmful effects of CO_2 on the African continent were examined by Nathaniel et al. (2019). They found that even if African countries do not feature as high emitters, they are not exempted from harmful repercussions. The factors to CO_2 emissions in South Africa were investigated by Aboagye (2019), who found that Eskom is the biggest emitter of greenhouse gases.

Recently there has been a big push for China to strategically engage African countries (Tawiah et al., 2021; Tull, 2006). Tawiah et al. (2021) argued that the China-African partnership involves significant investments that significantly impact the business environment. Since China is both a high contaminator of the environment and a pioneer in renewable energy and smart technology, Asongu (2018a, 2018b) argues that China's dominance in African countries with weak or poor environmental standards and communications technology is detrimental to the environment. These gaps can be a blessing or a curse on the environment of African countries. In their halo and haven hypothesis, Benzerrouk et al. (2021) found that global investment and foreign economic trade within a country could provide more support for green practices and environmental sustainability, thereby promoting low carbon emissions.

The effect of technology transfer on the environment and economic growth in 41 African countries has been investigated by Fernandes et al. (2021). A significant positive relationship was found between technology and skills transfer and economic growth. Similarly, the correlation between investments and CO_2 pollutants has also been confirmed by Namahoro et al. (2021). Benzerrouk et al. (2021) found that foreign international investment (FDI) minimizes carbon emissions in emerging markets. However, a negative relationship between FDI flow and CO_2 emissions was found by Mohmmed et al. (2019). Dong et al. (2018) established that utilizing non-renewable energy for domestic and industrial purposes positively affects CO_2 emissions.

In Africa, the relationship between commercial progress and carbon emissions in 28 Sub-Saharan African countries was examined by Dhrifi et al. (2020). The study showed that using fossil fuel energy for economic development contributes to a significant increase in carbon emissions both immediately and for years. In a study conducted in 24 countries in Africa, Mesagan et al. (2022) highlighted the effects of economic development on carbon emissions and energy utilization. Similarly, Wang and Dong (2019) showed that an increase in economic growth leads to an increase in CO_2 emissions. These authors further provided evidence and confirmed the findings of Chaudhry et al. (2020), who established that clean energy decreases CO_2 emissions.

Asumadu-Sarkodie and Owusu (2017) soundly argue that the economy's advancement leads to a decline in environmental pollution in Rwanda, while population growth increases carbon emissions and negatively affects the economy. Appiah et al. (2019) found that as the economy grows,

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more CO_2 emissions are evident, while higher energy demands lead to a drop in environmental degradation in Uganda.

In the analysis conducted in Kenya, Uganda, Sudan, and other countries on the impact of energy utilization, Bélaïd and Youssef (2017) showed that as the population increases, the amount of CO_2 emissions also tends to increase. Bélaïd and Youssef (2017) further found that economic advancement increases CO_2 emissions. Chaudhry et al. (2020) established that energy utilization has a mixed effect on carbon emissions. However, no research has been conducted on the economic impact of CO_2 emissions in Africa. Furthermore, few studies have investigated the effect of renewable and non-renewable on CO_2 emissions and economic growth. Therefore, it would be stimulating to analyze how developing the economy can affect the environment in the African continent under the use of meta-analysis.

It is not surprising that prior research has not yet reached an agreement on the issue. The results of studies report three alternative outcomes as positive significant, negative significant, and insignificant economic effects on carbon (CO_2) emissions. The continuous usage of not only renewable but also non-renewable energy sources in Africa, which rose exponentially, has the potential to subject the continent to more environmental calamities (Nkengfack & Fotio, 2019). The impact of CO_2 emissions in some African countries was examined by Ushie and Aderinto (2021). They found the Central African Republic, Eritrea, South Africa, Nigeria, Ethiopia, Nigeria, South Sudan, Chad, Sierra Leone, and Kenya to be the countries most negatively exposed to climate change. This was one of the motivating factors for this study, whether or not CO_2 emissions have truncated economic growth in the African continent. Therefore, this paper study seeks to understand and quantify a genuine authentic empirical economic impact of carbon emissions in Africa.

