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CAN THE TOURISM SECTOR ENABLE AFRICA TO MEET ITS 2030 ECONOMIC GROWTH AND CARBON EMISSION REDUCTION TARGETS? - EVIDENCE FROM COUNTRIES WITH BIOCAPACITY RESERVES.

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Abstract

Many research investigations the link between CO2 emissions and tourism. However, several studies in Africa have looked closely at this relationship. This study evaluates how tourism development and economic growth affect carbon emissions in the African region. The study is based on 16 African economies with biocapacity reserves (divided into 4 groups). In particular, the article investigated whether an increase in Ecological Footprint, urbanization, Renewable Energy Consumption, International tourism, and Gross Domestic Product impact CO2 emissions in those 16 African countries. The data are from the World Bank, Global Footprint Network, and World Tourism Organization from 2002 to 2019. The study applied Kao, FMOLS, and DOLS methods. The Kao approach demonstrates that the panel unit roots cause the variables to cointegrate in the long-run. According to the FMOLS test, group 1, 2, and 3 CO2 emissions decrease with a 1% increase in ecological footprint, while group 4 CO2 emissions increase. Group 1, 2, and 4 CO2 emissions decreased, and group 1 emissions increased with a 1% increase in foreign direct investment. Urbanization increases by 1% decreases CO2 emissions in group 2 by 0.50%, but increases emissions in groups 1, 3, and 4 by 0.60%, 0.39%, and 0.28%, respectively. Group 2, 3, and 4 emissions decreased by 0.13%, 2.17%, and 1.14%, respectively, in a 1% increase in renewable energy; however, group 1 emissions increased by 1.51%. CO2 emissions will decrease with a 1% increase in tourism development. The results validate the validity of the Environmental Kuznets Curve by demonstrating the inverted U-shaped link between CO2 emissions and economic growth. According to the DOLS findings, a 1% increase in ecological footprint eventually lowers CO2 emissions for groups 1 and 3 but raises CO2 emissions for groups 2 and 4. On the other hand, in the long-run, a 1% increase in foreign direct investment raises CO2 emissions for the other groups while decreasing CO2 emissions for groups 1 and 3. For groups 1, 3, and 4, a 1% increase in urbanization results in an increase in CO2 emissions. In the long-run, a 1% rise in the usage of renewable energy will lower CO2 emissions in groups 1, 2, and 3, but increase CO_2 emissions in Group 4. Tourism development and economic growth are similar to FMOLS. The findings provide policymakers and stakeholders valuable insights into achieving environmental stability, tourism development, and climate stability in Africa.

Keywords: Environmental stability, Tourism development, Climate stability, Africa.

I. Introduction

One of the most important issues that nations, governments, politicians, and scientists deal with is climate change. Thus, the media and researchers are becoming more and more concerned with increasing public awareness of environmental protection and carbon dioxide emission factors. Insofar as multiple research studies have demonstrated a relationship between CO2 emissions and a variety of factors, such as tourism, economic expansion, urbanization, energy use, and gross domestic product.

Few studies have thoroughly examined the connection between tourism development and rising CO2 emissions. [1,2]**.** Various surveys have focused on the negative impacts of climate change or global warming on tourism. For them, climate influences the choice of activities and tourist destinations [3–5]**.** Tourism is a key global economic sector that has experienced considerable growth in emerging economies and developing countries. Tourism is considered a very climate-sensitive sector and is sometimes affected by climate change and environmental changes. On the other hand, tourism has a big potential to cut carbon emissions. It accounts for nearly 8.5% of the GDP of Africa. Additionally, the sector is expanding quickly, with an average yearly growth rate of 5.5% between 2010 and 2020. African countries possessing reserves of biocapacity hold significant potential for fostering sustainable tourism. They boast abundant and varied natural and cultural resources and a pleasant climate for tourists. However, tourism can also have a big impact on the environment, particularly when it comes to carbon emissions. The tourism sector must prioritize sustainable development if it is to lower carbon emissions and boost Africa's economy.

These days, the tourism industry can be very important to the sustainability and stability of the environment. Economic growth may contribute to a climate stability system, and affect positively people's day-to-day lives. [6–9]**.** It should be highlighted that there are many ways that tourism may impact environmental sustainability. For instance, Africa's rising economic growth, increased energy consumption, and increased demand for natural resources will all cause the continent to emit more carbon dioxide in the future. Technological developments and scientific advancements in the tourism industry support energy management and economic growth that lowers carbon emissions. As a result, the government must be conscious of the state of the tourism sector, particularly its innovative practices and ongoing operations. Indeed, tourism is among the most important economic industries and has the greatest scope for development, accounting for 9% of global GDP [10–16]. While its expansion is the main option for all the world's economies. At a time when the continent's growth is collapsing, tourism development seems to be one way to boost the African economy. Africa can turn tourism into an industry that can revive the continent's green economy, which has been paralyzed by the COVID-19 pandemic. Of course, the continent will draw in a lot of interested partners because of its continued appeal to investors despite its complicated socioeconomic situation to develop sustainable tourism in Africa, which benefits both local people and the environment.

According to [17], Africa has a sustainable tourism policy in place that aims to reduce the environmental impact of the sector. For ref [17] Kenya's policy reduced carbon emissions from the tourism sector by 20% between 2010 and 2020. Rwanda has also developed sustainable tourism, with a focus on environmental protection and the involvement of local communities [18]. The country has been recognized as among the most sustainable travel destinations worldwide. South Africa has significant potential for sustainable tourism, due to its rich and diverse natural and cultural resources. The country is developing initiatives to promote sustainable tourism, including community-based tourism and responsible tourism. Only 6.7 million tourists visited Africa in 1990; by 2012, that figure had risen to 33.8 million. Since 2012, tourism-related revenue has surpassed $36 billion, directly contributing 2% or 8% of the region's GDP, for a combined direct and indirect contribution of 7.3%. The World Tourism Organization (UNWTO) reports that, in the year 2019, the number of persons arriving in Africa decreased by 70% compared to the global average of 74%. Therefore, Africa must reinvest in tourism, especially after a prolonged absence due to the COVID-19 pandemic. The Sustainable Development Goals (SDGs) state that tourism helps create jobs and fights poverty. Nations with a long history of tourism have every incentive to encourage tourism as a driver of economic growth because they understand that the industry is intricate and affects a wide range of other economic endeavors. African nations have a wealth of natural and cultural resources, including stunning beaches, a wide variety of flora and fauna, and the possibility of adventure that they must seize to realize their dreams. Tourism-related products that are currently in high demand, like ecotourism, adventure tourism, cultural tourism, and health and wellness tourism, have a lot of potential in Africa.

To support climate or environmental stability, it is critical to draw attention to the process of evaluating and enhancing the tourism industry. It would help to understand this in a few ways. Since success in the tourism industry is not correlated with income levels, nations with underdeveloped tourism industries should be supported. Table 1 indicates that two low-income nations—Zambique and Mozambique—are among the top performers, while two nations—Botswana and Namibia—are classified as "consolidation" nations. Tourism has the potential to generate millions of jobs and numerous other economic advantages if it is developed successfully. However, only Namibia and Botswana have been able to grow their tourism industries. Shortly, Zambia and Mozambique could experience similar success, and the six pre-emerging and six potential nations could emulate them.

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Table 1 SSA Countries by Tourism Development Level and World Bank Income Ranking

Level of Development Tourist	Low-income countries	Income countries Intermediate, Slice Inferior	Income countries Intermediate, Slice Superior
Pre-emerging countries	Guinea, Guinea-Bissau, Republic of Macedonia Central African Republic, Democratic Republic of Congo, Chad.	The Republic of Congo,	N/A
Potential Country	Madagascar, Mali.	Angola, Cameroon, Ivory Coast.	Gabon
Emerging countries	Mozambique, Zambie	N/A	N/A
Countries in the consolidation phase	N/A	N/A	Botswana, Namibia

Source: Authors based on World Bank Country Rankings 2009 data; World Bank 2010a. Note: N/A = not applicable. Income ranking from GNI per capita.

Tourism as a sector of the economy influences both environmental management and economic advancement. Research has demonstrated a connection between FDI and tourism in terms of economic growth and sustainable development [19,20]. Tourism is often seen as following the pace of a country's development or growth [21,22]. Furthermore, African tourism is still growing. Figure 1 confirms encouraging signals with the arrival of tourists in Africa. Tourist arrivals into Africa experienced a significant decline in 1990; nevertheless, over time, the number of arrivals from certain countries rose. The increasing number of visitors arriving in Africa is encouraging for the continent's tourism industry. The African economy depends heavily on the tourism industry, which also creates jobs, generates large incomes, and fosters cross-cultural understanding. To prevent negative environmental effects, tourism development must be done sustainably. Thus, it's critical to take action to lessen greenhouse gas emissions, safeguard natural resources, and minimize adverse effects on nearby communities.

