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Article

Tourism, growth, and carbon emissions in Sub-Saharan Africa: a balancing act

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Abstract. Tourism is one of the major determinants of global economic growth, creating jobs within the sector, and Africa is no exception. The target of the sub-Saharan African (SSA) countries is to consider tourism as an alternative means of economic expansion. However, tourism is a means of environmental imbalance. This study investigates the complex relationship between tourism, economic growth, and carbon emissions in 47 Sub-Saharan African countries from 2005 to 2020. While economic growth significantly increases carbon emissions, tourism revenue shows a potential mitigating effect. Trade openness also contributes to emissions, while employment shows a negative correlation. These findings highlight the need for stricter environmental regulations and policies that leverage the region's labor surplus for sustainable tourism practices. Implementing such measures is crucial for minimizing the environmental damage associated with foreign direct economic activities and ensuring long-term sustainability.

Keywords: tourism revenues; carbon dioxide emissions; economic growth; trade openness; Sub-Saharan Africa

JEL classification : Z330, Q540, O4, F100, O55

1. Introduction

Tourism affects the economy in three major ways, namely, its contribution to growth, leisure and carbon emissions (Wijesekara et al., 2022; Du, Lew, & Ng, 2016; Haller et al., 2021). Regarding growth, tourism destinations increase huge revenue through investment in several sectors of the industry. Also, globally, evidence shows that the tourism industry remains one of the most important contributors of carbon dioxide emissions to the environment (Chen, Thapa, & Yan, 2018; Jong, Soh, & Puah, 2022). This has been due to the normative effects that tourism usually brings to the environment. Predominantly, given the tourism industry's various sectors, including hotel and

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lodging, aviation and airline, tourist attractions, and food and drink, the tourism industry is known to be extremely energy-dependent (Adedoyin, et al., 2021). Therefore, tourism activities are known for their high cause of climate change because of environmental degradation and a negative rise in energy consumption (Gyamfi, et al., 2021a; Kyara et al., 2022). Tourism has continued to have direct contributions to the growth of the world economies through tourist arrivals and receipt which could have effect on the physical environment. In addition, tourism contributes to economic growth and reduces poverty (Kyara et al., 2022)

However, the complexity of the relationship between environmental sustainability and tourism has continued to be explored in diverse ways among scholars (Pal & Mitra, 2017). Africans have been facing excessive carbon emissions, which are scientifically and empirically proven to contaminate the atmosphere and harm human beings and the natural environment in Sub-Sahara Africa (SSA). One of the sustainable development goals (SDG’s) is focused on climate change. Thus, there is a need to research and identify numerous solutions to combat climate change issues effectively among SSA countries. Across countries, carbon dioxide emissions are continuously causing externalities issues to human existence and environmental inequality. For example, previous studies confirmed that air pollution accounted for 1.1 million deaths across African countries in 2019 (Fisher et al., 2021) and approximately 7 million premature deaths in 2017 in Eastern Africa (Wipfli et al., 2021) as well as bronchial asthma increased due to air pollution among SSA countries (Ku et al., 2021). It has been empirically established that the African continent is suffering because of contaminated air (Fisher, et al., 2021). The particulate matter (PM) 2.5 was highly recorded in Kampala and Uganda (Awokola et al., 2020) and the dispersion modelling and spatial analysis confirmed that PM10 concentrations were higher during the day and eventually distributed to wide areas at night (Tshehla & Wright, 2019).

In particular, economic indicators have an impact on carbon dioxide emissions. In Africa alone, empirical research has confirmed that foreign direct investment, economic growth, tourism and governance positively increased carbon dioxide emissions (Agyeman, et al., 2022). Similarly, findings by Djellouli et al. (2022) reveal that economic growth and foreign direct investment among twenty SSA countries determined carbon dioxide emissions between 2000 and 2015. Besides, low socioeconomic status caused women to be exposed to poor air quality in Adama, Ethiopia (Flanagan et al., 2022). Furthermore, Al-mulali & Binti Che Sab (2012) contend that energy consumption in the thirty SSA economies played a significant role in boosting economic growth and financial development, but at the cost of excessive pollution. Along with various other factors, the level of income generally correlates with an increase in CO2 emissions. Delving into these previous studies, however, as a matter of importance, these existing findings on the relationships between CO2 emissions and economic growth in the SSA countries, have rarely produced any study on tourism's impact on economic expansion in the region. Simply, examining the relationships between tourism revenue, economic growth and carbon dioxide is uncommon among scholars despite the gains of growth as well as contributions of tourism to growth.

Thus, this study examines the impact of tourism revenue and economic growth on carbon dioxide emissions in the 47 SSA countries. Specifically, the study examines the linear associations among tourism arrivals, receipts, environmental pollution and economic growth in the SSA countries’ tourism industry. The study estimates the correlation between carbon dioxide and confounding variables, including GDP, EC, Tourism revenue, Trade Openness and labour surplus.