Pervasive topics in the literature on the environment and economic growth are the environmental Kuznets hypothesis, renewal of energy sources, financial growth, energy consumption, and development, amongst others. Hence, the purpose of this study is to get an aggregated view of the relationship between economic growth and carbon emissions in Africa over the last five years.

2. METHODOLOGY

The method of selecting the most relevant papers was Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). PRISMA provides a structure to report on systematic reviews and meta-analyses (Moher et al., 2015). Systematic reviews generally utilize PRISMA to ensure rigor and quality are strictly followed in the extraction of papers (Chatzigeorgiou & Andreou, 2021 cited in Sam et al., 2020). Reporting on meta-analysis, if not systemized, is prone to digression; hence, numerous studies on meta-analysis and systematic reviews have used the PRISMA methodology (Chatzigeorgiou & Andreou, 2021 cited in Sam et al., 2020). PRISMA was used to scan the literature in the last 5 years on the topic "economic impact of carbon emissions in Africa." The steps in using PRISMA include defining the objective of the study, scanning the literature, screening and selecting relevant articles, and, after that, analyzing and reporting the results (Zhang & Liu, 2020 cited in Moonsamy et al., 2021).

The inclusion criteria for this study focused on all African studies that assessed the economic impact of carbon emissions. The systematic retrieval process used several search strings: "economic growth and carbon emissions in Africa," "Environmental Kuznets Curve in Africa," "industrialization and carbon emissions in Africa," "economic growth and top emitters in Africa," "insights of carbon emissions in Africa," "financial development and carbon emissions in Africa," "relationship between economic growth and carbon emissions in Africa," and "energy and carbon emissions in Africa." Searches were conducted between 2018 and 2022.

Articles published in foreign languages were excluded from the search. Book reviews, book chapters, books, theses, and commentaries were excluded from the search. All countries besides African countries were excluded from the study. Systematic reviews were excluded from this study. All articles published before 2018 were excluded from this study. The objectives of the study were used to determine the eligibility for the study. In this study, 189 articles were excluded based on refinements. After further refinements, 227 articles were excluded. The process is presented through the PRISMA flow diagram, as represented in Figure 1.

Numerous databases were examined, including Google Scholar, ACM, Science Direct, Pro Quest, Scopus, Emerald, Taylor and Francis online, EconLit, and Business Source Premier. Databases were searched using single or multiple search strings with a combination of Boolean operators, namely, 'AND', 'OR' and 'NOT'. The following are given as examples used, "economic growth" AND "carbon emissions" ("industrialization OR financial development") AND "carbon emissions," "carbon emissions" AND NOT "population growth."

Latent Dirichlet Allocation (LDA) is a machine learning technique used to analyze the 11 selected articles on carbon emissions and their effect on Africa's economy. LDA is based on topic modeling of unsupervised classification from the selected articles (Jelodar et al., 2019). Therefore, LDA is essential for summarization, similarity, classification, and novelty detection (Blei et al., 2003).

3. RESULTS

Figure 1 shows the literature search results on the economic impact of carbon emissions in Africa.

Figure 1 illustrates the logic using the PRISMA methodology of how 11 papers were selected for this study from a possible 591 papers identified through database searches. Table 1, logically created from the methodology of Figure 1, provides finer details of the 11 selected articles by study identity (S), author (year), title, and emissions versus economic growth in Africa.

The articles in Table 1 were selected, using the PRISMA methodology, as the most appropriate for the "economic impact of carbon emissions in Africa." The impact of economic growth in Africa versus emissions for each study is provided in column 4 of Table 1.

Table 2 captures details of the selected studies in terms of countries where the study took place, the period when the study was conducted, the methodologies used, and the data sources used.

Table 2 shows the methodology used for each study. World Development Indicators database of the World Bank is the most popular data source. The eleven selected studies covered the period from 1981 until 2019. Table 2 shows

Source: Adapted from Moher et al. (2015).