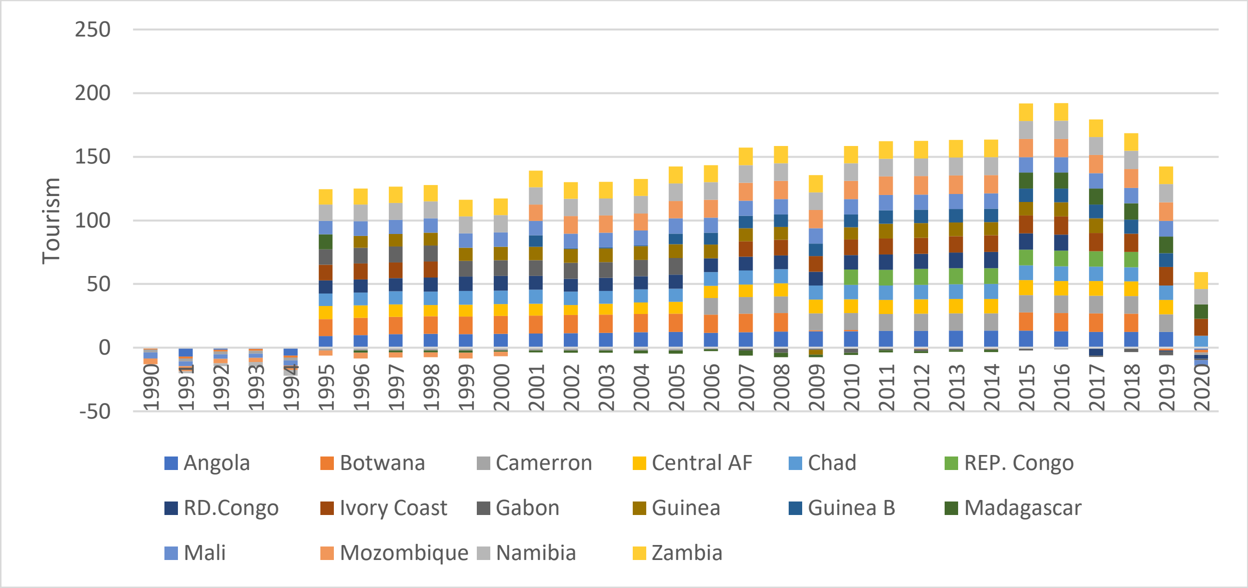

Figure 1: Tourism Arrivals

Nonetheless, it's crucial to remember that to promote economic empowerment and the control of CO_2 emissions, African governments must guarantee responsible tourism and concentrate on effective environmental or climate management. According to some researchers, greenhouse gas emissions are primarily caused by human activity, and this also applies to tourism [23,24]. Although tourism has improved people's living conditions, it also consumes a lot of energy, directly or indirectly increasing the amount of greenhouse gas

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emissions [25–27]. Although the rate of carbon emissions during the 1980s and 1990s was 19 million km, or 80% [28], energy consumption had a negative effect on the quality of the environment [29, 30]. Figure 2 illustrates how carbon dioxide emissions dramatically rise in four countries over time while falling in the other countries. Carbon emissions may rise or fall over time for a variety of reasons. The following elements could play a role in the variations seen amongst nations: Ecological Footprint, Foreign Direct Investment, Urbanization, Renewable Energy Consumption, and international tourism, receipts for travel items. The ecological footprint is a measurement of natural resources that a person, community, or country consumes. A high ecological footprint indicates that people or countries consume more resources than the planet can sustainably provide. Increasing a country's ecological footprint can lead to increased CO_2 emissions, as the production of the goods and services consumed requires energy, often produced from fossil fuels. African countries with biocapacity reserves generally have a smaller ecological footprint than developed countries. However, urbanization and economic growth can lead to a rise in ecological footprint and thus CO_2 emissions [28,29]. Foreign direct investment contributes to increasing carbon dioxide emissions in a country because it increases production and consumption. Yet, this foreign direct investment can also help reduce CO_2 emissions by financing renewable energy and energy efficiency projects. Urbanization could lead to an increase in a country's CO_2 emissions, as cities traditionally consume more energy than rural areas. But urbanization also helps to lower CO_2 emissions by increasing the use of public transport and renewable energy. Renewable energy consumption helps to decrease carbon dioxide emissions, as these energy sources do not produce carbon dioxide[30]. In the same way, using renewable energy may increase the production of electricity, it additionally boosts CO2 emissions. Travel abroad may be a factor in the rise in CO2 emissions in African countries as it often involves international travel. However, international tourism also helps to reduce CO_2 emissions, as it can increase the demand for local products and environmentally friendly tourism activities.

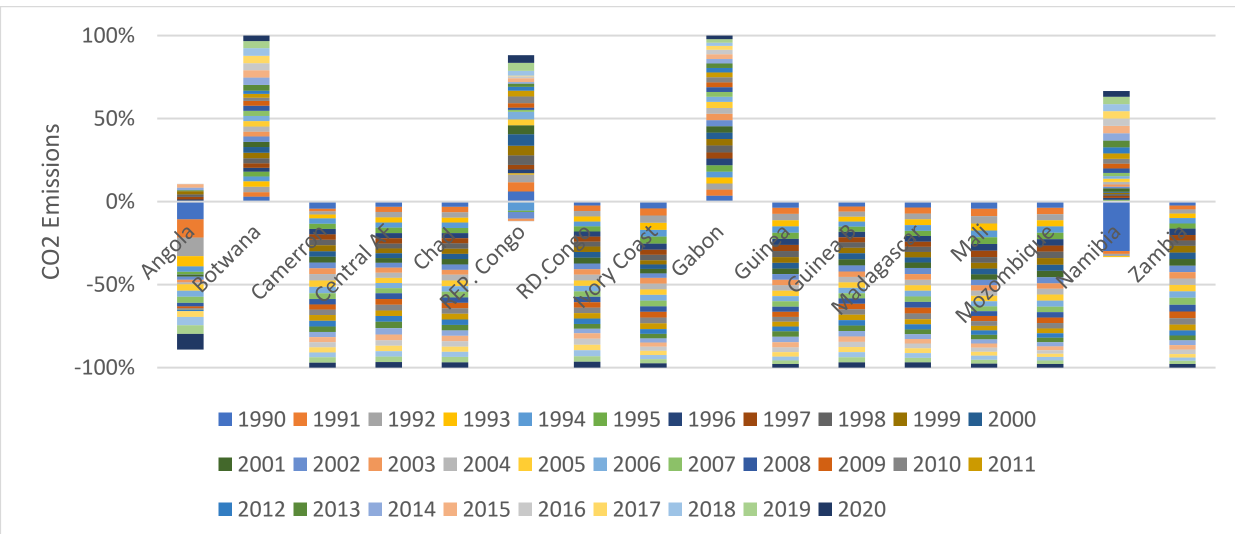

Figure 2 CO_2 Emissions

Tourism activities indeed affect the environmental quality through the emissions of greenhouse gases emitted during the export process, but the link between tourism development and carbon emissions has rarely been explored. Some studies focus on carbon emissions emitted in tourist transport [31–33], others focus on emissions associated with tourist accommodation [34–37] or tourism activities [38–40], and especially direct and indirect emissions linked to the tourism sector [41–44]. On the other hand, another group of researchers is embarking on the study of the eco-efficiency of tourism as a solution to environmental and climate problems [32,45–49].

Tourism development, the environment, and climate change in Africa have not been studied in depth. This study evaluates how tourism development and economic growth affect carbon emissions in the African region. The study is based on 16 African economies with biocapacity reserves (divided into 4 groups). Specifically, in group1 all 16 countries. Group2, 5 countries in the southern region (Angola, Botswana, Mozambique, Namibia, Zambia); group3, 5 countries in the West and West regions (Côte d'Ivoire, Guinea, Mali, and Madagascar), and finally group4, 6 countries in the Central Region (Cameroon, Central African Republic, Chad, Republic of Congo, Democratic Republic of Congo and Gabon). In particular, the article investigated whether an increase in Ecological Footprint, urbanization, Renewable Energy Consumption, International tourism, and Gross Domestic Product impact CO2 emissions in those 16 African countries. The data are from the World Bank, Global Footprint Network, and World Tourism Organization from 2002 to 2019. The study applied Kao, FMOLS, and DOLS methods. We use the following variables: Ecological Footprint, Foreign Direct Investment,

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Urbanization, Renewable Energy Consumption, international tourism, receipts for travel items, and CO_2 Emissions during the period 2002-2019 to describe and explain the objectives of this study. Countries are selected based on their biocapacity and potential for tourism development. This research is a step forward and a great contribution is expected from this study, as the biocapacity of these countries is greater than their ecological footprint, meaning that they hold the capacity to produce more natural resources than they consume. This gives them an enormous capacity for sustainable development, particularly in the tourism sector. In addition, this article also uses two methods; panel fully modified least squares (FMOLS) and panel dynamic least squares (DOLS). These two methods make it possible to control the long-term link between CO_2 emissions and the rest of the variables studied. Ultimately, the results will support authorities in effectively overseeing the tourism, environmental, and climate sectors. The literature review is covered in Section 2. The Materials and Methods is covered in Section 3. The results and discussion form the basis of Section 4, and the article is concluded in Section 5.

II. Literature review

The relationship between CO2 emissions and tourism has long piqued scientific curiosity. Many research projects employ different methods to try to find solutions to this problem. Not much research has been done on how ecological footprint affects the relationship between CO2 emissions and tourism growth in African nations. Consequently, the goal of this research is to find out how the ecological footprint affects the relationship between CO2 emissions and the other factors chosen for this article.

2.1 Relationship between Ecological Footprint and CO2 emissions

Author [50] findings show that the Kuznets environmental curve (EKC) hypothesis is valid for the ecological carbon footprint, pollutants, and CO2 emissions and that the U-shaped pattern holds for the entire ecological footprint while considering breaking points. The author Sohail Abbas studies how Pakistan's energy use and environmental impact affect the country's CO2 emissions. The study discovered that the short-term effects of conventional energy, renewable energy, and ecological footprint on CO2 were negligible.

