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Modelling tourism-environmental pollution-health outcomes nexus in Africa

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Abstract

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Abstract

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Keywords: *tourism arrivals, environmental pollution, health outcomes.*

JEL Classification: L83, Q53, I10

1. Introduction

Tourism has been recognised, both theoretically and empirically, as a key driver of economic growth and development, contributing to employment creation, poverty and inequality reduction, small business expansion, and infrastructure development (Raifu, 2024; Raifu and Afolabi, 2024). However, the rapid growth of tourism and its socioeconomic benefits do not come without costs to society and tourism destination countries. Environmental and health economists argue that over-tourism leads to environmental pollution, which directly or indirectly affects population health or the quality of life in general (Raifu and Obaniyi, 2024; García-Buades et al., 2022; Raifu, Opeloyeru and Agbalogun, 2023). These experts provide explanations on how tourism contributes to environmental pollution and negatively impacts people's health. According to them, the tourism industry encompasses numerous activities from its subsidiary industries (hospitality and travel industries). Each of these industries relies heavily on energy generated from fossil fuels, which are the primary source of greenhouse gas emissions. According to the World Travel and Tourism Council (2023), apart from the COVID-19 period, tourism-related greenhouse gas emissions grew at an average annual rate of 2.5% between 2010 and 2019, reaching approximately 4,131 billion kilograms of CO_2 in 2019. This amount represents about 8.1% of global emissions. Moreover, the tourism industry, particularly the hospitality industry, generates waste, which contributes to ecosystem disruption, environmental pollution, and degradation (Eyuboglu and Uzar, 2020; Ahmad and Ma, 2022). Pollution poses risks to people's health. Godovykh and Ridderstaat (2020) argue that while tourism provides important health benefits, it also poses significant health risks through waste generation and the spread of diseases, as witnessed during the COVID-19 pandemic, which led to widespread economic shutdowns, including those in the tourism sector (Raifu, 2022a, b; Raifu and Kumeka, 2023). The extensive literature on pollution and health risks shows that environmental pollution impairs respiratory function and contributes to diseases such as asthma, cardiovascular conditions, and cancer. These health impacts are especially pronounced in developing countries, where lower income levels and weaker health systems exacerbate the negative effects on health outcomes, particularly life expectancy (Shetty et al., 2023). The

World Health Organisation estimated that about 7 million people die annually due to environmental pollution.[1] Thus, understanding the interconnections among tourism, environmental pollution, and health outcomes through empirical investigation with policy implications is a worthwhile endeavour.

The objective of this study is to model the nexus among tourism arrivals, environmental pollution, and health outcomes in Africa. The study integrates three sets of empirical literature to contribute to the existing body of research on this topic. First is the literature on tourism and environmental pollution (Raifu and Obaniyi, 2024; Ahmad and Ma, 2022). The second strand of literature focuses on tourism and health (Godovykh and Ridderstaat, 2020; Badulescu et al., 2022; Konstantakopoulou, 2022), while the third strand examines the relationship between environmental pollution and health outcomes (Shetty et al., 2023; Lloret et al., 2021). While these studies have significantly contributed to our understanding of the relationship between tourism, environmental pollution and health, none have been able to model the nexus among the three variables in a single study. Thus, we believe that our current approach to modelling the interaction among these variables adds to the existing research in the fields of tourism, health and environmental economics.

To contribute to the existing studies, we first test the direction of causality among the three variables. Specifically, we investigate whether tourism arrivals and environmental pollution can jointly Granger-cause health outcomes, meaning that both factors could jointly predict health outcomes. While many studies have investigated the causal nexus between tourism and environmental pollution, as well as tourism and health outcomes, and environmental pollution and health outcomes, to the best of our knowledge, no study has yet modelled tourism arrivals and environmental pollution as combined predictors of health outcomes. We employ a novel panel causality method by Juodis, Karavias, and Sarafidis (2021) to model this causal relation. The advantage of this method is that it can be used to model multivariate causality analysis in such a way that two variables can jointly Granger-cause one variable, unlike Konya's (2006) panel causality method, which could also be used for multivariate causality analysis, but treated the third variable (say, economic growth) as an auxiliary variable in modelling a causal relationship, say, between tourism and environmental pollution.