From the empirical findings of this study, the selected SSA countries' economic growth significantly contributed to carbon dioxide emissions. Moreover, African countries' tourism revenue shows a potential indication that this sector could reduce carbon dioxide emissions.

The rest of this study are structured as follows: the first section reviews previous research on the topic that is both current and pertinent; section three discusses empirical technique; section four gives the findings and discussion; and section five closes the study.

2. Literature review

2.1. Tourism and economic growth

In most nations globally, including Africa, the tourism sector is without a doubt one of the energy-intensive sectors that significantly boosts national GDP and creates jobs. To strengthen an economy, many developing nations, especially those in SSA, are increasingly focusing on the growth of tourism (El Menyari, 2021; Adedoyin & Bekun, 2020). Kyara et al. (2022) used time series data from 1995 to 2017 to examine the environmental impacts of tourism growth in Tanzania. The study employs Autoregressive Distributed Lag Bounds Testing, Vector Error Correction Model (VECM), and Granger causality test for analysis and the Wild Bootstrap approach to check the accuracy of the computed statistics. Hence, the VECM Granger causality test indicates that environmental degradation in Tanzania is compacted by foreign tourist arrivals and trade openness, while it is accelerated by urbanization and primary energy use. Furthermore, although the variables have long-term cointegration, the environmental Kuznets curve hypothesis was not ascertained in Tanzania. Su et al. (2023) study examined the environmental effect of financial stability in Iceland from 1995 to 2019. Using the nonlinear ARDL and Fourier-based techniques. The results of nonlinear bound tests and Fourier-based approaches show that CO2 emissions and financial stability frequently cointegrate. The NARDL results demonstrated that a positive variation in financial stability reduces CO2 emissions, whereas a negative variation has no effect. Additionally, positive income variation causes CO2 emissions, whereas negative income variation has no influence on CO2 emissions. Conversely, a decrease in trade openness has increasing effects on CO2 emissions, whereas an increase in CO2 emission-mitigation effects is a positive development. Also, Sun et al. (2022) reviewed 81 Environmental Kuznets Curve research published between 2013 and 2021 to determine whether tourism has an impact on carbon emissions and its consequences on development plans. However, none of the researchers examined international aviation emissions. Nonetheless, the results show that there is a paradoxical relationship between tourism and emissions, with divergent findings reported across nations, income levels, and the sector's economic significance. Indicating the need to critically re-evaluate the ways in which tourism and carbon are related, as well as the techniques employed in empirical research.

The World Travel and Tourism Council (2019) confirm that the tourism industry provides 330 million job opportunities for the world generally and increases the world gross domestic product (GDP) by US$8.9 trillion, representing 10.3% of the world (GDP). This has shown that tourism creates jobs and eventually increases the economic growth of such nations. According to the European Union

(EU, 2012), tourism plays an important role in most sectors of the economy, including the creation of jobs and a source of economic development. Also, it contributes positively to a country's balance of payment. An increase in both international and domestic tourism arrivals has boosted the country's revenue, which has indirectly led to growth in the energy consumption sector (Dogru & Bulut, 2018). For instance, the channel of growth has been by increasing tourism activities such as transportation facilities and hotel stays. However, if a country is an export industry, tourism creates export revenues and contributes to economic growth. Furthermore, a country can experience an economic growth process mainly through tourism activities (Nyasha et al., 2021). In comparison, China and Turkey have experienced tourism-led growth over time, while Russia and Spain experienced growth-led tourism (Ongan, et al., 2017).

2.2 Tourism and environmental degradation

In light of the aforementioned, Adedoyin and Bekun (2020) study indicated that, as of 2019, the tourist sector had surpassed the building sector to rank among the top environmental polluters in the world, accounting for 8% of global CO2 emissions. However, the transportation sector, like air transportation, contributes significantly to the increase in energy consumption and emissions. The study by Isik, et al. (2020) found that tourism has a negative impact on the environment in Greece. Suess et al. (2020) found that tourism has both negative and positive impacts on emissions in different countries. Using the World Bank data indicators database from 1990 to 2016, Bekun (2022) investigates the impact of economic growth, investment in the energy sector, non-renewable energy, renewable energy, and renewable energy on CO2 emissions in India. The study employs fully modified least squares (FMOLS), dynamic least squares (DOLS), and canonical cointegration regression (CCR) techniques, And the empirical analysis indicates that a positive relationship exists between CO2 emissions and non-renewable and GDP growth. However, a negative relationship exists between CO2 emissions and renewable energy. For the Granger analysis, the findings show a one-way causality among renewable energy and CO2 emissions, economic development, and energy investment.

Using a different technique and sector-specific findings of Bekun et al. (2019) from the Pooled Mean Group-Autoregressive Auto regressive distributive lag model (PMG-ARDL estimations show that "overdependence on natural resource rent affects environmental sustainability if conservation and management options are ignored". This is also reflected in the non-renewable energy consumption and economic growth, both of which contribute to carbon dioxide emissions in the panel countries.

