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ECOLOGICAL FOOTPRINTS AND HEALTH OUTCOMES IN LOWER MIDDLE INCOME WEST AFRICAN COUNTRIES

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Abstract

This study examines the effects of ecological footprints on health outcomes in seven lower-middle-income West African countries over the period 1990–2024, using the Common Correlated Effects Mean Group (CCEMG) and Augmented Mean Group (AMG) estimators, which account for cross-sectional dependence, slope heterogeneity, and non-stationarity in panel data analysis. The empirical results show that an increase in ecological footprint reduces life expectancy, while increasing maternal mortality and infant mortality. At the component level, built-up land, forest products, and fishing grounds emerge as the most significant drivers of deteriorating health outcomes in the region. In contrast, government health expenditure and urbanization significantly reduce both maternal and infant mortality, while secondary school enrollment positively influences life expectancy and also helps to reduce infant mortality. However, GDP per capita is found to have no statistically significant effect on any of the health outcome indicators. Overall, the findings underscore the urgent need for environmentally sustainable development policies, as well as targeted investments in healthcare and education, to improve population health outcomes across lower-middle-income West African countries.

Keywords: Ecological footprint, life expectancy, infant mortality, maternal mortality, Augmented Mean Group

JEL Classification Codes: I15, O55, Q53.

1.0 Introduction

The enhancement of the population health is a key goal of the development policy in the entire world, and health indicators like life expectancy and infant mortality are the critical indicators of social progress and human well-being (Kassouri & Altintas, 2020; Biyase et al., 2023). The economic growth is based on a productive and healthy population, and the factors that determine health such as economic development, environmental quality, and social infrastructure have received significant research interest (Iurchenko & Iurchenko, 2022: Ogunbode et al., 2025). The United Nations Sustainable Development Goal 3 (SDG 3) worldwide requests that all age groups should receive guarantees of healthy living and that well-being should be enhanced, with priorities including maternal and child health, control of communicable and non-communicable diseases, universal health coverage, and fair access to safe and affordable medicines. However, even with such promises, most countries especially in sub-Saharan Africa still lag far behind the health targets of 2030.

The health situation is especially complicated in most African region and countries counted among the lower-middle countries are affected the most especially those in the West African countries. The average life expectancy in Africa was about 64.38 years as of 2024, hence showing only tangible improvements over the past few years, with the infant mortality rate in the continent also being high at 40.65 deaths per 1,000 live births (World Bank, 2024). These statistics reveal the extent to which environmental factors have affected the health status indicators. To worsen the issue is the fact that ecological footprint, propelled by blistering urbanization, deforestation, agricultural development, and natural resource exploitation, is growing more severe in West Africa (Ofoezie et al., 2022; Yilanci et al., 2025).

One of the most commonly known indicators is the ecological footprint that measures the biologically productive land and water space needed to support the resource consumption of a population, as well as absorb its generated waste (Dasgupta et al., 2023). It is a holistic measure of the claim of natural ecosystems on humanity, representing the environmental negative aspects of production and consumption processes (Dai, 2025). The increase in ecological footprints in the West African low middle-income nations has been influenced by the increasing energy consumption, industrial growth, rampant urban sprawl, and the pressures of climate change- all of which have wider implications on environmental sustainability and human health. Although there is an increasing awareness of environmental-health nexus in the world literature, the exact pathways by which ecological footprints can be converted into negative health outcomes in the West African setting is under-researched.

Although some of the studies have investigated the correlation between environmental degradation and health outcomes in various other developing regions, such as South Asia and the E7 economies (Biyase et al., 2023), a conspicuous gap in the literature on West Africa is evident. The majority of studies that have been done have concentrated on carbon emissions as an indicator of environmental degradation without considering the more holistic and comprehensive ecological footprint that considers land use, biodiversity, carbon absorptive capacity and resource depletion at the same time. In addition, the existing literature has been heavily based on the application of the first-generation econometric techniques that do not address the issue of cross-sectional dependence nor the issue of slope homogeneity which no doubt is common in panel data that are based in developing countries with structurally diverse economies. To fill these gaps, this paper examines how ecological footprint affect indicators of healthcare using the Augmented Mean Group (AMG0 and the Common Correlated Estimated Mean Group (CCEMG) that are regarded as second generation econometrics techniques and can address the issue of cross-sectional dependence and slope homogeneity when present in panel set.