Second, we model the interaction among tourism, environmental pollution and health outcomes as a system that connects different equations. Such a system is characterised by a situation in which independent variables in one equation are dependent variables in other equations within it. For instance, in the equation of health outcomes, the explanatory variables are tourism and environmental pollution, while in the equation of tourism, health outcomes and environmental pollution could be explanatory variables. Endogeneity problems arise in such a system due to the correlation between the explanatory variables and the error terms in the equations. To address this, we employ the three-stage least squares method developed by Zellner and Theil (1962). This method enables us to solve all the equations in the system simultaneously while addressing endogeneity problems.

Section 2 presents the methodology. While section 3 presents empirical findings, section 4 concludes with policy recommendations.

[1] https://www.who.int/health-topics/air-pollution#tab=tab_2

2. Methodology

2.1. Causality Method

Following Raifu and Obaniyi (2024), Xiao et al. (2023) and Raifu et al. (2025), a multivariate JKS Granger non-causality is specified as follows:

$$ho_{i,t} = \alpha_{0,i} + \sum_{q=1}^{Q} \alpha_{q,i} ho_{i,t-q} + \sum_{q=1}^{Q} \beta_{q,i} tor_{i,t-q} + \sum_{q=1}^{Q} \lambda_{q,i} ep_{i,t-q} + \varepsilon_{i,t} \quad (1)^2$$

Where ho represents health outcomes. We use life expectancy as a proxy for health outcomes. tor denotes tourism, and it is proxied by tourism arrivals, and ep is the environmental pollution proxied by CO_2 emissions. For $q = 1, ..., Q$, $\alpha_{0,i}$ represents the individual-specific effects. $\alpha_{q,i}$ represent the heterogeneous autoregressive coefficients, $\beta_{q,i}$ and $\lambda_{q,i}$ represent the heterogeneous feedback coefficients or Granger-causality parameters.

The null hypothesis that tor and ep do not Granger cause ho is expressed as a set of linear restrictions on the parameters in equation 1, which is specified as follows:

$$H_0 : \beta_{q,i} \Lambda \lambda_{q,i} = 0, \quad \text{for all } i \text{ and } q \quad (2)$$

This implies that the past values or the lags of *tor* and *ep* do not offer statistically significant information to predict *ho* beyond what values of *ho* already provide. In other words, the past values of *tor* and *ep* cannot predict the present value of *ho*. The alternative hypothesis can be specified as

$$H_0 : \beta_{q,i} \Lambda \lambda_{q,i} \neq 0, \quad \text{for some } i \text{ and } q \quad (3)$$

The alternative hypothesis in equation 2 states that the past values of *tor* and *ep* provide enough information in predicting *ho*. If the null hypothesis is rejected, we can conclude that tourism and environmental pollution Granger-cause health outcomes.

2.2. Three-Stage Least Squares (3SLS) Method

From a theoretical perspective, the health equation often expresses health outcomes as a function of several inputs, including tourism and environmental pollution as exogenous inputs (Azimi and Rahman, 2024; Raifu, Obaniyi and Ditep, 2025). Therefore, we can specify the health outcome equation as follows:

$$ho_{it} = \alpha_0 + \alpha_1 tor_{it} + \alpha_2 ep_{it} + \alpha' X + \varepsilon_{it} \quad (4)$$

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[2] *Note: It is also feasible to have the same equations for tourism and environmental pollution when both are dependent variables.*

Where ho , tor and ep remain as defined above, $X's$ are arrays of explanatory variables which include real GDP per capita and urbanisation. Health expenditure and population growth (Azimi and Rahman, 2024; Raifu and Ditep, 2024). ε is an error term.

Similarly, several studies have also shown that tourism arrivals at a particular tourism destination are a function of the level of environmental pollution and health facilities in that country. (Badulescu et al. 2022). Thus, following that argument, the tourism equation can be expressed as follows:

$$tor_{it} = \alpha_0 + \alpha_1 ho_{it} + \alpha_2 ep_{it} + \alpha^{'} X + \varepsilon_{it} \quad (5)$$

Here $X's$ are the explanatory variables, such as GDP per capita, governance, exchange rate, and inflation rate (Raifu and Afolabi, 2024).

Based on econometric and theoretical arguments, environmental pollution could also be expressed as a function of pollution and health outcomes and other explanatory variables. The pollution equation can be expressed as follows:

$$ep_{it} = \alpha_0 + \alpha_1 ho_{it} + \alpha_2 tor_{it} + \alpha^{'} X + \varepsilon_{it} \quad (6)$$

Where $X's$ are real GDP per capita, fossil fuel consumption, population growth, trade openness, etc. (Raifu, Opeloyeru and Agbatogun, 2023).