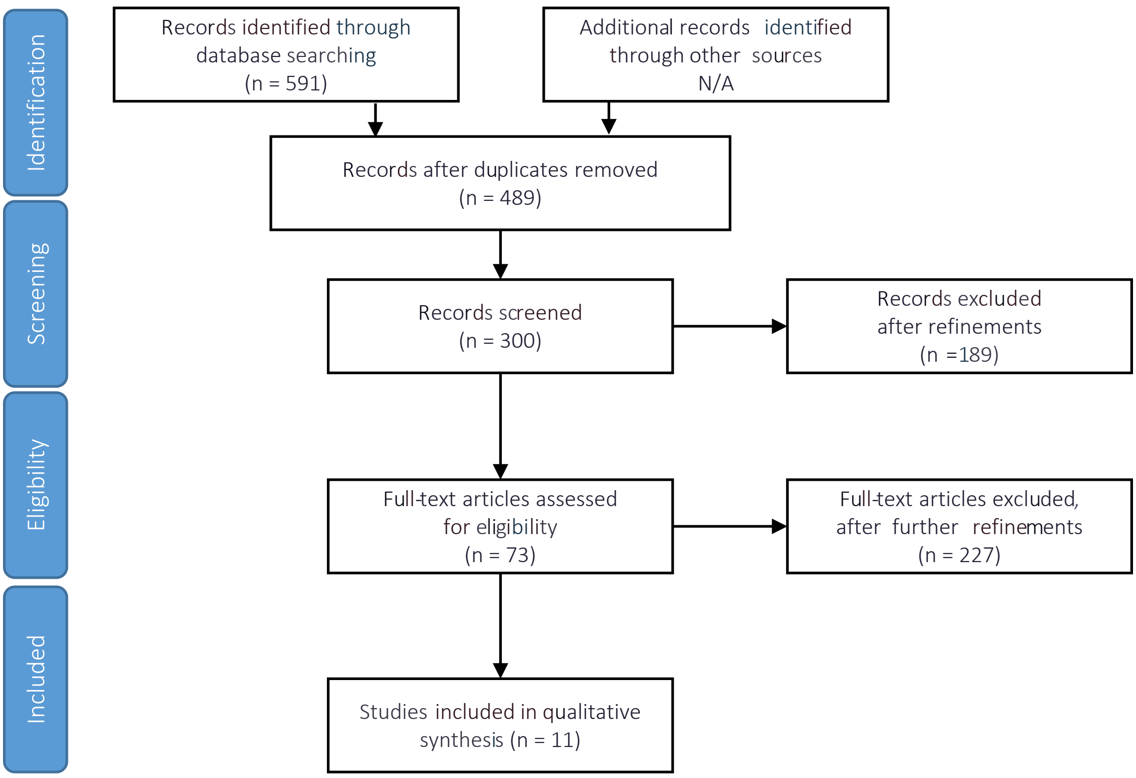

Figure 1. PRISMA flow diagram of literature retrieval

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Table 1. Selected papers on the economic growth in Africa versus emissions