Kiracı and Bakır (2019) used panel data covering low, lower-middle, upper-middle- and high-income countries from 1995-2015. A fully modified ordinary least square (FMOLS) was used, and it was found that tourism and corruption are the main contributors to C02 emissions. However, the contributions of the C02 emissions have more effect in the lesser-income nations than in high-income nations. Furthermore, Anser et al. (2020) utilize Dynamic GMM and Granger causality estimate with panel data spanning from 1665-2018 covering 132 countries comprising Algeria, Albania, Angola, Benin, Belgium, Chile, Canada, Egypt, Ecuador, Georgia, Ghana and Iraq etc. The result shows that the cost incurred on C02 emission decreases inbound tourism and international tourist receipts. In other words, the C02 emission translates to increasing international tourist expenditure in these selected countries. In Nyashay et al. (2020), panel data covering SSA from 2002-2018 was used to explore tourism and economic growth using the generalized method of moments (GMM). The findings reveal that tourism expenditure has a negative effect on economic growth, while tourism receipt has a positive effect on economic growth. While tourism receipts are robust in low-income countries, tourism expenditures are robust in the middle-income sub-sample countries. Also, using Panel smooth transition regression (PSTR), as recommended by Nosheen et al. (2021), discover the link between tourism, growth, and environmental degradation, which is important in the current era. The study demonstrates that when tourism development declines, environmental deterioration rises. Second, as tourism grows, the environment is not being harmed as much. However, as the populace increases, the environment degenerates. While urbanisation has a temporary and large positive impact on environmental degradation, it was later changed to negative by using panel data from 1995-2017 covering 20 countries Austria, Canada, China, France, Germany, Greece, Hong-Kong, Italy, Japan, Malaysia, Mexico, Netherland, Poland, Portugal, Russian, Federation Spain, Thailand, Turkey, and USA.

2.3. Tourism and economic indicators

It is imperative to understand that foreign direct investment (FDI) in tourism-hosting countries usually affects tourism development. Hence, by testing for long and short-run effects and examining the environmental Kuznets Curve using time series data spanning from 1971 through 2012 in India and China, Pal and Mitra (2017) establish a long-run effect on economic activity and trade openness. Also, the short-run effect of energy use on C02 emission was discovered to be positive. Furthermore, instead of the U-shaped expected, the result placed emphasis on the N-shaped relationship between C02 emission and per capita GDP. They argued in favour of the sampled countries that, as per capita GDP increases, the C02 emission also increases, but CO2 emission decreases as per capita GDP reaches a certain level.

Yusuf et al. (2023) examined Australia's energy use and its relatedness with trade liberalisation, CO_2 emission, GDP and industrialisation using autoregressive distributed lag (ARDL) technique and a vector error correction model (VECM). The findings indicate that energy use and GDP positively and significantly affect CO_2 emissions. However, trade liberalization has a significantly adverse influence on emissions. Likewise, the relationship between industrialisation and CO_2 emissions is insignificant but positive in Australia. Bekun et al. (2022) examine the function of international tourism influx on E7 countries, an EKC environment economy. Its nexus on income, trade, and institutional quality on CO2 emission is also assessed from 1995 to 2016. The study utilised data from the World Bank Development Indicators database and employs second generational panel estimator with the Driscoll-Kraay robust estimator to analyse the data. The findings indicate that non-renewable energy and per capita GDP diminish the environment quality. As well, CO2 emissions in E7 economies is due to an increase in non-renewable energy and tourism influx. The quality of institutions improves the quality of the environment. Qin et al. (2023) employ the time-varying parameter-stochastic volatility-vector auto-regression (TVP-SV-VAR) model to examine the interactions among blockchain market (BCM), green finance (GF) and carbon neutrality in China (CNP). The study, from June 2017 to August 2022, used weekly time series data to achieve this objective. The results show that blockchain market development creates long-term inducement that has both positive and negative effects on carbon neutrality in China. Green finance development can continually enhance carbon neutrality, though not at the same pace as the blockchain market. Likewise, green finance has a positive influence on BCM, as compared to BCM on GF.