Based on the data availability, we used data from 27 SSA countries, spanning the period from 2000 to 2020.[3] All the variables are sourced from the World Development Indicators.

3. Empirical Findings

Table 1 shows the results of the summary statistics and unit root test. Descriptive statistics provide valuable information about the characteristics of the variables of interest, including tourism arrivals, life expectancy, and environmental pollution. The results show that the average life expectancy is 61.26 years, with a range of 41.96 years to 76.47 years, and a standard deviation of 7.58. This indicates the existence of considerable disparities in health outcomes across African countries. Tourism arrivals average about 2.17 million, with a standard deviation of 3.16 million and a range of 28,000 to 15 million, suggesting substantial variation in tourism activity across the continent. It also implies that some countries depend more heavily on tourism than others. Environmental pollution has a mean of 40,251.8 kilotons, a high standard deviation of 83,560.60, and a range from 659 kilotons to 448,298 kilotons, indicating significant discrepancies in industrial activity and environmental management. Other variables, such as government health spending (% of GDP), population growth, urban population, GDP per capita, exchange rate, trade openness, and fossil fuel consumption have

[3] Algeria, Angola, Benin, Botswana, Cameroon, Congo Dem. Rep., Congo Rep., Cote d'Ivoire. Egypt, Ethiopia, Gabon, Ghana, Kenya, Libya, Mauritius, Morocco, Namibia, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Tunisia, Zambia and Zimbabwe.

mean values of 1.92%, 2.33%, 47.35%, USD 2,853.05, 17,813,344 (domestic currency per dollar), 66.66%, and 45.82%, respectively.

To conduct the unit root test, we utilised the Im-Pesaran-Shin (2003) panel unit root test for the unit root analysis. The results of the IPS unit root test, presented in Table 1, show that all the variables are not stationary at levels but become stationary after first differencing, suggesting that they are integrated of order one, I(1). It also means that all of these variables exhibit long-term trends over time, whereas their short-term changes fluctuate around a stable mean.

Table 1: Descriptive Statistics and IPS Unit Root Test Results

			Summary Statistics			IPS Unit Root	
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Level**	**First Difference**
Life Expectancy	567	61.264	7.584	41.957	76.474	-1.549	-2.461**
Tourism Arrivals	567	2169097.7	3163765.6	28000	15000000	-1.090	-3.394***
Environmental Pollution	567	40251.8	83560.578	658.87	448298	-0.947	-4.063***
Govt Health Expenditure	567	1.916	1.659	.062	15.726	-1.190	-4.661***
Population Growth (%)	567	2.327	.963	-5.28	4.156	-1.315	-2.752***
Urban Population (%)	567	47.346	17.142	14.74	90.092	1.282	-6.036***
GDP per Capita (USD)	567	2853.052	2599.503	255.1	13729.2	-0.874	-2.559***
Exchange Rate (%)	567	17813344	3.153e+08	.044	6.700e+09	-0.058	-2.920***
Trade Openness (%)	567	66.685	26.825	9.955	156.862	-1.542	-4.195***
Fossil Fuel (%)	567	45.821	31.98	1.64	109.86	-0.668	-4.224***

Note: ***, ** and * denote 1%, 5% and 10% levels of significance. IMPS is used for the unit root test.

Table 2 displays the JKS's Granger non-causality results for both bivariate and multivariate analyses. Although our goal was to perform a multivariate causality analysis among the variables (life expectancy, CO2 and tourism arrivals), we initially focused on bivariate causality to see whether one of the variables Granger caused the other. For example, we examined whether tourism and life expectancy are Granger-causal. The bivariate causality results indicated that tourism and life expectancy Granger-caused each other, signifying a bidirectional relationship between the two variables. This bidirectional relationship suggests that increased life expectancy, which is driven by improved access to healthcare amenities and infrastructure, may serve as a magnet that attracts tourists to a country. Tourism activities, particularly those involving recreation and wellness-oriented services, can also help to increase life expectancy by improving overall health and well-being (Lasisi et al., 2024). Tourism and environmental pollution are mutually reinforcing. This two-way causality between tourism and environmental pollution is perfectly consistent with environmental pollution theory, particularly ecological footprint theory, which states that higher tourism inflows cause pollution through transportation emissions, waste generation and pressure on natural ecosystems (Raifu and Obaniyi, 2024). Conversely, environmental pollution has a negative impact on tourism inflows (Azimi and Rahman, 2024). Our findings also show a bidirectional causal relationship between life expectancy and environmental pollution. This study supports a well-established theory, which holds that rising pollution decreases life expectancy by degrading air and water quality. Improving public health systems and enforcing strong environmental regulations, which enhance health outcomes, can promote stricter pollution control and the preservation of ecosystems. This, in turn, reduces pollutant levels and further improves health outcomes (Raifu, Obaniyi, and Ditep, 2025; Raifu and Ditep, 2024). Thus, at the 1% significance level, we reject the null hypothesis, which states that none of these variables Granger causes each other.