Study Identity	Author (year)	Title	Economic growth in Africa versus emissions
S1	Ganda and Milondzo (2018)	The Impact of Carbon Emissions on Corporate Financial Performance: Evidence from the South African Firms	Overwhelming evidence of a negative relationship between carbon emissions and corporate financial performance
S2	Ganda (2019)	Carbon Emissions, Diverse Energy Usage and Economic Growth in South Africa: Investigating Existence of the Environmental Kuznets Curve (EKC)	The EKC is supported in energy combined data in both the short and long run but varies in separated data
S3	Mapapu and Phiri (2018)	Carbon Emissions and Economic Growth in South Africa: A Quantile Regression Analysis	Empirical results indicate that shallow levels of carbon emissions are most beneficial for economic growth
S4	Ssali et al. (2018)	Impact of Economic Growth, Energy Use and Population Growth on Carbon Emissions in Sub-Sahara Africa	The empirical findings indicate that when CO2 is the dependent variable, Economic growth and population growth are statistically significant. As the economy grows, governments can invest in renewable energy to lower emissions. Hence, the EKC hypothesis is supported
S5	Appiah et al. (2019)	Causal relationship between industrialization, energy, intensity, economic growth and carbon dioxide emissions	In the long run, both economic growth increase of 1% will increase carbon emissions by 31.1%
S6	Nathaniel et al. (2019)	The determinants and interrelationship of carbon emissions and economic growth in African economies: Fresh insights from static and dynamic model	Africa's energy mix is mainly non-renewable. Non-renewable energy increases emissions, thereby reducing environmental quality. Hence, by inference, as countries flourish economically and can afford renewable energy, the EKC hypothesis is supported
S7	Nkengfack and Fotio (2019)	Energy Consumption, Economic Growth and Carbon Emissions: Evidence from the Top Three Emitters in Africa	Aggregate energy consumption and economic growth have positive and significant impacts on carbon dioxide (CO2) both in the long and short run
S8	Olubusoye et al. (2020)	Carbon emissions and economic growth in Africa: are they related?	"This result shows that carbon emissions increase as economic growth increases in 79% of the countries while economic growth will lead to lower carbon emissions in only a few countries (21%)
S9	Vitenu-Sackey (2020)	Financial Development, Foreign Direct Investment and Carbon Emissions: A Comparative Study of West Africa and Southern Africa Regions	It was found that the EKC hypothesis exists in the Southern Africa region; thus, economic growth and carbon emissions have a U-inverted relationship
S10	Khobai and Sithole (2021)	The Relationship between Economic Growth and Carbon Emissions in South Africa.	The results also validated the EKC hypothesis both in the long and short run
S11	Ushie and Aderinto (2021)	Energy consumption, economic development and environmental degradation nexus for Nigeria.	The study established an inverted U-shaped environmental degradation-economic development relationship that validated the EKC hypothesized inverted U-shape for CO2 emissions

Table 2. Selected papers by country, time series, methodology, and data source

Study Identity	Country	Time Series	Methodology	Data Source
S1	South Africa	2015	Heteroscedasticity-robust standard error estimates	IndexMundi; CDP South Africa 2015 report; INET BFA
S2	South Africa	1980–2014	Autoregressive distributed lag (ARDL) bounds test and Johansen cointegration tests	United States Energy Information Administration (US-EIA); Word Development Indicators (WorldBank) database
S3	South Africa	1970–2014	Quantile regression methodology	World Bank online database
S4	SSA: Kenya, Nigeria, Botswana, Benin, Togo, and Mauritius	1990–2014	Unit root test, cointegration test, VECM (Vector Error Correction Model), and FMOLS (Fully Modified Ordinary Least-Square)	World Development Indicator 2017

Table 2 (cont.). Selected papers by country, time series, methodology, and data source

Study Identity	Country	Time Series	Methodology	Data Source
S5	Uganda	1990–2014	Augmented Dickey-Fuller (ADF); and Philips and Perron (PP) test	World Bank Data 2016
S6	Algeria, Cameroon, Nigeria, Senegal, Congo rep, Egypt, Ethiopia, Gabon, Ghana, Kenya, Morocco, Sudan, Togo, South Africa, and Tunisia	1990–2014	Sys-GMM	World Development Indicators database of the World Bank
S7	Algeria, Egypt, and South Africa	1971–2015	ARDL STIRPAT2 (Stochastic Impact by Regression on Population, Affluence, and Technology)	BP Statistical Review of World Energy; International Energy Agency 2017 database; World Development Indicators issued by the World Bank
S8	43 African Countries	1980–2016	Autoregressive Distributed Lags (ARDL) model	World Bank Development Indicators 1980–2016
S9	10 West African countries and 7 Southern African regions	1995–2015	Dynamic panel data estimation methods	World Bank 2017 WDI
S10	South Africa	1984–2018	ARDL bounds technique	World Bank and International Energy Statistics
S11	Nigeria	1981–2019	Auto Regressive Distributed Lag (ARDL) method	World Development Indicators (WDI) and the Global Footprint Network