Aside from the introduction, the rest of the paper is structured as follows: Section 2 presents the review of literature. The methodology employed is presented in section 3. Section 4 presents the results and discussion of findings while section 5 concludes and provide suggested recommendations for the selected West African countries.

2.0 Literature Review

2.1 Conceptual Issues

Health Outcomes are the quantifiable changes in the health condition of an individual that are caused by medical assistance, community health measures, personal decisions, or the environment (World Health Organization, 2023). They are the final result of all activities and decisions concerning health, and they indicate whether a patient or a population has improved or deteriorated or even stayed the same after an exposure or an experience of the care. Health outcomes may be physical, mental, or social that include ability to perform in everyday life. Literature over the years have regarded life expectancy, infant mortality, and maternal mortality as major health outcomes indicators. Infant mortality represents the number of deaths of children that are below 1 years out for every 1,000 children born is regarded as one of the most sensitive measures of the quality of healthcare provided by a country, its socioeconomic status, and the effectiveness of health care provided to mothers and children: high infant mortality rates indicate poor health outcomes and insufficient access to maternal and children health care. Combined, these indicators can assist governments, healthcare organisations, and policymakers evaluate the efficiency of health systems, recognise care gaps, and implement interventions to enhance overall well-being and survival of individuals and communities.

Ecological footprint is an environmental impact of human activity measured in terms of land and water area needed to generate the resources used and to absorb the generated wastes (Sarwar et al., 2025; Hamed et al., 2026). Unsustainable practices mean that the ecological footprint is high and the rate of consumption of resources is higher than the regeneration abilities of the Earth, which results in the degradation and depletion of the environment and natural resources (Ibimilua & Ayiti, 2023: Kumar et al., 2023). According to Kazemzadeh et al (2023), among the influencing factors are population size, consumption behavior, technological efficiency, and economic activities

2.2 Theoretical Framework

The theory that has been chosen to discuss this study is the Planetary Health Theory, which was introduced by the Rockefeller Foundation-Lancet Commission in 2015. The theory sees human health and well-being as fundamentally reliant upon the health of the natural systems on this planet, and contends that the increasing degradation of the ecosystems on this planet - through human actions like deforestation, fossil fuel burning, overuse of land and pollution - constitutes one of the most significant threats to human health in the modern era. It assumes that the same ecological pressures that cause environmental degradation also produce direct and quantifiable effects on human populations, such as a heavier disease burden, a shorter life expectancy, more infant and child death, food and water insecurity, and worse mental health. The theory confronts the traditional biomedical concept of health by placing it in a larger planetary framework and saying that there is no sustainable enhancement in the achievement of human health without also including in this the destruction of natural systems on which life relies.

The applicability of Planetary Health Theory to this research is that it can be directly applied to explain how ecological footprints, which quantify how much human demand on nature surpasses the regenerative capacity of the Earth, can result in poor health in lower middle-income countries of West Africa. In such countries where pressure on the environment through deforestation, land degradation, air and water pollution, and carbon emissions meet the weak health systems and scarce resources, the theory offers a logical and holistic perspective of understanding the relationship between ecological overuse and health measures like life expectancy and infant mortality. This theory is strong in that it is interdisciplinary and empirically based; it combines environmental science, epidemiology, public health, and social policy, and thus has the potential to represent the complexity of the ecological-health nexus. Moreover, it has been embraced extensively in the health research and policy discussion throughout the world, which gives it credibility and academic power in its use in the current study, as well as providing practical implications to policy makers hoping to enhance health outcomes by implementing environmentally sustainable development solutions in West Africa.

2.3 Empirical Literature

Jarallah et al. (2026) examined the environmental and socioeconomic determinants of health outcomes in the MENA. The analysis used the pooled ordinary least squares and the static and dynamic panel threshold regression models on the 20 countries between 2000 and 2022. The results indicated that ecological footprint significantly lowers life expectancy by (average) 1.159 years within the region; although disaggregated data indicated a positive impact on oil exporting nations and a negative impact on non-oil exporting nations, which is heterogeneity.