In Shaheen et al. (2019) and Ozpolat et al. (2021), both studies discovered a link between rising FDI as a result of tourism, energy use, and CO2 emissions. The authors reaffirmed that there is a convincing relationship between the growth of foreign tourism and an increase in energy consumption, which has a direct detrimental outcome on the environment. In a similar study, Hanif (2018) examines the relationship between environmental degradation and GDP in sub-Saharan Africa using GDP, consumption of fossil fuels, sustainable energy, and carbon emissions. It was found that South Africa, Madagascar, Nigeria, Mauritius, Ghana, Uganda, and Cameroon are among the top-ranked developing nations of Sub-Saharan Africa, increasing environmental pollution, CO2 and GHG emissions. This correlates with The World Health Organization (2019) position that a half million people die each year in sub-Saharan Africa as a result of this increase in environmental pollution. This accounts for the increase in serious biological damage. Evidence also revealed a mixed relationship between CO2 and other environmental pollutants, energy use, GDP, and foreign direct investment (Bataka, 2020). Furthermore, considering the importance of CO2 emissions on economic growth, particularly in African regions, Kyara et al. (2022) used time series data from 1995 to 2017 to examine the environmental impacts of tourism growth in Tanzania. However, as important as their study is, the scope is limited to a single country in the African region solely. Other recent studies of Sun et al. (2022), Su et al. (2023), Su et al. (2022), Qin et al. (2023), Bekun et al. (2022), Yusuf et al. (2023), and Bekun (2022) emphasise the importance of CO_2 emissions, trade liberalisation, technology innovation, blockchain market, industrialisation and energy usage on economic growth and tourism in other regions and countries, except on the tourism's impact on economic expansion in African region.

Also, Bataka (2021) applies the panel specification with the estimation approach by Hoechle. It is used to account for auto-correlation spatial dependency and heteroscedasticity. Plane data were used to cover the Sub-Saharan African countries from 1980 to 2017, and C02 emission data was sourced from the emission database of the Global Atmospheric Research Base (CEGAR). However, the impact of energy consumption on tourism cannot be underestimated because the policy perspective clarifies the significant effect of energy consumption on economic growth, because it serves as a preliminary stage for industrial society. It provides facilities for household consumption, industrial production, resource mining, and transportation sectors, which have shown that economic growth and development cannot be achievable without the proper significant of energy.

Hence, this study aims to look into the following objectives: 1. To examine whether economic expansion in the SSA countries contributes to carbon dioxide emissions 2. To investigate whether the tourism industry's revenue contributes to the carbon dioxide emissions in the SSA countries.3. To analyse the extent of tourism inducement on environmental pollution in the SSA countries. 4. To determine if labour-intensive technique through employment generation contributes to the rising of greenhouse emissions in the SSA countries. The following section of this paper discusses and explains the empirical techniques and econometrics used in this investigation's analysis and presentation. Therefore, it is deemed crucial to comprehend how tourism revenue and economic growth contribute to carbon dioxide emissions in Sub-Saharan African countries. Thus, within the context of the SSA economies, this study provides a clearer empirical analysis of the topic.

3. Methodology

3.1 Data and source

This study explores the contributions of tourism revenue and economic growth impacted on carbon dioxide in the 47 SSA countries (see Appendix of the list of countries used in the study). In other words, the study examines the nexus between greenhouse gas emissions and economic growth between 2009 and 2020 using a panel data set. The study used CO_2 emissions, trade openness, international tourism revenue, GDP, tourism receipts, fossil fuels, electricity generation and labour force in SSA countries. The labour force was selected because there is labour surplus in the SSA countries that could be used instead of capital-intensive equipment capable of generating emissions. The carbon dioxide emission in this study represents greenhouse gas emission, and it measures thousands of tons. In detail, carbon dioxide emissions are derived from burning fossil fuels and consumption of solid, liquid and gas fuels and gas flaring. The study focused on the economic growth variable, GDP, which is measured in billions of U.S. dollars. Moreover, the study introduced regressors, namely energy consumption, tourism revenue, trade openness, and labour. Hence, the data were downloaded from the Global Economy website on the stated indicators for 47 SSA countries. The list of the 47 sampled countries of the SSA is in Appendix I. Table 1 describes the variables' symbols, measurements and expected signs.

Table 3. Operationalization of factors

Variables	Description	Measurement	Expected sign
Dependent Variable			
CO2E	Carbon Dioxide Emissions	thousands of tonnes kt	
Independent Variables:			
GDP	Gross Domestic Product	billions of U.S. dollars	+
EC	Fossil fuels electricity generation	billion kilowatt hours	+
TorismR	International tourism revenue	million USD	-
TradeO	Trade Openness	percent	+
Labour	Labour force	million people	+

Furthermore, previous studies have shown neoclassical growth theory, which confirmed economic growth association with environmental degradation, namely air pollution and water pollution (Gao, et al., 2021). Also, econometric analysis employs the Cobb-Douglas production function to examine the effect of economic growth on carbon dioxide emissions (Chaabouni & Saidi, 2017; Gao, et al., 2021). Thus, this study replicated the above similar theoretical framework to examine economic growth and carbon dioxide emissions. Again, the prior study focused on only the top ten tourism countries (Destek & Aydın, 2022). Although the tourism sector has contributed to economic growth, it is a factor that causes environmental degradation through many channels. Unlike other studies, this study classified SSA countries into regions, namely Eastern Africa, Middle Africa, North Africa, South Africa and Western Africa. This is to cover the gap in Ohajionu et al. (2022) who urged future researchers to examine potential variables that might cause environmental degradation in SSA countries.