Ref (Adebayo et al., 2022) examines the factors that affect load capacity, ecological footprint, and CO2 emissions in Thailand. Since the PHH mainly relates to CO2 and load capacity measures along with the ecological footprint, the study's findings demonstrate that the PHH's reliability shifts based on environmental indicators. Furthermore, the only substance that can improve environmental quality is renewable energy. According to [52], there are differences in how environmental degradation is measured between carbon emissions and ecological footprint. According to [53], the global carbon footprint of tourism has grown from 3.9 GtCO2e to 4.5 GtCO2e, which is four times higher than the previous estimate and accounts for about 8% of all gas emissions. The article highlights the different vulnerabilities of tourist destinations. For refs [54–56], all destinations must adapt to the risks and opportunities presented by climate change and climate policy. The ability of biofuels to decrease carbon emissions was evaluated by the authors [57] The investigation showed that the least carbon-efficient form of local transportation is public land transportation.

2.2 Relationship between Foreign Direct Investment and CO_2 emissions

Foreign direct investment, CO2 emissions, and economic growth are examined in reference [58] results show that the three variables (FDI, CO2, and GDP) have a co-integrated relationship. The findings of the FMOLS, which was carried out by ref [59], showed that foreign direct investment had no long-term effect on CO2 emissions. However, countries with low revenues have a positive long-term association with carbon emissions and FDI inflows. Ref [60] uses novel SOR unit root test and bootstrap bounds test methods on French countries' information for the years 1955 to 2016 and finds a positive impact of FDI and innovations in energy-related investigation have had an adverse effect on France's carbon emissions. Foreign direct investment damages the environment, thus supporting the hypothesis that France is a "pollution paradise."

They use a unique firm dataset from 13 cities in Jiangsu Province, China, to study the link between foreign direct investment and energy intensity. According to their research, there is a noteworthy negative correlation between foreign direct investment and energy intensity, meaning that foreign investment companies rely on less energy than those that operate locally [61]. At the same time, the refs [62] use the autoregressive distributed lag cointegration (ARDL) method and breakpoint unit root test as well as structural breakpoints in the model to test whether the influx of foreign direct investment should be responsible for the increase in domestic carbon dioxide. The bounds tests indicate that a steady, long-term partnership exists among selected variables in each model. The refs [63] studied how financial development and economic expansion affected environmental deterioration during the period 1980-2007, excluding Russia (1992-2007), using panel cointegration techniques. Results support the Environmental Kuznets Curve (EKC) hypothesis, which states that while foreign direct investment is not flexible with energy consumption in the long run equilibrium, CO2 emissions are. The causal analysis's findings show that there is a strong, unidirectional, and bidirectional causal relationship between production and FDI as well as between emissions and FDI. Pollution harbors, halo, and scale effects appear to be supported by the evidence.

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2.3 Relationship between Urbanization and CO_2 emissions

By adding explanation factors like urbanization into empirical models and analyzing the EKC hypothesis, they learn more about how to deal with the deterioration of the environment. Long-term urbanization raises CO2 emissions; Bangladesh has demonstrated EKC. [64]. Ref [65] used data from 1960 to 2013 to demonstrate a positive relationship between urbanization and CO2 emissions; the EKC was upheld for Turkey. Ref created an identical case with data from 27 nations with developed economies. But the article [66], used panel data from China and the GMM method. Although this study did not confirm the EKC hypothesis, it did imply that urbanization increases CO2 emissions. Conversely, ref [67], provided proof that, in the context of Sri Lanka, urbanization had a negative relationship with CO2 emissions. The results obtained indicate that effective growth and environmental regulations allow the technique of urban area growing for better environmental quality. Ref author [68] incorporated urbanization as a factor of explanation into their EKC structure. The findings demonstrate that urbanization gradually raises CO2 emissions. Ref [69] found that the process of urbanization raised CO2 emissions. However, the studies were not in agreement about using each other to demonstrate the viability of the EKC hypothesis, which the EKC conducted [70–72]. These incompatible outcomes regarding the EKC hypothesis suggest that more research is necessary to determine whether Malaysia should adopt the EKC hypothesis. But the rapid urbanization has also given reason for worries about changes in the climate [73–75]. This study assesses how, in China, foreign direct investment (FDI) influences the causal relationship between urbanization and CO2 emissions between 1996 and 2018. The findings imply that increasing urbanization speeds up CO2 emissions, however, that adverse effect lessens once a certain amount of foreign capital is attained. Additionally, they discover that the government, financial, and technological sectors can encourage urbanization with greater success in lowering CO2 emissions based on how developed they are [76].

2.4 Relationship between Renewable Energy Consumption and CO_2 emissions

The production of renewable and non-renewable energy in Italy was examined by ref [77]. An ARDL approach demonstrates how the production of renewable energy lowers CO2 emissions while trade increases them. To get the relationship between population, GDP, CO2, and renewable energy intensity in 128 countries between 1990 and 2014, ref [78] kindly used the CCE-MG method. Results show that while renewable energies lessen the spread of CO2 emissions, population growth and economic expansion both encourage CO2 emissions. According to Ref [79] CO2 emissions decrease with every 1% increase in renewable energy. Sharif [80] investigates the relationship between the use of renewable energy sources and CO2 emissions using a Quantile-on-Quantile (QQ) regression approach. The results prove that, in the top ten polluted countries chosen, there is a negative correlation between CO2 emissions and the use of renewable energy. Ref [81] employed the ARDL and VECM techniques in China for the years 1980–2014 to find that renewable energy production reduces CO_2 emissions, meanwhile, non-renewable energy accelerates CO_2 emissions. Ref [82] applying a panel data set of 17 economies in the OECD over the years 1977–2010, researchers looked at the dynamic effect of renewable energy consumption on CO2 emissions and put out panel FMOLS and panel DOLS predictions. The results support the group's EKC theory, showing that GDP per capita and GDP squared per capita have both positive and negative effects on CO2 emissions and that using renewable energy has a negative impact on CO2 emissions. Using the Markov switching model, the economic growth, carbon dioxide emissions, and energy consumption of South Korea are examined [83]. The analysis results show that South Korea's economic growth and carbon emissions are stochastic. Analysis of the correlation between national economic growth and energy consumption indicates the strong relationship found between economic expansion and fossil fuels that release greenhouse gases into the atmosphere, such as coal used in industry, petroleum products used in transportation and industry, and liquefied natural gas (LNG) used in residential and commercial sectors. The refs [84] The references [84] concentrated on European nations and attempted to use panel data to estimate the environmental Kuznets curve to clarify how economic growth affects CO2 emissions. The findings supported the existence of an expanded EKC by demonstrating a considerable impact of renewable energy on CO2 emissions.

2.5 Relationship between international tourism, receipts for travel items, and CO_2 emissions

The authors [85,86] indicate that the development of tourism is going to result in a rise in emissions of carbon dioxide and environmental consequences. As a result, these researchers demonstrate that tourism growth increases national emissions only slightly. However, a zero-carbon target will always require emissions reductions at an absolute level. For the authors [87–90], emissions decrease when tourism helps bring the economy to a given level of confidence. The same view is also supported by authors [91–93] and they conclude that tourism brings economic and economic benefits, environmental benefits due to its significant contribution to GDP growth and emission reductions. However, other studies do not support these hypotheses. The results of the authors [12,26,94–96] on tourist destinations find that tourism increases CO_2 emissions. Most studies have focused on destinations with a higher proportion of international tourists or with higher tourism dependency ratios. There are no agreements on the most famous tourist destinations. Refs [92,97]found that tourism reduces carbon emissions in ten tourist destination countries, while Muhammad Imran Qureshi has, [98] found the opposite for 37 tourist destination countries. Ref [99] reports neutral results for 50 tourist destination countries. The author [100]

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discovered that tourism lowers CO2 emissions. While ref [79] discovered that every 1% increase in tourism rise CO2 emissions. Research on tourism-dependent Small Island Developing States (SIDS) has found that tourism would reduce the overall carbon emissions of these destinations [51,101].

2.6 Relationship between Gross Domestic Product and CO_2 emissions

Refs [2,102] confirm that GDP has a beneficial effect on emissions. When examining the link between clean energy consumption, economic growth, and carbon dioxide emissions, [103] points out that there exists no link between real GDP per capita, energy consumption, and carbon dioxide emissions in the US and the UK in the following countries: Canada, France, and Italy. However, cointegration occurs in Germany, even though real GDP per capita and CO2 emissions have been the dependent factors, and in Japan, CO2 emissions were a dependent indicator. However, the findings of the causal test show that the actual per capita GDP of Canada, Germany, and the United States is caused by clean energy consumption, while Germany's carbon dioxide emissions are caused by clean energy consumption. Behnaz [104] found that economic growth or gross domestic product has an inverse U-shaped relationship with CO_2 emissions Authors [102] study the issue of long-run causality employing an autoregressive distributed lag-bound cointegration test approach to investigate the link with employment ratio, economic growth, carbon emissions, and energy consumption in Turkey. At the 5% level of statistical significance, the results show a consistent relationship between the factors in Turkey. From 1960 to 2010, Ref [105] looked at the relationship between the US economy's energy consumption, real GDP, CO2 emissions, real GDP2 squared, trade openness, urbanization, and financial development. According to the results of the Granger test of causality, there appears to be a bidirectional causal relationship between CO2 and GDP, CO2 and energy consumption, CO2 and urbanization, and GDP along with trade accessibility, even though there does not appear to be a causal relationship between natural gas, emissions, and financial development. According to refs [69,71], while addressing economic concerns, it is important to take into account the links between GDP, energy use, and environmental deterioration, particularly carbon dioxide emissions, which are thought to be connected to the real production and consumption of energy. CO2 emissions and GDP growth are positively correlated, according to ref [106]. [107] use annual data from 1997 to 2014 to investigate the relationship between real GDP and CO2 emissions in 17 transition economies. The results show a statistically significant cointegration relationship between real GDP and CO2 emissions over the long run.