To assess the connection between human development and ecological sustainability, Wang et al. (2026) applied the linear panel models and panel threshold regression methods to a balanced sample of 140 countries in 1990 to 2022, with a globalization index to reflect the effects of deglobalization. The results indicated that ecological footprint was significantly and strongly correlated with human development (HDI) and the relationship was found to be statistically significant and significant among all income groups albeit with different magnitudes with globalization being found to moderate this relationship.

Osakede et al. (2025) examined the effect of carbon emissions and renewable energy use on the mortality of people in Africa based on the data published between 2011 and 2023 in the World Bank Development Indicators. The research used the PraisWinsten (PW) model and Feasible Generalized Least Squares (FGLS) method to deal with the problems of cross-sectional dependence/heterogeneity. The results have shown that higher carbon emissions have a significant positive effect on mortality whereas renewable energy consumption has non-negative effects on mortality in general except that female and male adult mortality showed a negative relationship under FGLS estimation indicating that the mitigating effects of renewable energy on mortality are limited.

Samara et al. (2025) examined the impact of climate change on maternal and fetal health by reviewing English-language literature between 2000 and 2024 and policy documents to explore the role of policy in addressing climate change issues. The analysis established that stressors related to climate like extreme weather, water shortage, malnutrition and environmental pollution are major causes of poor pregnancy outcomes such as preterm births, low birth weights and developmental complications, with worse effects in the low-resource environments caused by poor healthcare facilities, thus increasing maternal health disparities.

Popescu et al. (2024) looked at the relationship between the ecological footprint, urbanization, education, health expenditure, and industrialization in Eastern Europe and the relationship between these factors and child mortality by using data between 1993 and 2022 as part of the Grossman Health Outcome framework. The research used the Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) model and Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) to enhance strength. Results showed that health expenditure and education significantly decrease child mortality, and ecological footprint, industrialization, and unemployment significantly increase it, with consistent results across models showing that education is the most powerful in reducing child mortality and ecological footprint is a major factor increasing mortality rates.

In a study on the relationship between environmental pollution and maternal mortality among female entrepreneurs in Nigeria, Ovharhe and Odepeli (2024) used annual time series data of female entrepreneurs in Nigeria between 1981 and 2023. The authors used Toda-Yamamoto causality estimation method and review analysis to evaluate the implications of post-COVID-19. It was found that there was no causal association between the emissions of carbon dioxide, nitrous oxide, and particulate matters with maternal mortality but there was unidirectional causality between maternal mortality and carbon dioxide emissions implying that, maternal mortality increases environmental pollution in the period of analysis.

Biyase et al. (2023) examined how ecological footprint is related to health outcomes in E7 countries during 1990 and 2017 by applying a panel Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methods. The results indicated that the ecological footprint positively influences life expectancy and thus the current level of ecological resource consumption might potentially result in better health outcomes but the study warned that, in the long term, the effect of ecological footprint on life expectancy could be negative and therefore had to promote the idea that the ecological footprint needs to be moderated.

Alan et al. (2023) employed an introspective research method to examine the effects of climate change on human health through secondary sources such as books, reports, journals, and government publications. These results showed that climate change is a risk multiplier which further escalates existing public health issues by exposing people to more climate-related diseases, non-communicable diseases, and outbreaks of infectious diseases, especially in vulnerable regions like Pacific Island countries, and itself contributes to heat-related illnesses, the spread of vector-borne diseases and more general environmental health risks.

3.0 Methodology

3.1 Data Required and Source.

The sample includes seven West African nations that are lower middle-income, namely Benin, Cape Verde, Cote d'Ivoire, Ghana, Mauritania, Nigeria, and Senegal. The data collected covers the period between 1990 and 2024. Data used are life expectancy at birth, total (years), mortality rate, infant (per 1,000 live births), maternal mortality ratio (modelled estimate, per 100,000 live births), ecological footprint, global hectares per capita, current health expenditure (% of GDP), urban population (% of total population), unemployment, total (% of total labour force) national estimate, and GDP per capita (current US$). Macro-level data are taken at the World Bank, World development Indicators while data on ecological footprint are sourced from https://data.footprintnetwork.org.