Model estimation

This section explains various econometrics estimation techniques to examine the relationships between the tourism industry and greenhouse emissions.

There are three level estimations in this study. First, the study determines the correlation between the examined variables to understand the extent to which each variable affects one another. Also, the basic correlation analysis provides some basic hints on variable association regardless of the dependent and independent variables' status. Second, the study analysed pooled ordering least square (POLS) which allows small variation in estimation that obeys best linear unbiased estimation. In this instance, we assumed that there are no unobservable entity-specific effects. Simply, we proposed that all the data set of member countries of SSA had the same underlying characteristics during the period. Finally, the study employed Least Square Dummy Variable (LSDV), with the assumption that each region in the SSA countries could control its carbon dioxide emission levels differently.

Correlation Analysis

This study performed pairwise correlation analysis to determine the correlation coefficient range among variables and identify coefficient signs.

Pooled OLS

The study applies the pooled panel Ordinary Least Square (OLS) to measure the overall influence of economic growth on carbon dioxide emissions without controlling for countries' heterogeneity. The study considered the Poole OLS, considering that all the data set had the same underlying characteristics during the period. The Pooled OLS model is specified in equation [1].

$$CO2E_{it} = \phi_i + \phi_1 GDP_{it} + \phi_2 EC_{it} + \phi_3 TR_{it} + \phi_4 TO_{it} + \phi_5 L_{it} + \varepsilon_{it} \quad [1]$$

In Model 1, $CO2E_{it}$ is the dependent variable and $\phi_i$is the intercept, ϕdenotes slope coefficients and independent variables are GDP represents Gross Domestic Product, EC denotes Energy Consumption, TR refers Tourism Revenue, TO describes Trade Openness and $L$is Labor. On the other hand, pooled OLS estimation subjects biased and inefficient outcomes.

Finally, the study employed the Least Square Dummy Variable (LSDV). We assumed that each region in SSA could be determining carbon dioxide emission levels differently. Also, different SSA region groups might have different patterns regarding economic growth, energy consumption, and tourism revenue generation. This section is dedicated to formulating LSDV estimation methodology that pooled 47 SSA countries data information from qualitative variables in econometric model. The model contains dummy variables to measure qualitative influence by coding the different possible outcomes with continuous variables. The dummy variable has dichotomized the possible outcomes and assigned the values of 0 and 1.

Thus, SSA regions have been coded as DMA_{it}= 1 for Middle Africa, 0 otherwise; DNA_{it}= 1 for Northern Africa, 0 otherwise; DSA_{it}= 1 for Northern Africa, 0 otherwise.$D2012_{it}$= 1 for 2012, 0 otherwise and $D2018_{it}$= 1 2018, 0 otherwise. Study has derived regression model that included dummy variables as below

$$CO2E_{it} = \phi_i + \phi_1 GDP_{it} + \phi_2 EC_{it} + \phi_3 TR_{it} + \phi_4 TO_{it} + \phi_5 L_{it} + \phi_6 DMA_{it} + \phi_7 DNA_{it} + \phi_8 DSA_{it} + \phi_9 DWA_{it} + \phi_{10} D2012_{it} + \phi_{11} D2018_{it} + \varepsilon_{it} \quad [2]$$

The descriptive statistics of the data collected is presented in Table 2.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2	658	1.002	1.907	.02	11.68
GDP	735	31.342	74.52	.14	546.68
EC	713	6.316	32.421	0	233.05
TourismR	551	4.455	7.292	0	42.18
TradeOp	683	73.996	37.632	9.96	311.35
Labour	736	7.727	10.849	.05	63.23

The descriptive statistics show that the data used in this study is unbalanced. This was accommodated by the software used.

4. Results and discussions

The results and discussions section is divided into three sub-sections, namely, the Pairwise Correlation coefficient and pooled OLS and LSDV estimations.

4.1 The Pairwise Correlation coefficient

This sub-section presents the results of the pairwise correlation coefficient and the p-value to understand the significant level of the relationship. The results id presented in Table 3.

Table 3. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) CO2	1.000					
(2) GDP	0.306*	1.000				
	(0.000)					
(3) EC	0.534*	0.683*	1.000			
	(0.000)	(0.000)				
(4) TourismR	0.464*	-0.154*	-0.048	1.000		
	(0.000)	(0.000)	(0.259)			
(5) TradeOp	0.401*	-0.215*	-0.078*	0.591*	1.000	
	(0.000)	(0.000)	(0.046)	(0.000)		
(6) Labour	-0.042	0.702*	0.245*	-0.210*	-0.366*	1.000
	(0.286)	(0.000)	(0.000)	(0.000)	(0.000)	

***** Significant at p <0.05.

We analysed pairwise correlation analysis to identify the strength of the partial relationship between carbon dioxide emissions, economic growth, energy consumption, tourism revenue, trade openness and labour. Table 3 presents pairwise correlation results. Thus, we have possible and negative correlations across variables. For example, energy consumption has shown a positive and substantial correlation with carbon dioxide emissions and GDP because EC coefficients lie between 0.50 to 0.69. Besides, tourism revenue has shown a positive coefficient at 0.464 and a moderate correlation with carbon dioxide emissions. However, tourism revenue has indicated negligible and negative correlation with GDP as well as insignificant correlation with energy consumption.