III. Materials and Methods

Annual data on the variables Carbon emission represented by CO_2 emissions per capita, Ecological Footprint is the global hectares per capita, Foreign Direct Investment is measured by (% of GDP), Urbanization is determined by the total population, the urban population, Renewable Energy Consumption is total final energy consumption, International tourism, receipts for travel items (current US$) proxy of tourism development, Gross Domestic Product is measured by per capita (constant 2015 US$), and the square of Gross Domestic Product is measured by per capita (constant 2015 US$), were collected for African countries with biocapacity reserves during the period 2002 to 2019. These variables are all indicators of tourism development. The data are from the World Bank (https://databank.worldbank.org/source/world-development-indicators), the Global Footprint Network (https://data.footprintnetwork.org/#/), and the World Tourism Organization (https://www.unwto.org/tourism-statistics/tourism-statistics-database). The study covers 16 countries in Africa with biocapacity reserves distributed as follows: group1 the all countries. Group2, 5 countries in the southern region (Angola, Botswana, Mozambique, Namibia, Zambia); group3, 5 countries in the West and West regions (Côte d'Ivoire, Guinea, Mali, and Madagascar), and finally group4, 6 countries in the Central Region (Cameroon, Central African Republic, Chad, Republic of Congo, Democratic Republic of Congo and Gabon). The selection of African countries with biocapacity reserves is based on two main criteria: A country's biocapacity must be greater than its ecological footprint. This means that they can produce more natural resources than they consume. The country must have a viable potential for tourism development. This means that they have the natural, cultural, and human resources essential to develop sustainable tourism.

In the timed data analysis, our analysis follows the approach derived from the work of Zhang and Liu (2019) and Zhang and Gao (2016), we use the above variables to determine the link between CO_2 emissions in African countries with biocapacity reserves and especially to analyses the long-term link between the variables to see to what extent the tourism sector will promote Africa's development and emission reductions of greenhouse gases in Africa. In addition, this paper proposes two methods to examine these relationships between variables aimed at reducing emissions and increasing economic development in Africa. Thus, the first equation will be built on the following equation:

$$CO2_{jt} = f(EF_{jt}, FDI_{jt}, URB_{jt}, REC_{jt}\ , ITR_{jt}\ , GDP_{jt}) \quad (1)$$

Where CO_2 is carbon emissions, EF is Ecological Footprint per capita, FDI is Foreign Direct investments, URB is Urbanization, REC is Renewable Energy Consumption, ITR is international tourism, receipts for travel items, and GDP is Gross Domestic Product. Next, j

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represents the number of countries and t represents the time or period of the study between 2002 and 2019. However, equation (1) will be enriched and transformed by equation 2.

$$LNCO2_{jt} = a_0 + \Delta_1 LNEF_{jt} + \Delta_2 LNFDI_{jt} + \Delta_3 LNURB_{jt} + \Delta_4 LNREC_{jt} + \Delta_5 LNITR_{jt} + \Delta_6 LNGDP_{jt} + e_{jt} \quad (2)$$

$LNCO2_{jt}, \Delta_1 LNEF_{jt}, \Delta_2 LNFDI_{jt}, \Delta_3 LNURB_{jt}, \Delta_4 LNREC_{jt}, \Delta_5 LNITR_{jt}, and\ \Delta_6 LNGDP_{jt}$
Are the natural logarithm forms of the variables $CO2_{jt}, EF_{jt}, FDI_{jt}, URB_{jt}, REC_{jt}, ITR_{jt}, and\ GDP_{jt}$. Renewable ennergy (Δ4) is expected to have a negative coefficient because it is essential to reducing carbon emissions. If the government encourages renewable energy, the expected emissions will be $\Delta 4 < 0$, $\Delta 1 < 0$, $\Delta 3 < 0$, $\Delta 5 < 0$, indicating that tourism will benefit to the reduction of CO_2 emissions. However, if they don't choose to consume renewables, then we expect $\Delta 4 > 0$, indicating the expected pollutant emissions. This is because tourism development may necessitate increased energy consumption, leading to the use of fossil fuels. Here, however, Keep in mind that $\Delta 2 < 0$ and $\Delta 6 < 0$. Tourism helps a great deal with economic growth and development; however, it also has the potential to minimize CO2 emissions. Thus, if the coefficients of FDI and GDP can be positive, it means that economic growth is expected to lead to a rise in greenhouse gas emissions, and if the coefficients are negative, it means that these two variables play an important role in reducing carbon emissions. The expected positive/negative interaction between the variables allows us to apply the Kuznets curve, initially identified by studies [108,109], then [110] that attempts to clarify the link between carbon emissions and a U-shaped curve and multiple additional factors to maximize the reduction of greenhouse gases. Therefore, in this paper we will follow the same idea of Glassman and Krueger and then Ahmed rewrites the model while evaluating the square of GDP and adding the error term in equation 3:

$$LNCO2_{jt} = a_0 + \Delta_1 LNEF_{jt} + \Delta_2 LNFDI_{jt} + \Delta_3 LNURB_{jt} + \Delta_4 LNREC_{jt} + \Delta_5\ LNITR_{jt} + \Delta_6 LNGDP_{jt} + \Delta_7 LNGDP^2_{jt} + \mathcal{E}_{jt} \quad (3)$$

$LNGDP^2_{jt}$ represents the square of $LNGDP_{jt}$ j represents the number of countries, t represents the period or time, and finally Ɛ represents the error term, $a_0$is the constant, Δ_1, Δ_2, Δ_3, Δ_4, Δ_5, Δ_6, and $\Delta_7$represents the coefficients of their respective variable. However, if $\Delta_6 > 0$ and $\Delta_7 < 0$ then it means that GDP has a significant positive value, while the square of GDP has a significant negative value which would confirm the inverted v-shaped link between CO_2 emissions and economic growth. No matter what, the environmental Kuznets curve will continue to be applicable due to the inverse U-shaped connection between CO2 emissions and economic growth. once determining the Kuznets curve, the turning point that occurs can be calculated through the following equation: $T = ag(-\Delta_6 / \Delta_7)$. Panel unit root tests are carried out to determine how well variables are stationary, or if their trends change over a period. Therefore, we were inspired by Im, Pesaran and Shin W-stat, ADF - Fisher Chi-square and PP - Fisher Chi-square, Δ_7 Levin, Lin and Chu (LLC) (2002) [111] to verify the root test. Panel unit root tests are appropriate for the CO2 variable and the other variables used in this article. The study's results will show the possibility that the variables in question are stationary. The unit root test for the following statistical procedure is:

$$\pi = -2 \sum_{j=1}^{\sigma} \ln \varphi j \quad (4)$$

As Well it depends on an estimate of Equation 5, recommended by Levin et al. (2002):

$$\boldsymbol{\omega\gamma_{jt} = \mu_j + \Delta\gamma_{j,t-1} + \sum_{j=1}^{\varphi j} \Delta_{jt}\,\theta\gamma_{j,t} + \epsilon_{jt}} \quad (5)$$

where j is the number of regions and t is time. $\boldsymbol{\gamma_{jt}}$ is the series of the country in period t. $\boldsymbol{\epsilon_{jt}}$ is the residual assumed to represent the I.I.D. the number of lags is φj. The null hypothesis is H0: $\Delta = 0$, and the substitute hypothesis is H1: $\Delta < 0$. But LLC presumes that individual cross-section is homogeneous. Ref [112] argue that the IPS test is better to LLC since it expects heterogeneity over the sample, allows for panel data imbalance, and is favorable over short periods. The IPS test is established on equation 4 (Δ) can change. The null hypothesis tested is H0: $\Delta_j = 0\forall_j$and the substitute hypothesis is H1: $\Delta_j < 0\forall_j$. Likewise, the test proposed by author [113] does not require bias correction and can eradicate dynamic panel bias. The LLC and Breitung tests lack balanced panel data, whereas the IPS,

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Fisher ADF, and Fisher PP use balanced or unbalanced data. Now we can test for cointegration between variables and conformation the following model to check the panel unit roots between variables and check the order of integration of the variables. Equation 6 will be written under the following model:

$$\vartheta_{jt} + \Delta_j + \alpha_j t + \Delta_{1j}\gamma_{1,jt} + \Delta_{2j}\gamma_{2,jt} + \Delta_{3j}\gamma_{3,jt} + \Delta_{4j}\gamma_{4,jt} + \Delta_{5j}\gamma_{5,jt} + \Delta_{6j}\gamma_{6,jt} + \varepsilon_{jt} \quad (6)$$

J represents the number of countries, t represents time, Δ_j and α_j represent the interception and deterministic trend of individual countries.

Among the tests offered by refs [114], panel cointegration tests and second-group panel cointegration tests are the most widespread. Panel cointegration tests are heterogeneity tests performed within the sample, while group average panel cointegration tests are homogeneity tests that are performed across the sample. The residuals test provider evidence for cointegration as follows:

$$\varepsilon_{jt} = \ddot{\Upsilon}_{jt}\varepsilon_{jt-1} + \psi_{jt} \quad (7)$$

Next, the cointegration of ref [115] is carried out in the form of the following model:

$$\vartheta_{jt} = \gamma_{jt}\forall + \tau'_{jt}\text{ꞃ} + \varepsilon_{jt} \quad (8)$$

Where ϑ_{jt} and γ_{jt} represent the order of integration, ε_{jt} represents the error term of white noise, τ'_{jt} represents the exogenous at each fixed effect.