3.2 Model Specification

In examining the effect of ecological footprint on health outcomes in lower-middle West African countries, this study adopts a modified version of the model specified by Biyase et al (2023). The model establishes a functional relationship between health outcomes and selected environmental and socio-economic variables. The functional form of our model is expressed as:

$$HO_{it} = f\left(ECFP_{it}, CHE_{it,}URP_{it}, SSE_{it}, GDPK_{it}\right) \quad 3.1$$

Where: HO represents health outcomes measured by life expectancy at birth, infant mortality and maternal mortality ratio, ECFP stands for ecological footprint, CHE represents current government expenditure, URP stands for urban population, SSE represents secondary school enrollment, GDPK stands for GDP per capita, *i* represents the cross -sectional unit, which is the country, *I* = 1, 2, 3, …, 7), and *t* represents the time periods, *t* = 1990, 1991, …, 2024.

Equation 3.1 is respecified in econometric form as shown in equation 3.2.

$$HO_{it} = \alpha_0 + \alpha_1 ECFP_{it} + \alpha_2 CHE_{it} + \alpha_3 URP_{it} + \alpha_4 SSE_{it} + \alpha_4 GDPK_{it} + \varepsilon_{it} \quad 3.2$$

Where α_0 is constant, $\alpha_1 - \alpha_5$ represents the independent variables coefficient and ε_{it} represents the stochastic error term.

Equation 3.2 is reformulated in its a log-log model to linearize nonlinear relationships and interpret the coefficients as elasticities, indicating percentage changes in the dependent variable for percentage changes in the independent variables. The equation is thus formulated as:

$$logHO_{it} = \alpha_0 + \alpha_1 logECFP_{it} + \alpha_2 logCHE_{it} + \alpha_3 logURPO_{it} + \alpha_4 logSSE_{it} + \alpha_5 logGDPK_{it} + \varepsilon_{it} \quad 3.3$$

Where $logHO_{it}$ is the logarithmic form for the indicators of health outcomes, $logECFP_{it}$ is the logarithmic form of ecological footprint, $logCHE_{it}$ stands for logarithm form of current health expenditure, $logURPO_{it}$ is the logarithmic form of urban population, logSSE_{it} is the logarithmic form of secondary school enrollment and log$GDPK_{it}$ is the logarithmic form of GDP per capita.

3.3 Estimation Techniques

Cross – Sectional Dependence

To address potential biases and inconsistencies that arise in panel data in the presence of cross-sectional dependence, this study employs four diagnostic tests to determine the presence or absence of cross-sectional dependence among the variables. Specifically, the Breusch-Pagan LM test (1980), the Pesaran CD test, the Pesaran Scaled LM test, and the Bias-Corrected Scaled LM test are applied. Each of these tests evaluates the null hypothesis of cross-sectional independence against the alternative hypothesis of cross-sectional dependence, thereby providing robust statistical evidence on whether the panel units are correlated with one another. The application of multiple tests is particularly important given that individual tests may differ in their power and size properties depending on the panel's dimensions, and together they offer a more comprehensive and reliable assessment of cross-sectional dependence in the data. The four tests are as follows:

$$LM = \sum_{i=1}^{N-1}\sum_{j=i+1}^{N} T_{ij}\,\hat{p}_{ij}^{2} \rightarrow \chi^{2}\frac{N(N-1)}{2} \quad 3.4$$

Where $\hat{p}_{ij}^{2}$ is the residual correlation coefficient extracted from the equation.

The Pesaran (2004) LM statistics follows:

$$LM_{s} = \left(\frac{1}{N(N-1)}\right)^{2}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left(T_{ij}\hat{p}_{ij}^{2} - 1\right) \rightarrow N(0,1) \quad 3.5$$

Bias-corrected Scaled LM test

$$LM_{BC} = \left(\frac{1}{N(N-1)}\right)^{2}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left(T_{ij}\hat{p}_{ij}^{2} - 1\right) - \frac{N}{2(T-1)} \rightarrow N(0,1) \quad 3.6$$

Pesaran CD test, which is based on the mean coefficients of correlation $\hat{p}_{ij}$ and it can be represented as follows:

$$CD_{p} = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} T_{ij}\hat{p}_{ij} \rightarrow N(0.1) \quad 3.7$$