Table 3. Impacting factors on carbon emissions in Africa

Study Identity	Factors/variables considered by studies
S1	Return on equity (ROE), return on investment (ROI), return on sales (ROS), growth, firm size, leverage, and capital intensity (control variables)
S2	Primary coal, secondary coal, electricity, and hydrocarbon gas consumption
S3	gross domestic growth, economic growth, CPI inflation, employment, international trade, gross domestic investment
S4	Economic growth, energy use, and population
S5	Energy intensity, Industry value added, GDP per capita
S6	GDP per capita, GCF, Trade (% of GDP), in kg of oil equivalent per capita, and financial development
S7	Economic growth and energy consumption
S8	GDP (economic growth) and energy consumption (EC) variables
S9	GDP per capita, financial development variables, foreign direct investment, trade openness, and financial openness
S10	Economic growth (GDP), energy consumption (EN), foreign direct investment (FDI), and trade openness (TR)
S11	Energy consumption (E), gross domestic product (GDP) per capita, the square value of gross domestic product per capita (GDP2), ecological footprint (EFP),) and gross fixed capital formation (GFCF)

autoregressive distributed lag (ARDL) as the most popular method used. It also suggests that more data sources are required for African data on carbon emissions. Next, Table 3 provides details of the impacting factors of the studies S1 to S11.

Figure 2 shows the results of the unsupervised machine learning algorithm, Latent Dirichlet Allocation (LDA). Keywords and weights were extracted from the corpus of the eleven selected articles.

The algorithm produced four topics, namely Topic 0, Topic 1, Topic 2, and Topic 3, from the corpus of the text from the 11 selected articles that were input. The weights of the most significant syntax were extracted and shown in Figure 2. Logically, the topics produced by the algorithm can be simplified into themes. Next, Figure 3 shows the topic keywords in terms of their weights on a bar graph.

Figure 3 shows that the keywords from Topic 0 (blue) carry the most weight in the corpus of