After the panel cointegration test, two methods are used, the (FMOLS) method and the (DOLS) method. The Pedroni and Kao tests do not provide any signal about the coefficients of the variables under study; they only consider long-run relationships. Many estimators are available for panel data. For example, the following types can be used: dynamic ordinary OLS (DOLS), fully modified OLS (FMOLS), random effects (RE), fixed effects (FE), ordinary least squares (OLS), and generalized method of moment (GMM). Panel cointegration should consider FMOLS and DOLS, as shown in refs [116,117] review of the finite properties of OLS and the demonstration of inconsistent properties of OLS estimators based on panel data. DOLS and FMOLS estimates are superior because they perform better with small samples and can address endogeneity and serial correlation problems by adding lags and leads to the model. [116,117] proposed the DOLS method. The DOLS method is an econometric estimation method that takes into account time and individual fixed effects as well as autocorrelation effects. Autocorrelation is the condition where consecutive observations are related to each other. DOLS is a robust method for analyzing panel data with collinearity and autocorrelation issues. Other methods are easy to implement but do not account for time or individual fixed effects and do not allow for control of individual fixed effects or autocorrelation. At the same time, refs [118,119] proposed the concept of FMOLS. The FMOLS method is an econometric estimation method that considers time and individual fixed effects. Fixed-time effects are effects that remain permanent per unit over time, such as ecological footprint, renewable energy, or CO_2 emissions. Individual fixed effects are constant effects per unit, such as population size or level of economic development. FMOLS is an efficient method for analyzing complex panel data. This is useful when panel data has collinearity issues. Other methods are easy to use but do not account for time or individual fixed effects and do not allow control for individual fixed effects or autocorrelation.

IV. Results and discussion

The research uses two models, FMOL and DOLS, to examine how variables have related to one another over time. In contrast, with different regression models that might need a large number of observations, FMOL and DOLS models can present robust results even with limited data. Table 3 presents the results of the descriptive analysis of the variables observed in African countries with biocapacity, which have been subdivided into 4 groups or regions. Table 2 shows that the database contains 519 observations for group 1, 154 observations for group 2, 183 observations for group 3, and 151 observations for group 4. The mean CO2 and LNGDP were negative for all groups in the sample. This means that most of the sightings are below average. This proves that most tourist destinations have below-average CO_2 and LNGDP2 emissions. The Std. Dev of these two variables is low, meaning that the data are relatively concentrated around the mean. This suggests that CO_2 and LNGDP2 emissions are relatively uniform across destinations. The LNEF has a negative average in all groups. This means that most tourist destinations have a below-average ecological footprint and CO_2 emissions. It's also worth noting that the Std. Dev. is lower, which means that the data is relatively concentrated around the average. The mean of the LNFDI, LNGDP, LNURB, LNREC, and LNITR are positive, meaning that the largest number of observations is above average. This shows that the majority of tourist destinations have above-average LNREC, LNURB, foreign investment, LNTR, and GDP. Their maximum variation is also positive, confirming that most observations are above average—the Std. Dev for LNTR is high, confirming that the

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data are relatively scattered around the average. Skewness and kurtosis are two measures of the distribution of a variable. Skewness is proportioned on a scale of -3 to 3, 0 indicates a symmetrical distribution. Positive values indicate a right-skewed distribution and negative values indicate a left-skewed distribution. Kurtosis is calculated from 0 to 3, where 0 represents a normal distribution. Values greater than 0 represent a sharper distribution than the normal distribution, while values less than 0 represent a distribution flatter than the normal distribution. In our study, CO_2 skewness is negative in the majority of the variables of the groups, explaining a slight asymmetry on the left. This shows that the majority of African tourist destinations have below-average CO_2 emissions. However, a few have high CO_2 emissions. Kurtosis is positive in all groups, indicating that the distribution is sharper than a normal distribution. This means that most countries share similar travel trends. The same is true for the other variables.

Tables 2: Descriptive statistics of variables

Variable	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
			All countries			
LNCO2	-1.183	1.664	-3.912	1.399	0.212	1.860
LNEF	-3.266	-1.415	-4.585	0.615	0.645	3.877
LNFDI	0.663	3.835	-6.089	1.410	-0.987	5.132
LNURB	7.122	9.101	5.317	0.981	0.393	1.869
LNREC	4.221	4.588	-1.609	0.456	-4.784	53.066
LNITR	7.491	15.326	-6.908	6.677	-0.547	1.542
LNGDP	3.739	4.501	3.035	0.358	0.204	2.377
$LNGDP^2$	-1.987	22.81	-4.814	1.611	7.138	109.122
Observations: 519						
			The South African Zone			
LNCO2	-0.540	1.190	-3.912	1.166	-0.492	2.104
LNEF	-3.549	-2.514	-4.585	0.582	-0.083	1.631
LNFDI	1.252	3.693	-3.277	1.117	-0.706	4.919
LNURB	7.483	8.777	5.317	0.970	-0.577	2.188
LNREC	3.980	4.545	-1.609	0.642	-4.368	38.26
LNITR	9.380	14.870	-6.908	6.915	-1.111	2.418
LNGDP	3.745	4.261	3.238	0.275	0.143	1.936
$LNGDP^2$	-1.237	0.641	-4.176	1.157	0.076	1.901
Observations: 154						
			The Central African zone			
LNCO2	-1.449	1.664	-3.684	1.729	0.430	1.660
LNEF	-3.265	-2.184	-4.151	0.475	0.131	1.824
LNFDI	0.516	3.835	-4.725	1.560	-0.674	3.508
LNURB	7.028	9.101	5.776	1.043	0.696	2.220
LNREC	4.415	4.588	4.004	0.135	-0.832	3.027
LNITR	6.241	13.893	-6.215	6.285	-0.327	1.299
LNGDP	3.787	4.501	3.035	0.422	-0.186	2.210
$LNGDP^2$	-2.607	-0.221	-4.814	1.121	0.396	2.256
Observations: 183						
			The West and West African Zone			
LNCO2	-1.849	-0.855	-3.029	0.500	-0.013	2.700
LNEF	-3.289	-2.643	-3.804	0.318	0.310	2.037
LNFDI	0.163	2.935	-6.089	1.386	-1.377	6.586
LNURB	6.590	7.720	6.027	0.480	1.137	2.879
LNREC	4.394	4.513	4.126	0.095	-1.226	3.780
LNITR	6.154	14.543	-4.605	6.316	-0.284	1.283
LNGDP	3.555	3.945	3.149	0.201	-0.065	2.126
$LNGDP^2$	-2.306	22.81	-3.520	2.112	11.226	134.027
Observations: 151						

Source: Authors based on results from Eviews.10

4.1 Cross-section dependence test results

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When all the variables in a cross-section are related, it is referred to as a pervasive cross-sectional dependence, which can happen with panel data. Usually, this has to do with the influence of some variable that was not noticed that affects each group differently but is the same for all groups. Since the constatation of distinct collaborators is assumed to be distinct, the majority of panel data models are considered [120]. In theory, it is common for economic variables to exhibit behaviors that lead to mutual dependence. If the variables are interdependent, the assumption of cross-sectional independence could result in inconsistent estimates. Given that the countries studied have a lot in common, it is crucial to recognize this fact and not take it for granted [121]. Therefore, performing an initial cross-sectional dependence test before model estimation is essential. We can also make an informed decision about using first- or second-generation unit root tests based on the results of a cross-sectional dependency test. The Breusch-Pagan Lagrange multiplier (LM), the Pesaran Lagrange multiplier (LM), the bias correlation scale Lagrange multiplier (LM), and Pesaran cross-sectional dependence (CD) tests were used to determine whether cross-sectional dependence existed in the data. The cross-sectional dependence test is performed without cross-sectional dependence as a null hypothesis (H0 = no cross-sectional dependence)[122–125]. Based on the findings in Table 3, all four panels rejected the null hypothesis that there was no cross-sectional dependence. We deduce that the data has a cross-sectional dependence. This implies that there are significant economic interdependencies and connections throughout Africa. Unit root tests using second-generation panels should be performed when cross-dependency is provided.