The four tests were tested under the null hypotheses as follows:

$$H_{0}: \hat{p}_{ij} = cor\left(\mu_{it,}\mu_{jt}\right) = 0 \; for \; i \neq j \quad 3.8$$

Westerlund Cointegration Test

The study used the Westerlund (2007) panel cointegration test that is best suited to deal with the problems of cross-sectional dependence and slope heterogeneity in the panel that can often dominate non-stationary time series data to establish the presence of long-term equilibrium relationships between the variables. The Group Mean Statistic (G_t) of cointegrating and adjustment (G_a) coefficients, the panel statistic of pooled cointegrating coefficient (P_a) and the speed of adjustment (P_t) are the specific test of the Westerlund (2007) cointegration test. The statistics of cointegrating coefficient is given in the Group Mean of cointegrating coefficient:

$$G_{t} = \frac{1}{N}\sum_{j=1}^{N}\frac{\theta_{j}^{t}}{SE\theta_{j}^{e}} \quad 3.9$$

Where G_t is the group mean statistic, representing the average of the individual statistics for the estimated cointegrating coefficients (θ_{j}^{t}) across all units in the panel. $SE\theta_{j}^{e}$ denote the standard error of the estimated cointegrating coefficients. When the value of G_t is significantly different from zero, it suggests evidence of cointegration in the entire panel. The Group Mean statistic for Adjustment Coefficients takes the form

$$G_{a} = \frac{1}{N}\sum_{j=1}^{N}\frac{T_{j}^{t}}{\theta_{j}^{t}(1)} \quad 3.10$$

Where G_a represents the average of the individual t-statistics for the adjustment coefficients T_{j}^{t} across all units in the panel.

The adjustment coefficients capture the speed at which deviations from equilibrium are corrected. A statistically significant coefficient for G_a indicate the presence of an error correction mechanism

$$P_t = \frac{\theta_j^t}{SE(\theta^t)} \qquad 3.11$$

Equation 12 describes the panel statistic for pooled cointegrating coefficient. P_t represents the pooled cointegrating coefficient (θ_j^t) that captures the long-term relationship between the variables in the panel, while $SE(\theta^t)$ denote the standard error of the cointegrating coefficient. The equation of the speed of adjustment is specified as follows:

$$P_a = \frac{\theta^f}{T} \qquad 3.12$$

Where P_a represents the speed of adjustment towards the long-term equilibrium, calculated as the ratio of the pooled adjustment coefficient (P_a) to the total number of time periods (T).The speed of adjustment indicates the annual rate at which deviations from equilibrium are corrected in the model.

Panel Unit Root Test

Where there is cross-sectional dependence of variables, the traditional first-generation unit root tests are ineffective and unreliable. To overcome this shortcoming, the paper will use the Cross-sectional Im, Pesaran, and Shin (CIPS) test suggested by Pesaran (2007). CIPS statistic is calculated in the following manner:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i \qquad 3.13$$

Common Correlated Estimated Mean Group (CCEMG) estimation

The study employed the second-generation econometric techniques comprising of the Common Correlated Estimated Mean Group (CCEMG) estimation techniques proposed by Pesaran (2006) and the Augmented Mean Group (AMG) by Ebehaldt and Teal were used. The CCEMG estimator offers comparable estimates of coefficients when there is a cross-sectional dependence by eliminating unobserved common factors, and is thus applicable in both stationary and non-stationary variables. This is an effective panel data estimation method that is flexible and robust and is very useful when cross-sectional dependence is involved. It permits heterogeneity within cross-sectional units and is able to accommodate unobserved common factors which could be correlated with the regressors. The AMG estimator does this by adding the cross-sectional averages of the regressors of the dependent variable and the regressors, which effectively captures the effects of these common factors and gives accurate estimates. The augmented model is given as:

$logHO_t = \alpha_0 + \alpha_1 logBUL_t + \alpha_2 logCAB_t + \alpha_3 logCRL_t + \alpha_4 logFGS_t + \alpha_5 logFGP_t + \alpha_5 logGRL_t + \overline{\delta_1 logHO_t} + \overline{\delta_2 logBUL_t} + \overline{\delta_3 logCAB_t} + \delta_4 \overline{logCRL_t} + \delta_5 \overline{logFGS_t} + \delta_5 \overline{logFGP_t} + \delta_6 \overline{logGRL_t} + v_i$ 3.14