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```
[(0,
  '0.040*"country" + 0.036*"hypothesis" + 0.031*"emission" + 0.030*"carbon" + '
  '0.027*"ekc" + 0.021*"economic" + 0.020*"growth" + 0.019*"result" + '
  '0.017*"long" + 0.015*"study"'),
 (1,
  '0.027*"emission" + 0.027*"energy" + 0.023*"growth" + 0.020*"economic" + '
  '0.019*"variable" + 0.018*"carbon" + 0.013*"consumption" + 0.013*"increase" '
  '+ 0.012*"result" + 0.011*"test"'),
 (2,
  '0.010*"petroleum" + 0.007*"total" + 0.007*"valid" + 0.007*"association" + '
  '0.006*"article" + 0.006*"hold" + 0.005*"separate" + 0.005*"renewable" + '
  '0.004*"involve" + 0.004*"vector"'),
 (3,
  '0.028*"emission" + 0.024*"carbon" + 0.017*"financial" + 0.013*"company" + '
  '0.008*"development" + 0.008*"firm" + 0.007*"effect" + 0.007*"ce_intensity" '
  '+ 0.007*"study" + 0.006*"scope"')]
```

Figure 2. Topics and weights produced by Latent Dirichlet Allocation (LDA)

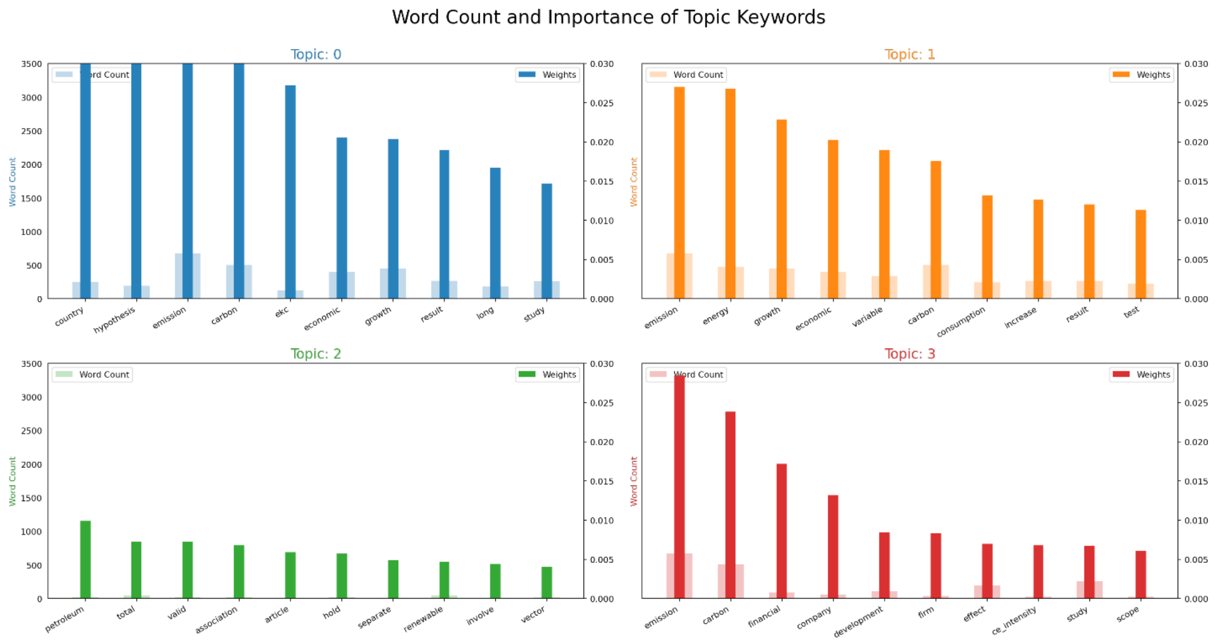

Figure 3. Topic keywords in terms of their importance (weights)

the 11 selected papers. Next, Figure 4 shows the word clouds for each topic.

The topics are color-coded. Topic 0 is represented in blue. Topic 1 is represented in orange. Topic 2 is represented in green, and Topic 3 is represented in red. The most important words in each topic are larger in size than the other words. The size of the word also gives its relative importance in the corpus of the 11 selected documents. The following themes were derived from each topic cloud represented in Figure 4 as a means of dimensionality reduction: "Environmental Kuznets Curve Hypothesis" (Topic 0); "Impact of economic growth on carbon emissions" (Topic 1); "Renewal energy sources versus non-renewable energy sources" (Topic 2); and "Impact of companies financial development on carbon emissions" (Topic 3). Many studies assessed the existence of the Environmental Kuznets Curve Hypothesis, making Topic 0 very prominent in the debate on carbon emissions versus economic growth (Appiah et al., 2019; Ganda, 2019). Next, Figure 5 shows the sentence topic coloring for documents.

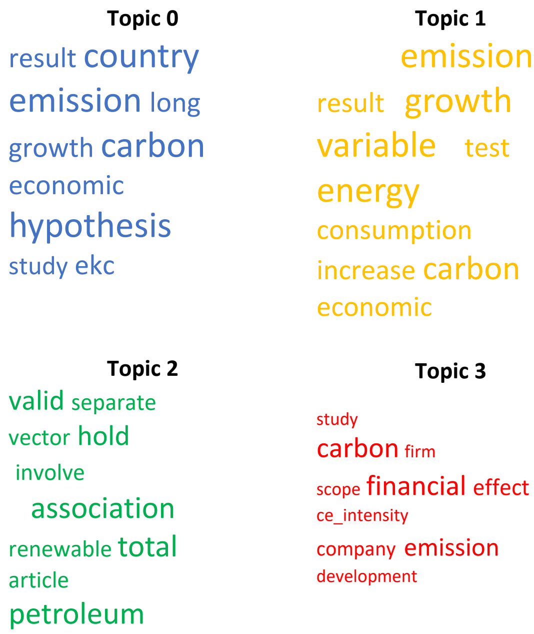

Figure 4. Word clouds of top keywords in each topic

Doc 0: Accept accord account activity add adjustment African alternative analysis applicable apply approach

Doc 1: Able accept accord account accumulation achieve activity adaptation adaption add addictive additionally adjustment

Doc 2: Able account achieve add adjustment administration advancement affect African agriculture alternative analysis

Doc 3: Able accept accord account achieve activity add additionally adopt adoption affect African air analysis