Table 3: Cross-section dependence test results

Variable	Breusch-Pagan, LM		Pesaran scaled LM		Bias-corrected scaled LM		Weigh CDs	
				All countries				
LNCO2	618.441*	0.000	29.252*	0.000	28.969*	0.000	3.848*	0.000
LNEF	1085.332*	0.000	57.562*	0.000	57.278*	0.000	20.498*	0.000
LNFDI	470.187*	0.000	20.263*	0.000	19.980*	0.000	14.557*	0.000
LNURB	1555.530*	0.000	86.071*	0.000	85.789*	0.000	11.278*	0.000
LNREC	983.277*	0.000	51.374*	0.000	51.090*	0.000	12.375*	0.000
LNITR	1422.579*	0.000	78.010*	0.000	77.727*	0.000	29.741*	0.000
LNGDP	3815.244*	0.000	223.087*	0.000	222.804*	0.000	61.484*	0.000
$LNGDP^2$	1305.256*	0.000	70.897*	0.000	70.613*	0.000	25.728*	0.000
				The South African Zone				
LNCO2	50.445*	0.000	9.044*	0.000	8.960*	0.000	3.688**	0.002
LNEF	102.125*	0.000	20.600*	0.000	20.516*	0.000	9.537*	0.000
LNFDI	24.413*	0.000	3.223*	0.000	3.139*	0.000	1.857***	0.063
LNURB	250.016*	0.000	53.670*	0.000	53.586*	0.000	15.780*	0.000
LNREC	88.113*	0.000	17.467*	0.000	17.383*	0.000	6.169*	0.000
LNITR	144.162*	0.000	29.100*	0.000	29.916*	0.000	11.264*	0.000
LNGDP	237.640*	0.000	50.902*	0.000	50.819*	0.000	15.194*	0.000
$LNGDP^2$	53.289*	0.000	9.680*	0.000	9.596*	0.000	4.727*	0.000
				The Central African zone				
LNCO2	23.594*	0.000	1.569*	0.000	1.469*	0.000	1.799***	0.072
LNEF	139.821*	0.000	22.789*	0.000	22.690*	0.000	8.325*	0.000
LNFDI	54.672*	0.000	7.2432*	0.000	7.143*	0.000	5.274*	0.000
LNURB	85.830*	0.000	12.932*	0.000	12.832*	0.000	-0.504***	0.614
LNREC	101.591*	0.000	15.809*	0.000	15.709*	0.000	-1.622***	0.104
LNITR	127.680*	0.000	20.572*	0.000	20.472*	0.000	6.117*	0.000
LNGDP	428.637*	0.000	75.519*	0.000	75.419*	0.000	20.690*	0.000
$LNGDP^2$	199.674*	0.000	33.717*	0.000	33.617*	0.000	9.472*	0.000
				The West and West African Zone				
LNCO2	100.550*	0.000	20.248*	0.000	20.164*	0.000	6.269*	0.000
LNEF	59.938*	0.000	11.167*	0.000	11.083*	0.000	4.969*	0.000
LNFDI	33.045*	0.000	5.153*	0.000	5.070*	0.000	3.724**	0.002
LNURB	59.940*	0.000	11.168*	0.000	11.083*	0.000	1.327***	0.184
LNREC	81.189*	0.000	15.918*	0.000	15.835*	0.000	8.130*	0.000
LNITR	54.647*	0.000	9.983*	0.000	9.900*	0.000	6.125*	0.000
LNGDP	305.895*	0.000	66.164*	0.000	66.081*	0.000	17.490*	0.000
$LNGDP^2$	118.874*	0.000	24.345*	0.000	24.262*	0.000	8.727*	0.000

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*, ** and *** denote significance level at 1%, 5% and 10%, respectively.

Source: Authors based on results from Eviews.10

4.2 Panel unit root test results

The unit root test is required to ensure that the variables are integrated in the correct order and to avoid obtaining outliers. We have recourse to Pesaran, ADF - Fisher Chi-square, and PP - Fisher Chi-square [126]. These unit root tests are reliable even in the presence of heterogeneity and cross-sectional dependence. In our investigation, we check the unit root variables at constant, constant, and trend levels, along with the first difference. Table 4 shows that $LNCO_2$, LNFDI, and LNGDP are stationary at the level, as in every country, variables become stationary following the 1st difference. As a result, the variables' integration order is I(0) and I(1). Group 2 variables are non-stationary at the level, but become stationary after an initial differentiation. As a result, the variable order in group 2 is I (1). Group variables 3 and 4 indicate that $LNCO_2$, LNFDI, and LNGDP2 are stationary at the level, while the rest of the variables become stationary after the first difference. This justifies the order of integration of I (0) and I (1) of the variables in the two groups.

TABLE 4. Panel unit root test results

Variable	Im, Pesaran and Shin W-stat		ADF - Fisher Chi-square		PP - Fisher Chi-square		Order of Integration
	Level	First Difference	Level	First Difference	Level	First Difference	
			All countries				
LNCO2	-2.330*	-11.561*	65.431*	193.260*	92.145*	346.096*	(0)
LNEF	0.838**	-13.930*	30.139	232.274*	39.779**	371.739*	(1)
LNFDI	-5.940*	-18.367*	100.522*	318.197*	132.293*	428.897*	(0)
LNURB	0.848***	-7.441*	27.816	123.643*	38.702	226.862*	(1)
LNREC	0.964	-10.482*	32.730	171.684*	50.433	314.018*	(1)
LNITR	-1.898	-8.993*	45.570	145.389*	45.764	302.198*	(1)
LNGDP	6.588	-7.122*	15.970	65.888*	120.497	118.631*	(1)
$LNGDP^2$	-2.654*	-17.498*	58.202*	298.854*	73.369*	382.852*	(0)
			The South African Zone				
LNCO2	-0.308**	-5.514*	11.891	50.327*	43.374**	72.098*	(1)
LNEF	0.263***	-11.116*	8.094	99.868*	11.747	146.447*	(1)
LNFDI	-2.150	-11.489	19.929	107.746*	44.968	144.872*	(1)
LNURB	0.960	-3.640*	4.178	33.747*	4.097	58.451*	(1)
LNREC	0.202	-5.790*	10.444**	51.903*	20.874*	87.218*	(1)
LNITR	-1.925	-4.409*	17.979	38.087*	14.415***	80.704*	(1)
LNGDP	1.173	-0.964*	6.842	11.622*	22.951	45.160*	(1)
$LNGDP^2$	-1.790	-9.636*	20.104	89.960*	16.749	113.989*	(1)
			The Central African zone				
LNCO2	-3.432*	-8.981*	43.194*	91.183*	36.572*	161.673*	(0)
LNEF	-0.726**	-8.377*	17.093	84.341*	22.688	119.629*	(1)
LNFDI	-2.646*	-10.327*	26.737*	106.257*	50.316*	133.107*	(0)
LNURB	0.020	-4.254*	10.293	40.354*	11.977	69.5421*	(1)
LNREC	0.292	-6.235*	9.405	60.234*	15.239	108.325*	(1)
LNITR	-0.462	-5.167*	12.863	49.360*	14.099	101.207*	(1)
LNGDP	4.528***	-2.208*	6.732	24.649*	68.589	54.1536*	(1)
$LNGDP^2$	-0.630	-11.694*	14.657	117.795*	27.045	144.294*	(1)
			The West and West African Zone				
LNCO2	-0.240	-4.923*	9.046***	42.681*	10.138	91.955*	(1)
LNEF	1.609	-4.262*	4.662	38.143*	4.832	85.825*	(1)
LNFDI	-5.200*	-8.959*	47.929*	84.131*	32.276*	121.155*	(0)
LNURB	0.570	-5.385*	12.043	48.053*	22.164	96.302*	(1)
LNREC	2.110	-4.670*	5.584	40.197*	7.663	97.846*	(1)
LNITR	-0.500	-5.385*	9.893	48.056*	11.560	101.121*	(1)
LNGDP	5.675	-11.064*	1.943	26.592*	10.536	24.827*	(1)

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$LNGDP^2$	-2.053*	-8.543*	20.142*	79.737*	26.646*	108.775*	(0)

*, ** and *** denote significance level at 1%, 5% and 10%, respectively.

Source: Authors based on results from Eviews.10

After the unit root test, the results show that the variables are embedded in the order l(0) and l(1), which allows us to test both our FMOL and DOLS models. But more importantly, it is reasonable to first look at the cointegration between the variables being studied.

4.3 Kao cointegration test results

The cointegration test is a statistical test used to define whether two or a few time series are cointegrated. These time series are co-integrated if they maintain a stable long-term linkage[114,115]. Table (5) shows that the null hypothesis of non-cointegration is rejected at the 1% level of significance. Our panels' variables are co-integrated, which means they are linked in the long-term. The residual variance was 0.015, 0.014, 0.018, and 0.005 for all countries, South Africa, central Africa, and East and West Africa respectively. HAC was 0.014, 0.013, 0.019, and 0.004 for all countries, South Africa, central Africa, and East and West Africa respectively. This means that our variables evolve together over the long term. Therefore, we can realize the FMOL and DOLS models.

Table 5: Kao cointegration test results

	All countries	
	t-Stat.	p-value
ADF	-5.227	0.000
Residual variance	0.015	
HAC variance	0.014	
	The South African	
	t-Stat.	p-value
ADF	-2.828	0.002
Residual variance	0.014	
HAC variance	0.013	
	Central African	
	t-Stat.	p-value
ADF	-3.849	0.000
Residual variance	0.018	
HAC variance	0.019	
	The East and West African	
	t-Stat.	p-value
ADF	-2.420	0.007
Residual variance	0.005	
HAC variance	0.004	

*, ** and *** denote significance level at 1%, 5% and 10%, respectively.

Source: Authors based on results from Eviews.10

4.5: Panel fully modified least squares (FMOLS)

Given the long-term link between the variables confirmed through the cointegration test, we then proceed to the analysis using the predictive method, since the cointegration test cannot indicate the estimation of the coefficient of the variables. Therefore, as we said above, this article uses two methods (FMOL and DOLS) to do this work. The FMOL method is used to extract the coefficients and the DOLS method is used to assert robustness. The findings of the FMOL method are discussed in Table 6 below.