Where: $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5,\ and\ \delta_6$ are the coefficients associated with the cross sectional averages of the logarithms of the variables$\overline{\delta_1 logHO_t} + \overline{\delta_2 logBUL_t} + \overline{\delta_3 logCAB_t} + \delta_4 \overline{logCRL_t} + \delta_5 \overline{logFGS_t} + \delta_6 \overline{logFPD_t} + \delta_7 \overline{logGRL_t} + v_{it}$, and v_{it} is the error term capturing individual – specific shocks.

The calculated mean group estimator therefore is computed by the average of the individual specific coefficient estimates as

$\hat{\beta}_{AMG} = \frac{1}{N}\sum_{I-1}^{N} \hat{\beta_\iota}$ 3.15

4.0 Results and Discussion of Findings

4.1 Presentation of Results

Descriptive Statistics

Table 4.1 gives the descriptive statistics of the variables in the seven chosen lower-middle-income West African countries, which are the life expectancy at birth, maternal mortality rate, under five mortality rate, ecological footprint, government current health expenditure, urban population, and secondary school enrollment. Interestingly, Cote d Ivoire is the country with the highest mean life expectancy of 71.143 years and Mauritania with 62.342 years. On the other hand, the lowest mean life expectancy of 45.487 years is in Nigeria whereas Cape Verde has the highest life expectancy of 76.593 years. This lays emphasis on the marked differences in health status and development indicators among these countries with diverse economic stability, health spending, and social infrastructures.

Nigeria had the highest average of 1145.152 deaths per 100,000 live births, and then Mauritania with 599.303. Cape Verde recorded the lowest with 35 deaths per 100,000 live births and Nigeria was the highest with 1356 deaths per 100,000 live births. The quality of healthcare infrastructure, economic stability and government policies are some of the factors that affect this pattern. Those nations, such as Cape Verde, which have more advanced healthcare systems and invest more in maternal health, have lower rates of mortality, whereas Nigeria has a larger economy but has inequities in access to healthcare systems and resource distribution, which results in larger rates of mortality.

Under-five mortality, Nigeria has the highest mean with 96.264 deaths per 1,000 live births with a lowest of 25.452 in Cape Verde. Cape Verde has also the lowest at

10.6 and Nigeria the highest at 124.4, which indicates inequalities in child healthcare and other socioeconomic statuses. In terms of ecological footprint Mauritania is the highest with the mean of 2.42 global hectares per capita, and Nigeria is the lowest with 1.006. The range of ecological footprint is great, ranging between minimum in Nigeria (0.801) and the maximum in Mauritania (2.794), indicating that the consumption and the impact on the environment differ.

Cote d'Ivoire tops the leader with an average of 5.029% of current health expenditure as a percentage of GDP and Mauritania lags with 2.82. The healthcare investment is different as the minimum is 0.219% in Mauritania and the highest of 7.683 percent in Cape Verde. The percentages of urban population indicate that Cape Verde is the highest with the average of 57.492 and Nigeria with the lowest of 40.555. Urban population is at least 29.68 in Nigeria and 67.545 in Cape Verde which means that there are varying degrees of urbanization.

Lastly, secondary school enrollment rates are highest on average in Cape Verde at 63.107%, while Mauritania has the lowest at 22.817%. The disparities in access to and participation in secondary education are reflected by the enrollment rates of 6.023% in Benin and 89.010% in Cape Verde.

Table 4.1: Descriptive statistics of variables

	Mean	Std. Deviation	Minimum	Maximum
Life Expectancy at birth				
Benin	57.405	2.031	53.292	60.454
Cape Verde	71.143	4.065	64.093	76.593
Cote d'Ivoire	54.154	3.096	50.81	59.319
Ghana	60.102	2.953	55.62	64.72
Mauritania	62.342	1.862	59.77	65.687
Nigeria	49.281	2.791	45.487	53.633
Senegal	61.884	4.595	56.418	68.526
Panel	**61.339**	**5.76977**	**45.487**	**76.593**
Maternal Mortality				
Benin	499.121	81.126	341	625
Cape Verde	102.03	690.887	35	258
Cote d'Ivoire	480.606	103.327	250	619
Ghana	425.849	158.935	244	749
Mauritania	599.303	89.045	431	684
Nigeria	1145.152	92.218	969	1356
Senegal	516.121	193.558	241	849
Panel	**538.312**	**312.021**	**35**	**1356**
Under Five Mortality				
Benin	76.515	14.919	53.6	104