4.2 Pooled OLS results and discussion

Table 4 presents pooled OLS model results that comprised 47 SSA countries. In detail, pooled OLS estimation has shown five statistically significant associations among economic growth, energy consumption, tourism revenue, trade openness and labour. Although the results have passed diagnostic tests, the model suffered from some limitations. We considered the limitations to be insufficient to explain the carbon dioxide emissions phenomenon without compromising the heterogeneity of the countries.

Hence, the finding shows that a 1% increase in GDP increases carbon dioxide emissions by about 0.004%. Basically, growth often comes with intensive use of capital, where electricity and fossil fuels are considerably used. Earlier, we hypothesized that economic growth will increase carbon dioxide emissions in SSA countries, as validated in previous findings.

The positive association is in line with the findings of Jiang et al. (2022), Liu et al. (2022) and Ouyang et al. (2019). The study has supported prior literature and neoclassical growth theory that decomposed economic growth that consisted of additional factors that could reduce the environmental quality in SSA countries. However, prior literature lists have always concentrated on non-linear estimation that emphasized EKC theory in countries such as China and OECD countries. Furthermore, researchers have focused on the causality between air pollution indicators such as PM 2.5 and GDP. This study has added to existing literature that 47 SSA countries air quality was reduced because of their lower economic activities. The fact that developing countries have fewer industrial activities compared with developed countries, their little economic activities have always neglected environmental quality, thereby breaching environmental law. As such, the SSA countries economic activities, legally or illegally, are expected to emit carbon dioxide that affects the environment.

Table 4. Linear regression: pooled OLS

CO2	Coef.	St.Err.	t-val	p-val	[95% Conf	Interval]	Sig
GDP	0.004	0.001	4.91	0.000	0.002	0.005	*
EC	0.03	0.001	25.23	0.000	0.028	0.033	*
TourismR	0.03	0.007	4.61	0.000	0.017	0.043	*
TradeOp	0.008	0.001	7.66	0.000	0.006	0.01	*
Labour	-0.03	0.004	-7.04	0.000	-0.039	-0.022	*
Constant	0.086	0.083	1.03	.305	-0.078	0.249	
Diagnostic Tests:							
Heteroscedasticity	12.11						
Multicollinearity	2.40						
Normality	pass						

Mean dependent var	0.828	SD dependent var	1.454
R-squared	0.809	Number of obs	481
F-test	402.993	Prob > F	0.000
Akaike crit. (AIC)	939.076	Bayesian crit. (BIC)	964.132

**Significant at p<.05*

The SSA African countries energy consumption reduced air quality. Again, the results in Table 4.2 showed that a 1% increase in fossil fuel consumption in the sampled SSA countries increased carbon dioxide emissions by 0.03%. In other words, the expected signs and findings show that fossil fuel usage deteriorates environmental quality (Chien, et al., 2021; Khan, et al., 2016). Again, and in no small measure, energy used by industries and households will emit harmful gases into the air, thereby reducing air quality. To this end, we introduced another important variable, i.e. electricity consumption, which used fossil fuel to generate power supply. The finding reveals that the higher the electricity consumption, the higher the air pollution.

Further, on the assumption that cross-country trade activities will cause greenhouse gas emissions, we found that a 1% increase in trade openness increases carbon dioxide emissions by about 0.008%. Although the contribution of trade openness to greenhouse emissions is extremely reduced, the positive relationship between trade openness and CO2 is consistent with previous findings (Kukla-Gryz, 2009; Lin, et al., 2014). Most importantly, the SSA low energy consumption contributes more to carbon dioxide emissions (Agyeman, et al., 2022), as reflected in the developed countries, is accountable to the low carbon dioxide emissions in the sampled countries of SSA.

Finally, there are two positions regarding the estimated labour variable. First, labour variable was introduced to understand that labour-intensive production might be better than using capital-intensive techniques. The more equipment used, the higher the emissions. Whereas using labour intensive techniques would reduce greenhouse emissions. Second, we argue that urbanization tends to increase emissions through pollution channels. The migration from rural to urban centres to join the accumulation of industries effect, CO2 would increase considerably. However, the result showed a negative relationship. Although at a minimal percentage, a unit increase in the labour indicator caused 0.03% reduction in carbon dioxide emissions in the selected SSA countries. This rather supports the labour-intensive technique of production (Li et al., 2020) against the assumption that labour increases air pollution.