Doc 4: Able accord account achieve activity add adjustment adopt adoption affect African answer apply approach

Doc 5: Accord account add adjustment adopt affect affluence African agency alternative analysis appendix applicable apply

Doc 6: Accept accord activity adopt advancement affect African analysis approach assess base become bidirectional carbon

Doc 7: Account activity adjustment administration adopt affect agriculture analysis approach atmosphere average base

Doc 8: Able accord achieve activity add additionally adopt adoption affect African analysis anthropogenic apply approach

Doc 9: Accord account add additionally adjustment adopt affect African air alternative analysis applicable apply approach

Doc 10: Able accord adopt African amplify analysis apply approach associate assume assumption attention average

Figure 5. Sentence topic coloring for documents

Figure 5 shows the representation of each topic, namely Topic 0 (blue), Topic 1 (orange), Topic 2 (green), and Topic 3 (red) in the corpus of documents. Each color of the enclosing rectangle is the topic assigned to the document. Clearly, Topic 1 ("Impact of economic growth on carbon emissions"), color-coded in orange, is the most represented topic in the corpus of 11 selected articles. This topic is represented in 8 of the 11 documents. Topic 1 "Impact of economic growth on carbon emissions" shows studies in the extant literature that support the existence of the environmental Kuznets hypothesis, such as that of the Khobai and Sithole (2021) study. At the same time, studies, such as Appiah et al. (2019), show no evidence of the environmental Kuznets hypothesis. Although opposing viewpoints are consistent in the literature, the effect of economic growth on the environment is dominant.

Figure 6 shows the visualization of interrelated topics together with the top 30 salient terms from the corpus of data.

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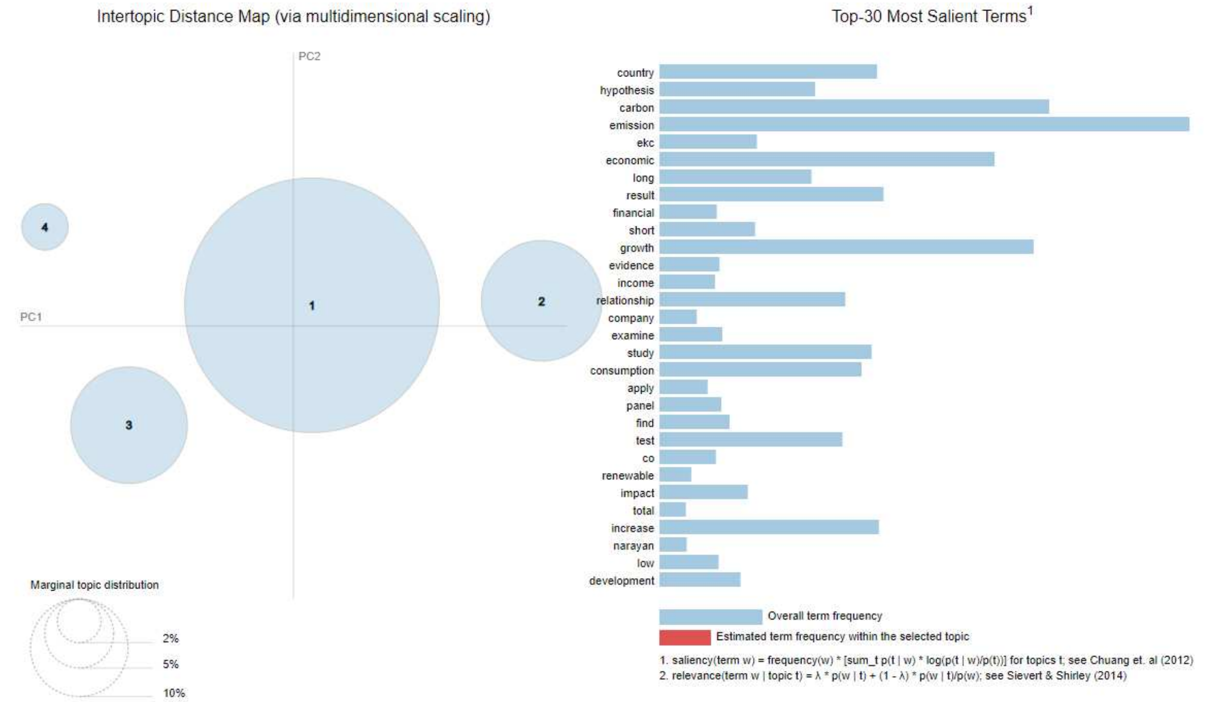

Figure 6. Visualization of inter-related topics

Figure 6 shows that the keywords "carbon," "emission," and "growth" are the most frequently used words in the corpus of 11 selected papers. The inter-topic distance map shows 4 distinct topics (themes) from the corpus of data. These were "Environmental Kuznets Curve Hypothesis," "Impact of economic growth on carbon emissions," "Renewal energy sources versus non-renewable energy sources," and "Impact of companies' financial development on carbon emissions." Figure 6 shows no overlapping or sub-topics. Studies such as Ssali et al. (2018) have chosen to take up the debate of Topic 3, "Renewal energy sources versus non-renewable energy sources." The issue of Topic 4, "Impact of companies' financial development on carbon emissions," investigated by Ganda and Milondzo (2018), is also prominent in the literature.