Cape Verde	25.452	11.158	10.6	45.4
Cote d'Ivoire	80.661	17.693	52.4	104.1
Ghana	54.391	15.336	31.6	80
Mauritania	50.694	14.096	31.4	70.8
Nigeria	96.264	18.987	68.5	124.4
Senegal	51.791	16.117	28.2	71.2
Panel	**62.252**	**26.839**	**10.600**	**124.400**
Ecological Footprint				
Benin	1.321	0.173	1.111	1.692
Cape Verde	1.456	0.195	1.162	2.109
Cote d'Ivoire	1.019	0.088	0.885	1.215
Ghana	1.571	0.251	1.069	1.882
Mauritania	2.42	0.166	1.956	2.794
Nigeria	1.006	0.109	0.801	1.205
Senegal	1.375	0.097	1.126	1.544
Panel	**1.453**	**0.470**	**0.801**	**2.794**
Current Health Expenditure				
Benin	2.831	0.255	2.368	3.304
Cape Verde	4.77	0.797	3.583	7.683
Cote d'Ivoire	5.029	1.444	2.64	7.242
Ghana	3.452	0.739	2.417	4.693
Mauritania	2.82	1.054	0.219	4.857
Nigeria	4.153	1.065	2.491	6.846
Senegal	3.591	0.919	1.513	5.151
Panel	**3.807**	**1.249**	**0.219**	**7.683**
Urban Population				
Benin	41.512	4.474	34.485	49.534
Cape Verde	57.492	7.288	44.12	67.545
Cote d'Ivoire	45.769	4.019	39.345	52.661
Ghana	47.845	6.67	36.441	58.615
Mauritania	44.829	6.395	38.091	56.923
Nigeria	40.555	7.558	29.68	53.521
Senegal	42.855	3.22	38.896	49.086
Panel	**45.833**	**7.869**	**29.680**	**67.545**
Secondary School Enrollment				
Benin	33.347	18.005	6.023	62.147
Cape Verde	63.107	26.192	18.888	89.01
Cote d'Ivoire	33.824	12.506	17.43	59.91
Ghana	47.226	16.84	29.493	77.352
Mauritania	22.817	7.723	13.013	37.45
Nigeria	34.394	10.571	18.198	54.883
Senegal	30.325	15.535	14.23	55.185
Panel	**37.863**	**20.269**	**6.023**	**89.010**

Source: Computed by Researcher, 2026

Cross Sectional Dependence Test

A cross-sectional dependence test was performed in order to determine the existence of correlations among the cross-sectional units of variables of the variables of the chosen countries. The importance of identifying these correlations is that failure to do so may jeopardize the validity of the statistical inferences conducted and thus wrong economic inferences regarding how the economies of these countries are intertwined. Cross-sectional dependence was ascertained using four tests namely the Breusch-Pagan LM, Pesaran Scaled LM, Bias-Corrected Scaled LM and Pesaran CD. The results are presented in Table 4.2, where the null hypothesis of no cross-sectional dependence was rejected in all four tests, meaning that economic activities and variables are interdependent in these countries, influencing each other and emphasizing the need to consider these dependencies in the analysis.

Table 4.2: Cross sectional dependence test

Variables	Breusch-Pagan LM	Pesaran Scaled LM	Bias Corrected Scaled LM	Pesaran CD
LEX	618.155***	91.062***	90.953***	24.828***
	(0.000)	(0.000)	(0.000)	(0.000)
MMR	467.588***	67.83***	67.72***	2.372
	(0.000)	(0.000)	(0.000)	(0.017)
IFM	666.661***	98.548***	98.438***	25.816***
	(0.000)	(0.000)	(0.000)	(0.000)
CFP	234.361***	31.842***	31.733***	12.842***
	(0.000)	(0.000)	(0.000)	(0.000)
CRFP	70.408***	6.543***	6.434***	1.090
	(0.000)	(0.000)	(0.000)	(0.276)
CHE	217.139***	29.185***	29.075***	-1.371
	(0.000)	(0.000)	(0.000)	(0.170)
URPO	664.066***	98.147***	98.038***	25.763***
	(0.000)	(0.000)	(0.000)	(0.000)
SSE	539.357***	78.904***	78.795***	23.174***
	(0.000)	(0.000)	(0.000)	(0.000)