From a multivariate perspective, our findings showed that tourism and environmental pollution predict life expectancy simultaneously, suggesting that both Granger-cause life expectancy. In other words, the interaction of economic activity (tourism) and environmental conditions has a significant impact on health outcomes or population health. We also discovered that tourism and health outcomes can collectively predict environmental pollution, as well as environmental pollution and tourism. The fact that tourism and life expectancy both contribute to environmental pollution implies that tourism-driven economic activity, if paired with the prevailing health condition, influences the level of environmental pollution on the continent. Also, the fact that health outcomes and environmental pollution both predict tourism implies that tourists are concerned about the environmental and health issues in a tourism-destination country. Clean environments and a strong public health system attract more tourists, while pollution and a poor health system deter tourism inflows (Raifu and Ditep, 2024). The key difference between the bivariate and multivariate causality results is that the multivariate causality produces a stronger causal relationship. This finding is consistent with the results reported by Raifu et al. (2025), who investigated a causal relationship between renewable energy and economic growth in OECD countries.

Table 2: JKS's Granger Non-Causality Test

Model	Bivariate	Model	Multivariate
Tourism→Health	570.74*** (0.000)	Tourism and Env. Pol. → Health	10000.00*** (0.000)
Health→Tourism	38.54*** (0.000)		
Tourism →Environmental Pollution	2300.00*** (0.000)	Tourism and Health → Env. Pol.	7700.00*** (0.000)
Environmental Pollution→ Tourism	177.90*** (0.000)		
Health →Environmental Pollution	704.23*** (0.000)	Health and Env. Pol. → Tourism	283.74*** (0.000)
Environmental Pollution→Health	147.08*** (0.000)		

Note *→ the direction of the arrow shows that the first does not Granger-cause the second variable (bivariate causality) or the combination of first two variables does not Granger-cause the third variable (multivariate causality)*

Due to the presence of causal relationships among the variables, it is evident that there is an endogeneity problem. Hence, the 3SLS estimation method was utilised to examine the interaction among tourism, environmental pollution and health outcomes. However, we first employed the GLS method to estimate individual equations for health outcomes, tourism and environmental pollution models. Table 3 displays GLS results. The table showed that in the health outcomes model, tourism arrivals and environmental pollution have a positive impact on life expectancy. The positive relationship between tourism arrivals and environmental pollution suggests that high tourism inflows typically stimulate income or revenue generation, create employment opportunities, and encourage government investment in health, sanitation, education, and public infrastructure, all of which contribute to a longer life expectancy.

Similarly, the effect of environmental pollution on life expectancy might seem counterintuitive; however, such an effect may reflect an early-stage development effect where pollution is increasing alongside urbanisation and industrialisation. According to the tourism model, life expectancy and environmental pollution have a positive and significant impact on tourist arrivals. The positive effect of life expectancy on tourism arrivals indicates that destinations with better health conditions and stronger healthcare systems are more attractive to tourists, as access to quality healthcare is a key consideration in destination choice. Meanwhile, the positive effect of environmental pollution may reflect an early-stage development phenomenon common in developing countries, particularly in Africa, where tourism growth and urbanisation both increase pollution, suggesting that pollution is a by-product of tourism expansion rather than a deterrent at this stage. Finally, in the environmental pollution model, it is revealed that tourism arrivals and life expectancy both have a positive effect on environmental pollution. The fact that tourism arrivals have a positive effect on environmental pollution shows that increased tourism activity leads to higher emissions and waste generation, which contributes to environmental degradation. Similarly, the positive effect of life expectancy on environmental pollution can be explained by the fact that life expectancy is often linked to higher levels of economic development and rapid urbanisation, both of which typically increase energy consumption and production activity, thereby contributing to greater pollution levels.