4.2 Least Square Dummy Variable (LSDV*)* approach

This section presents the results of the Least Square Dummy Variable (LSDV). Hence, we performed LSDV regression as presented in Table 5.

Table 5. LSDV Regression results

CO2	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
GDP	0.007	.003	2.54	0.012	.002	.013	**
EC	0.047	.008	5.77	0.000	.031	.063	***
TourismR	-0.039	.013	-3.04	0.003	-.064	-.014	***
TradeOp	0.001	.001	1.40	0.163	0	.003	
Labour	-0.057	.014	-3.92	0.000	-.085	-.028	*
region1#co: base 1	0	.	.	.	.	.	
Middle Africa	-0.007	.003	-2.00	0.047	-.013	0	*
East Africa	-0.005	.006	-0.83	0.405	-.017	.007	
South Africa	-0.01	.003	-3.06	0.002	-.017	-.004	*
West Africa	-0.009	.003	-2.97	0.003	-.015	-.003	*
2009b	0	.	.	.	.	.	
2010	0.016	.036	0.46	0.645	-.054	.086	
2011	0.035	.036	0.95	0.341	-.037	.106	
2012	0.061	.037	1.67	0.095	-.011	.134	*
2013	0.078	.038	2.06	0.04	.003	.152	*
2014	0.097	.038	2.52	0.012	.021	.172	*
2015	0.091	.039	2.34	0.02	.014	.168	*
2016	0.112	.04	2.78	0.006	.033	.191	*
2017	0.147	.042	3.49	0.001	.064	.229	*
2018	0.173	.045	3.86	0.000	.085	.262	*
Constant	0.964	.143	6.75	0.000	.683	1.245	*

Mean dependent var	0.854	SD dependent var	1.457
R-squared	0.214	Number of obs	342
F-test	4.316	Prob > F	0.000
Akaike crit. (AIC)	-373.141	Bayesian crit. (BIC)	-300.280

**Significant at p<.05.*

In Table 5, we computed the LSDV to explain the increment in carbon dioxide emissions levels in SSA countries between 2005 and 2020. As shown there, there are three parts of the LSDV analysis comprising continuous variables association, countries interaction with economic growth and dummy for years. First, the LSDV estimation produced results similar to those of pooled OLS except for the tourism revenue. The tourism revenue supported the earlier hypothesis that the tourism sector could improve environmental quality. Simply, tourism revenue demonstrates a negative relationship with carbon dioxide emissions at 1% significance level. it shows that 1% increase in tourism revenue decreased carbon dioxide emissions in about 0.039%.

Second, we decompose the SSA countries into regions to determine the regional dummy interaction with economic growth. Unlike previous studies that lumped a large list of countries into single estimation, we categorized SSA countries into sub-regions comprising Eastern Africa, Central Africa, Southern Africa and Western Africa where Eastern African region remains the base dummy to avoid dummy trap. Table 4.3, the constant value explains that carbon dioxide emissions from the controlled group Eastern Africa is 0.964. The GDP coefficient has shown marginal effects of economic growth for the control group Di= Eastern Africa. In other words, Eastern Africa contributed an additional 0.07 carbon dioxide emissions mt / % for an additional year of economic growth. Likewise, the Central Africa interaction with economic growth demonstrated that countries from this region emitted carbon dioxide [0.964- (0.007=0.957 units) for extra years of economic growth. As such, Central Africa region emitted carbon dioxide lesser units of 0.007 below the 0.964 threshold. Moving to South Africa region, considering the South Africa region interaction with GDP, we established that the region emitted [0.964- (0.01=0.95 units] for extra years of economic growth. This shows that South Africa region emitted carbon dioxide lesser units of 0.01 below the threshold. Finally, in the Western African region, the economic growth interaction with West African countries indicated that those countries from the region emitted [0.964- (0.009=0.955 units] for extra years of economic growth. This simply shows that the West African countries' carbon dioxide emissions contributed lesser units 0.01 below the threshold.

Third, we introduced a dummy year variable to explain the period that the carbon dioxide emissions actually hit the selected countries. We made 2009 the base year. Hence, the dummy year estimation reveals that the average carbon dioxide emissions were 0.016 mt / % higher in 2010 but not significant. After that, in 2012, carbon dioxide emission was given as 0.061, which was higher than 2010. In general, the coefficients of the dummy year have indicated a statistically significant increment in carbon dioxide emissions in 2013 (0.078 mt), 2014 (0.097 mt), 2015 (0.091 mt), 2016 (0.11 mt), 2017 (0.147 mt) and 2018 (0.173 mt). While other dummy years' results were high, the 2015 revealed that carbon dioxide decreased slightly to about 0.091, but later increased to 0.178 in 2018. This is to understand that the dummy year coefficients explained that holding dependent and independent variables constant, on average, carbon dioxide had greater emissions between 2012 and 2018 in the SSA countries.