Table 6: Panel fully modified least squares (FMOLS) test result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
		All countries		
LNEF	-0.374*	0.049	-7.642	0.000

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LNFDI	-0.003***	0.005	-0.581	0.461
LNURB	0.065***	0.058	1.124	0.261
LNREC	1.515*	0.096	-15.792	0.000
LNITR	-0.005*	0.001	-4.535	0.000
LNGDP	1.173*	0.116	10.121	0.000
$LNGDP^2$	-0.155*	0.022	-7.123	0.000
South African zone				
LNEF	-0.191**	0.064	-2.964	0.003
LNFDI	0.019***	0.015	1.256	0.211
LNURB	-0.509*	0.147	-3.473	0.000
LNREC	-1.373*	0.139	-9.866	0.000
LNITR	0.010*	0.002	4.270	0.000
LNGDP	2.332*	0.274	8.500	0.000
$LNGDP^2$	-0.026***	0.025	-1.037	0.301
Central African zone				
LNEF	-0.935*	0.115	-8.111	0.000
LNFDI	0.014**	0.006	2.262	0.025
LNURB	0.395*	0.080	4.963	0.000
LNREC	-2.170*	0.222	-9.788	0.000
LNITR	-0.005	0.002	-2.788	0.005
LNGDP	0.727	0.216	3.369	0.000
$LNGDP^2$	-0.048***	0.050	-0.964	0.336
East and West African zone				
LNEF	0.053***	0.066	0.809	0.420
LNFDI	0.004	0.006	0.704	0.483
LNURB	0.280*	0.087	3.229	0.001
LNREC	-1.146	0.126	-9.094	0.000
LNITR	-6.600***	0.001	-0.064	0.949
LNGDP	0.670	0.108	6.171	0.000
$LNGDP^2$	-0.282	0.031	-9.093	0.000

*, ** and *** denote significance level at 1%, 5% and 10%, respectively.

Source: Authors based on results from Eviews.10

The results in Table 6 show that the ecological footprint factors of groups 1, 2, and 3 are all negative. Whereas in group 4 it was positive. This means that a 1% increase in the ecological footprint reduces CO_2 emissions in these three groups of countries. But every 1% increase in the ecological footprint leads to an increase in CO_2 emissions for group 4, this agrees with refs [50–52,127] conclusions. This observation makes it possible to consider this indicator which promotes environmental stability in Africa. Mitigating environmental impact is key in the fight against climate change. By limiting CO_2 emissions, African countries are helping to protect the environment and prevent the harmful effects of the oceans, extreme weather events, and the deterioration of biodiversity. It also enables the shift towards a more stable economy and improves the quality of health of Africans. In short, it has a triple advantage; environmental, economic, and social. Although Africa's ecological footprint poses a low risk, however, it has been followed by a slight increase in recent years. This increase might be the result of population growth in some African economies driving up per capita natural resource consumption. This could have environmental impacts leading to increased CO_2 emissions. It is therefore important to implement policies that reduce the consumption of natural resources to minimize the spread of greenhouse gases in the atmosphere to protect the environment.

The LNFDI coefficient is positive for (The South African zone, the Central African zone, the West and West Zone) and negative for (all countries). This difference may be related to the environmental management that accounts for increasing or decreasing carbon dioxide emissions in African economies. For every 1% increase in FDI in the South Africa zone, Central Africa zone, and West and West Zone CO_2 emissions increased by 0.01%, 0.01%, and 0.00% respectively, the same result with [60]. An increase of 1% would reduce CO_2 emissions in all countries, the same result with [61]. The increase in CO_2 emissions from foreign direct investment in Africa may be due to an increase in goods and services leading to an increase in production, and infrastructure leading to high energy consumption. In addition, international travel leads to an increase in transportation-related emissions. It is important to understand that the above factors are not mutually exclusive. Energy-intensive tourism and poor environmental management are more likely to increase CO_2 emissions. But where environmental management is strict, carbon dioxide emissions may be reduced. However, the positive coefficient of foreign

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direct investment also does not mean that tourism development is not favorable to Africa's environment. Foreign direct investment can have a positive effect on the environment in other areas such as job creation and poverty reduction. However, it is better to consider its negative impact on CO_2 emissions to minimize its impact.

Urbanization is causing significant changes to social, economic, and environmental structures. Cities are growing into popular tourist destinations for a variety of reasons, and they always have an impact on the natural environment. Table 6 reveals that the South Africa zone group has a negative urbanization coefficient in terms of CO2 emissions. This suggests that urbanization decreases CO2 emissions in the nation of South Africa. Therefore, for each 1 percentage point rise in urbanization, the South Africa zone's CO2 emissions will fall by 0.50 percent. Public policies on urbanization may be at the center of a decrease in CO2 emissions in the South Africa zone. Countries in the region are prioritizing policies on construction, transport, transition to renewable energy, energy-saving policies, etc. However, urbanization itself is complex and brings both benefits and challenges. The urbanization coefficients are positive for all countries, the central Africa zone and the West and West Zone, indicating a positive correlation between urbanization and increased CO_2 emissions in these African economies. These results show that for every 1% increase in the rate of urbanization, carbon dioxide emissions increase by 0.60%, 0.39%, and 0.28% in all countries, Central Africa Zone and West and West Zone respectively. Our results match the results of ref (Saboori et al., 2016).Urbanization will reduce CO_2 emissions as urban buildings are traditionally more energy efficient than those in rural areas. Innovations in building technology are reducing the need for heating and cooling. In addition, public transport is more energy-efficient than personal transport. Urbanization policies are of great importance to ensure the smooth running of urbanization. To mitigate the adverse environmental damage of urbanization, governments should encourage the construction of standard-compliant buildings, develop an efficient transport sector, and promote appropriate consumption of natural resources.

The results also show that over the long term, every 1% increase in renewables reduces emissions by 0.137%, 2.17%, and 1.14% respectively in the South Africa zone, central Africa zone, and The West and West Zone. The findings suggest that renewable energy is environmentally friendly and has the potential to substantially decrease CO2 emissions in these three countries. The reference [128], found that a one percent rise in renewables lowers CO2 emissions. These results show that encouraging renewable energy consumption can reduce CO_2 emissions in these three groups of countries. Given the high proportion of renewable energy sources in Africa, African countries have the potential and the means to implement low-carbon policies. Renewable energy is a naturally renewable energy, including solar, wind, hydro, geothermal, and biomass energy. Africa needs to acknowledge the impact of fossil fuels; this is consistent with the results of researchers [129,130]. African countries have the opportunity and the ability to successfully lead the fight for more sustainable energy by coordinating the fight against climate change. In addition, the "all countries" group shows a positive renewable energy consumption coefficient. This proves that for every 1% increase in renewable energy consumption, carbon dioxide emissions increase by 1.51%. This is because renewable energy production requires natural resources such as concrete, steel, copper, and silicon. During extraction and storage, they result in CO_2 emissions. But it's important to recognize that the emissions associated with renewables are far more insignificant than those associated with fossil fuels. Technological innovation helps reduce carbon emissions from renewable energy by using more sustainable materials in production, improving the energy efficiency of renewable energy systems, and developing new ways to store renewable energy.

The results in Table 6 show a negative coefficient of tourism development in 3 groups of countries and a positive coefficient in 1 group of countries. According to the findings, CO2 emissions will eventually drop by -0.005, -0.005, and -6.60 for every 1% rise in tourism development in (all countries, Central Africa, East Africa, and West Africa) respectively. Based on these results, we can understand that tourism development is a good thing for Africa as it will play an important role in reducing the carbon dioxide emissions of these three groups of countries. This is consistent with the work of ref [100] who argues that tourism goes beyond economic growth and can contribute to the reduction of CO_2 emissions. However, these results are contrary to those of [128], who found that a 1% rise in tourism boosted CO2 emissions. We think that the distinction is caused by differences in data quality, time, and duration of the study. At the same time, for every 1% increase in tourism development, CO2 emissions in South Africa will rise by 0.010. This is in line with the findings of [79], who believe that a 1% rise in tourism would lead to an increase in carbon dioxide emissions. The discrepancy in results may be due to the governance policies of each group of countries as well as the sample size, data type, and duration of the study. Taking all these factors into account, each country has its own needs and priorities, which means that there is an urgency to improve the scope of the study because the results from each country cannot be generalized. The results also support the inverse U-shaped relationship between economic growth and carbon dioxide emissions in Africa, as the coefficient of economic growth was positive but its square value was negative. These results corroborate the analysis of the author [104]**.** This means that an increase in economic growth increases CO_2 emissions and then flips back to a negative square coefficient. The negative coefficient then indicates that an increase in economic growth reduces CO_2 emissions. This suggests that African governments need to implement various additional strategies to achieve the Sustainable Development Goals. Reducing carbon dioxide emissions is a complex issue that requires efforts from many parties. The spread of greenhouse gases can occur for a variety of reasons. It is important to implement a series of measures to have a significant impact. These measures lead to changes in technology, behaviors, and government policy. The EKC theory states that economic growth

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will lead to a deterioration or improvement of the environment, which leads us to reconsider the three aspects that cause this mobility: the scale effect, the composition effect, and the technological effect. The first determines the intensification of environmental pollution caused by the boom in industrial production. In fact, the more developed an economy is, the more goods and services are produced, leading to increased resource consumption and pollutant emissions. The second aspect has the effect of transforming the conditions and structures of production. For example, when the economy shifts from agriculture to manufacturing, the demand for natural resources increases, which can lead to environmental damage. Conversely, when an economy shifts from a manufacturing economy to a service economy, the demand for natural resources decreases, which is beneficial to improving the environment. The final measure is the reduction of carbon gases in the environment through technological progress. For example, the use of more efficient technologies can reduce pollutant emissions per unit of output. The Kuznets Environmental Curve is therefore well validated in Africa, but it is necessary not to focus exclusively on economic growth or sustainable development to claim to understand and reduce Africa's CO_2 emission rates. Renewable energy, tourism, ecological footprint, and urbanization are also taken into account in the fight against CO_2 emissions. The EKC is a useful model for recognizing the interaction between economic growth and the environment. However, governments should take these issues into account when implementing effective decarbonization policies in Africa [108,109].