CONCLUSION

This meta-analysis theoretically investigated the association between economic growth and carbon emissions for 5 years. An assimilated view of the corpus of the 11 selected articles was visualized using the unsupervised machine learning algorithm called Latent Dirichlet Allocation (LDA). Although studies have attested to both an increase and decrease in carbon emissions on economic development, the findings from the majority of studies in the corpus of selected articles show that the well-known Environmental Kuznets Curve hypothesis best explains the relationship between economic growth and carbon emissions. This paper added to the current body of knowledge by identifying, evaluating, and summarizing the findings of all relevant individual African studies on the impact of economic growth on carbon emissions. The current study fills a critical gap by surveying the studies conducted in Africa in the last five years.

Overall, this study has important implications for governments, as they should become more reliant on renewable energy sources to ensure sustainable economic growth and, at the same, lower carbon emissions. Furthermore, African countries must ensure that macroeconomic policies are in place to concomitantly protect the environment and promote economic growth in the long term. Therefore, greater commitment is required from African leaders to ensure that green energy sources are utilized to mitigate the rise of carbon emissions. Future research on carbon emissions in Africa on any of the four dominant topics identified by this study will assist in filling the research gap.

AUTHOR CONTRIBUTIONS

Conceptualization: Mogiveny Rajkoomar, Ferina Marimuthu, Nalindren Naicker, Jean Damascene Mvunabandi.
Data curation: Nalindren Naicker.
Formal analysis: Ferina Marimuthu, Nalindren Naicker.
Investigation: Mogiveny Rajkoomar, Ferina Marimuthu.
Methodology: Nalindren Naicker, Jean Damascene Mvunabandi.
Supervision: Ferina Marimuthu, Nalindren Naicker.
Validation: Mogiveny Rajkoomar, Ferina Marimuthu, Nalindren Naicker.
Visualization: Ferina Marimuthu, Nalindren Naicker.
Writing – original draft: Mogiveny Rajkoomar, Ferina Marimuthu, Nalindren Naicker.
Writing – review & editing: Jean Damascene Mvunabandi.

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