The results, however, differ significantly when we consider the endogeneity situation. For example, in the health outcomes model, whereas both tourism arrivals and environmental pollution have positive effects on life expectancy; only tourism arrivals have a statistically significant positive effect. This suggests tourism activity has the potential for improving life expectancy in SSA. In the tourism model, the results of GLS and 3SLS are the same in the sense that both life expectancy and environmental pollution have positive effects on tourism arrival numbers. The positive impact of life expectancy on tourism is plausible; however, the significant positive effect of environmental pollution on tourism arrivals appears implausible. Beyond the previously discussed reasons for this development, another possible explanation is that, even in a continent with relatively low levels of environmental pollution, certain tourists may still choose to visit the continent or a specific region. According to Datzira-Masip (2006), even in polluted tourism destinations, cultural attractions and historical heritage continue to attract tourists. As expected, our findings from the environmental pollution model showed that tourism arrivals have a positive and significant effect on environmental pollution. This finding is supported by findings of Raifu and Obaniyi (2024) and Ahmad and Ma (2022) who found that tourism arrivals contribute positively to environmental pollution. Although our results showed that life expectancy has a positive effect on environmental pollution, the effect is not statistically significant.

We now proceed to explain the effect of other control variables across all the models. In the model of health outcomes, population growth (3SLS) has a negative and significant effect on life expectancy, whereas other control variables such as government health spending, urban population and GDP per capita have a positive effect. In the tourism model, both urban population growth and the exchange rate have a negative impact of tourism; however, only the urban population growth is statistically significant. GDP per capita has a positive effect on tourism, suggesting that tourism growth is linked to the level of development. According to the environmental pollution model, GDP per capita and trade openness reduce pollution, while urban population growth and fossil fuels contribute positively to environmental pollution.

Table 3: Tourism, Environment Pollution and Health Outcomes Interaction Results

	Generalized Least Squares Method			Three-Stage Least Squares Method		
	Life Expectancy	**Tourism Arrivals**	**Environmental Pollution**	**Life Expectancy**	**Tourism Arrivals**	**Environmental Pollution**
Tourism Arrivals	0.004***		0.097***	0.014**		0.912***
	(0.001)		(0.017)	(0.006)		(0.031)
Life Expectancy		1.942***	1.42***		1.352***	0.177
		(0.499)	(0.280)		(0.387)	(0.391)
Environmental Pollution	0.015***	0.501***		0.006	0.814***	
	(0.003)	(0.048)		(0.005)	(0.028)	
Population Growth	0.001*			-0.014**		
	(0.001)			(0.006)		
Govt Health Spending	0.001			0.011		
	(0.002)			(0.008)		
Urban Population Growth	.196***	0-.358**	-0.346***	0.033**	-0.477***	0.713***
	(0.017)	(0.182)	(0.13)	(0.017)	(0.144)	(0.141)
GDP per capita	0.032***	0.49***	0.498***	0.027***	0.208***	-0.151**
	(0.004)	(0.109)	(0.066)	(0.010)	(0.073)	(0.076)
Exchange Rate		0.006			-0.017	
		(0.013)			(0.013)	
Trade Openness			-0.083**			-0.548***
			(.034)			(0.084)
Fossil Fuel			.441***			0.079
			(0.050)			(0.057)
Constant	2.947***	-1.205	-1.477	3.567***	0.846	-3.461***
	(.058)	(1.828)	(1.006)	(0.076)	(1.446)	(1.524
Observations	567	567	567	540	540	540
Wald Test	577.55	326.16	647.79	0.2814	0.5113	0.5454
	(0.000)	(0.000)	(0.000)			

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

4. Conclusion

In this study, we employed 3SLS and JKS Granger non-causality methods to examine the relationship between tourism, environmental pollution, and life expectancy in sub-Saharan Africa. We found a bidirectional causality between tourism and life expectancy, tourism and environmental pollution and life expectancy and environmental pollution, highlighting the interconnectedness of the variables. Tourism not only improves health outcomes, but it also contributes to environmental pollution through increased human activity. Furthermore, environmental pollution has a positive effect tourism arrivals; however, its significance depends on circumstances. Also, life expectancy has a positive effect on tourism arrivals. In light of our findings, we propose that governments in the SSA region should develop policies that promote sustainable tourism by balancing the economic gains with environmental and health issues. Governments, in particular, should strictly enforce the laws, regulating emissions and waste management.

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