4.6: Panel dynamic least squares (DOLS)

After analyzing the FMOL method, we continue to analyze the second method, the DOLS method Table 7. Here we will look at the long-term relationship between variables, as this is an important step in time series analysis. This allows you to better understand the relationships between variables and make more accurate predictions.

Table 7. Panel dynamic least squares (DOLS) test results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
		All countries		
LNEF	-0.017*	5.600	-311	0.000
LNFDI	-0.056*	3.130	-180	0.000
LNURB	0.303*	1.340	226	0.000
LNREC	-0.693*	1.440	-480	0.000
LNITR	-0.012*	2.470	-490	0.000
LNGDP	0.149*	3.880	383	0.000
$LNGDP^2$	-0.725*	1.050	-692	0.000
		South African Zone		
LNEF	0.098*	2.661	3.690	0.000
LNFDI	0.005*	9.581	569	0.000
LNURB	-1.288*	4.851	-2.660	0.000
LNREC	-0.435*	2.271	-1.920	0.000
LNITR	0.034*	4.971	6.950	0.000
LNGDP	3.483*	1.210	2.880	0.000
$LNGDP^2$	-0.015*	7.771	-1.880	0.000
		Central African zone		
LNEF	-1.538*	6.071	-2.530	0.000
LNFDI	0.004*	2.401	1.790	0.000
LNURB	0.250*	3.701	6.760	0.000
LNREC	-6.230*	9.661	-6.450	0.000
LNITR	-0.011*	8.351	-1.370	0.000
LNGDP	2.396*	1.020	2.340	0.000
$LNGDP^2$	-1.112*	1.301	-8.530	0.000
		West and West African Zone		
LNEF	1.302*	6.030	2.160	0.000
LNFDI	-0.139*	3.221	-4.330	0.000
LNURB	0.185*	4.380	4230	0.000
LNREC	2.020*	9.370	2.160	0.000

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LNITR	-0.045*	1.951	-2.320	0.000
LNGDP	0.206*	6.430	3208	0.000
$LNGDP^2$	-0.051*	2.181	-2.350	0.000

*, ** and *** denote significance level at 1%, 5% and 10%, respectively.

Source: Authors based on results from Eviews.10

In table 7, the ecological footprint shows that a 1% increase in the ecological footprint lowers CO_2 emissions in groups 1 and 3 in the long term while increasing CO_2 emissions in groups 2 and 4. The reasons for the reduction/increase may be attributed to several factors including the position of the economy, the standard of living, and environmental policies. A 1% increase in FDI reduces CO_2 emissions in groups 1 and 3 but increases CO_2 emissions in the other groups in the long run. In the long run, a 1% rise in urbanization increases CO_2 emissions from groups 1, 3, and 4. A 1% rise in renewable energy consumption reduces CO_2 emissions in groups 1, 2, and 3 in the long term, but increases CO_2 emissions in group 4. The results also show that in the long run, a 1% increase in tourism development reduces CO_2 emissions in groups 1, 3, and 4. On the other hand, a 1% increase in tourism development increases CO_2 emissions in group 2. The link between the square of economic growth and carbon dioxide emissions is formed like an inverted U. The robustness of the results demonstrates the importance of developing tourism and encouraging renewable energy in Africa. These results demonstrate the need for governments to develop environmental, climate, and investment policies to promote economic growth and reduce CO_2 emissions.

4.7: Wald test

The statistic of the Wald test determines the overall significance of the model. Table 8 shows that the Wald test statistic in both models has very high values. This indicates that these models are highly significant, meaning that the parameters of each model are significantly different from zero. The Wald test demonstrates the presence of long-term connection in almost all countries. All variables, except foreign direct investment, show statistical evidence of significant long-term relationships in all countries. We can conclude that LNEF, LNURB, LNREC, LNITR, LNGDP, and LNGDP2 have a statistically significant relationship with environmental sustainability in all countries over the long term. The South Zone and the Central Zone countries show statistically significant evidence of a long-term relationship between CO_2 emissions and all independent long-term variables. Also, the outcomes demonstrate that there was no proof. of a statistically significant long-term link between LNEF, LNFDI, LNITR, and CO_2 emissions in the West and West Zone countries. However, the remaining variables indicate significant long-term relationships between the West and West Zones.

Table 8: Wald test results

Variable	All countries	South African zone	Central African zone	West and West African Zone
METHOD: PANEL FULLY MODIFIED LEAST SQUARES (FMOLS)				
LNEF	58.40*	8.78*	65.78*	0.65
LNFDI	0.33	1.57**	5.11**	0.49
LNURB	1.26**	12.06*	24.63*	10.42*
LNREC	249.40*	97.34*	774.51*	1666.44*
LNITR	20.56*	18.23*	7.77*	0.06
LNGDP	102.42*	72.25*	11.35*	38.08***
$LNGDP^2$	50.73*	1.076**	0.93	82.68*
METHOD: PANEL DYNAMIC LEAST SQUARES (DOLS)				
LNEF	9.72*	1.36*	6.42*	4.66*
LNFDI	3.26*	3.24*	3.21*	1.87*
LNURB	5.13*	7.06*	4.57*	1.79*
LNREC	2.31*	3.67*	4.16*	4.65*
LNITR	2.41*	4.83*	1.89*	5.39*
LNGDP	1.47*	8.30*	5.48*	1.03*
$LNGDP^2$	4.79*	3.54*	7.27*	5.54*

*, ** and *** denote significance level at 1%, 5% and 10%, respectively.

Source: Authors based on results from Eviews.10

V. Conclusion, policy recommendations, and limitations

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5.1: Conclusion

Tourism is renowned as a driver of economic growth as it boosts income, employment opportunities, infrastructure expansion, domestic/international trade, and foreign direct investment. However, the economic benefits of tourism can come at the cost associated with lower energy usage, including fossil fuels and other environmentally destabilizing actions. Tourism development, the environment, and climate change in Africa have not been studied in depth. Therefore, this study analyzes the link between tourism development, and environmental stability on the reduction of carbon dioxide emissions in African countries with biocapacity reserves. We use the following variables: Ecological Footprint, Foreign Direct Investment, Urbanization, Renewable Energy Consumption, international tourism, receipts for travel items, and CO_2 Emissions during the period 2002-2019 to describe and explain the objectives of this study. The results indicate several recommendations that governments in Southern, Central, Eastern, and Western Africa need to implement to achieve the Sustainable Development Goals related to reducing CO_2 emissions, environmental stability, and stabilizing the climate.

5.2: policy recommendations

The following three areas could be the subject of recommendations for our research: Tourism Development, Environment, and Climate Stability. The question here is how to put environmentally sustainable tourism development policies and strategies into practice. Governments should encourage eco-friendly travel, fund environmental preservation, and increase public awareness of sustainability issues. To create cutting-edge travel offerings that showcase Africa's natural and cultural heritage. This will attract tourists from all over the world and bring money to the local community. African governments should encourage the development of African tourism and strengthen collaboration among African nations.

By "environment," we mean all the measures that can be taken by governments to lessen the negative effects of tourism on the environment. This might entail taking steps to encourage wise use of natural resources, enhance waste disposal, save Africa's biodiversity, and cut greenhouse gas emissions. This could involve taking steps like creating national parks and nature reserves, reducing pollution, and educating the public about the value of environmental preservation. The way that African nations manage their natural resources needs to be improved. This could involve taking steps like creating plans for sustainable land, water, and forest management.

In terms of climate stability, we are looking to reduce greenhouse gas emissions from tourism. This could include measures such as the use of renewable energy, improving energy efficiency, and promoting appropriate and less polluting modes of transport. Increase the resilience of local communities to the impacts of climate change. This could include measures such as developing climate change adaptation and mitigation plans, drawing public attention to climate change risks, and building the capacity of local societies. Strengthen international cooperation to combat climate change. This could incorporate measures such as participation in international climate stability negotiations, implementation of international climate agreements, and promotion of climate change research.

5.2.1: Policy implications with the FMOLS model

Policies should promote policies aimed at reducing the ecological footprint, as this will lead to decreases in CO_2 emissions for all groups except group 4. Policies should promote policies to reduce foreign direct investment in carbon-intensive sectors, as this would trigger a reduction in CO_2 emissions from sectors 2, 3, and 4. Governments should encourage policies that promote sustainable urbanization, as this would reduce CO_2 emissions from groups 1, 3, and 4. Governments must support initiatives that advance the implementation of renewable energy, as this would reduce CO_2 emissions from group 1 energy sources. Governments should encourage policies that promote sustainable tourism, as this would reduce group 2 CO_2 emissions. The results also show that economic growth can have a positive effect on the environment in the long term. It should be noted, however, that this relationship is inverted U-shaped, meaning that there is a threshold above which economic growth leads to an increase in CO_2 emissions.

5.2.2: *Policy implications with the* DOLS *model*

Policymakers should develop policies to reduce the ecological footprint of groups 2 and 4, such as those that promote sustainable consumption and waste reduction. Governments should develop policies to reduce foreign direct investment in carbon-intensive industries for groups 2 and 4. Governments should develop policies that promote sustainable urbanization, such as improving the management of urban waste and groups 1, 3, and 4 pollutions. Governments should formulate policies to promote the use of group 4 renewable energy. Governments can formulate policies to promote sustainable tourism and green economic growth.

5.3: Limitations of the study

We only used countries in Africa with biocapacity reserves. The comparison between countries with biocapacity reserves and countries without biocapacity reserves would provide a different approach to the research. The research used international tourism, receipts, while

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future research could consider all types of inbound, outbound, and domestic tourists to determine their impact on greenhouse gas emissions.

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