5. Conclusions and policy implications

The study investigates the relationship between tourism's revenue, economic growth and carbon dioxide emissions in the SSA countries. It further decomposes the SSA region into sub-regions and examines countries' interaction with economic growth and dummy years to understand each region's contributions to the accumulation of greenhouse emissions in SSA countries. Finally, the study determines the labour force involvement in greenhouse emissions across the sampled countries. As such, four independent conclusions were drawn. First, although the economic activities of the SSA countries are low compared with some Asia and Europe economies, the revenue realized from the tourism industry contributes greatly to the total emissions of the region. This is accountable to the reinvestment of growth gains into the tourism industry, which triggers the uncontrolled fossil fuels being used around the year and the trade openness through FDI channel. However, the world market competition does not and should not discourage considerable investment into the tourism industry in the SSA countries, otherwise, the region would remain undeveloped.

Second, with the decomposition of the region into sub-regions, we conclude that, although at varying degrees, the sub-regions jointly contributed to the high rate of greenhouse emissions in the SSA countries. For example, southern African countries contributed the highest percentage of greenhouse emissions compared to the other sub-regions due to heavy use of industrial equipment and high use of electricity. While the SSA sub-regions should not restrain from heavy investment into the real sector, the government could integrate into the global value chains for optimal use of equipment and resources.

Third, before the digital age (IR4.0), countries relied solely on capital-intensive techniques in the production process. This period of IR3.0 was a means of capital-intensive use of machines that de-emphasized the labour-intensive technique, which created a labour surplus in the long run. ., Although at a minimal rate, we conclude in favour of the labour-intensive technique as the result of this study showed, where it triggered the reduction of greenhouse emissions in the SSA countries rather than the capital-intensive use of production.

Fourth, developing sustainable tourism is one of the 2030 sustainable development goals (SDG) has an indirect effect on poverty reduction. This realization that the positive effect of tourism cannot be altered due to the infinitesimal incremental effect of tourism revenue on CO2 in the SSA countries. Thus, rather than curtailing tourism expansion in the SSA countries, the governments of the sampled countries should study those elements to increase emissions by developing or adopting alternatives to emission reduction. For example, if electricity consumption increases CO2 in a country or sub-region, it is imperative that the government consider the installation of Solar resources as a strong alternative policy to electricity consumption to mitigate against excess greenhouse emissions in such a country or sub-region.

Finally, the government of the sampled SSA countries should carefully consider acceptance of foreign direct investment (FDI) absorption into the economic system. This is especially necessary that bringing in an industry that would trigger carbon emissions into the country should be technically avoided. Rather, the government may consciously integrate itself into the digital age movement through intensive knowledge transfer in the space/digital exploration and intensive computer educational courses (e.g. Artificial Intelligence (AI), cloud computing, etc.) that allow for digital marketing, business development and physical services and construction.

Crucially, the empirical results demonstrated that the economic expansion of African nations had a major impact on carbon dioxide emissions. Furthermore, the tourism industry's potential to reduce carbon dioxide emissions is indicated by the revenue it generates for African nations. Therefore, it is recommended that the countries included in the sample implement stringent policies that prioritize environmental regulations. This will help to mitigate the negative impact of foreign direct economic activities on both the natural and human environments.

Limitations of the study and future research

The study analyses how tourism revenue and economic growth contributed to carbon dioxide emissions in selected 47 (SSA) between 2005 and 2020. other studies should look at how tourism revenue and economic growth contribute to carbon dioxide in more (SSA) countries on a wider range. Although the study employed pooled ordinary least square (OLS) and least square dummy variable (LSDV) as the study econometric technique, we observed that the study did not address the long-run relationships of the variables, which would have attracted panel cointegration. The future study may proceed to test for stationary to detect the best econometric method, such as panel autoregressive distributed Lag (Panel ARDL) model, panel vector error correction model, pooled mean group (PMG), and mean group (MG).

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Appendix I. List of countries in the panel data

S/N	Country	S/N	Country
1	Angola	25	Malawi
2	Benin	26	Mali
3	Botswana	27	Mauritania
4	Burkina Faso	28	Mauritius
5	Burundi	29	Mozambique
6	Cameroon	30	Namibia
7	Cape Verde	31	Niger
8	Central African Republic	32	Nigeria
9	Chad	33	Republic of the Congo
10	Comoros	34	Rwanda
11	Democratic Republic of the Congo	35	Sao Tome and Principe
12	Equatorial Guinea	36	Senegal
13	Eritrea,	37	Seychelles
14	Ethiopia	38	Sierra Leone
15	Gabon	39	Somalia
16	Gambia	40	South Africa
17	Ghana	41	Sudan
18	Guinea	42	Swaziland
19	Guinea-Bissau	43	Tanzania
20	Ivory Coast	44	Togo
21	Kenya	45	Uganda
22	Lesotho	46	Zambia
23	Liberia	47	Zimbabwe
24	Madagascar		