Note:*** denotes significance at 1%

Source: Computed by Researcher, 2026

Cointegration Test

To determine whether there is a long run relationship among the variables, the Bootstrap Westerlund and Edgerton (2007) cointegration test results was used. The result, as in Table 4.3, strongly disapproves the hypothesis of no cointegration. This rejection is justified by statistically significant p-values of all the four tests employed; Group t-Statistics (Gt) that tests the null hypothesis of no cointegration of each of the cross-sectional units in the panel data. Group a-Statistics (Ga) which tests the null hypothesis of no cointegration at each cross-sectional unit. It however, sums up the data of all the units to test cointegration in the panel. Panel t-Statistics (Pt) that tests the null hypothesis of no cointegration between the entire panel data set and where the panel is treated as a single unit and Panel-a Statistics that tests the cointegration across the entire panel. The test statistics are all far much less than the traditional 5% level of significance. This confirmation of cointegration shows that there is long term equilibrium relationship of studying variables. The study then goes on to estimate and test the relationship of the parameters of the models since cointegration has already been established to provide the correct and reliable analysis of the interactions of the variables.

Table 4.3. Westerlund Cointegration

Statistic	Value	Z-value	Prob.
Gt	-6.347***	4.984	0.001
Ga	-3.659**	5.1795	0.047
Pt	-6.856**	7.015	0.028
Pa	-3.758**	5.816	0.049

*Note: ***', '**', denotes significance at 1% and 5%. respectively.*

Source: Computed by Researcher, 2026

Unit Root Test

The traditional unit root test does not work anymore when the variables are used to test the stationarity of the variables since it is known that cross-sectional dependence exists among the variables used. The stationarity testing is necessary since without it, spurious regression results can take place. Thus, the second-generation unit root test of panel data developed by Im, Pesaran and Shin was used in the study. The results are reported in Table 4.4, and indicate that only maternal mortality (MMR) was at level I(0), with the other variables, namely life expectancy at birth (LEX), infant mortality (IFM), carbon footprint (CFP), crop land (CRFP), current health expenditure (CHE), urban population (URPO), and secondary school enrollment (SSE) all stationary only after their first difference. This implies that MMR did not have to be differenced to be in the stationary state, meaning that it does not show any trend over time, whereas the other variables had to be differenced at least once to reach the stationary state, which implies that they have a trend or unit root that has to be eliminated to prevent misleading regression results.

Table 4.4. Panel Unit Root Test

Variables	Level I(0)	1st Difference I(1)
LEX	1.862	-4.277***
	(0.969)	(0.000)
MMR	-2.149**	
	(0.016)	
IFM	-0.887	-4.936***
	(0.188)	(0.000)
CFP	-1.179	-8.525***
	(0.119)	(0.000)
CRFP	-1.128	-10.937***
	(0.130)	(0.000)
CHE	0.314	-5.189***
	(0.623)	(0.000)
URPO	4.566	-9.037***
	(1.000)	(0.000)
SSE	2.998	-5.359***
	(0.999)	(0.000)

*Note: *** and ** denotes significance at 1% and 5% respectively*

Source: Computed by Researcher, 2026

Effect of Ecological Footprint on Health outcomes

The regression Table 4.5 shows the results using panel dynamic ordinary least squares (PDOLS) and indicates that the ecological footprint has a significant influence on the health outcome in the countries of the Lower Middle Income West Africa. The ecological footprint coefficient (logECOF) indicates that the one percent increase of ecological footprint causes the reduction of life expectancy (logLEX) by 0.077 percent, the increase of the maternal mortality rate (logMMR) by 0.519 percent, and the increase of the infant mortality rate (logIFM) by 0.624 percent. The results are important and in agreement with a priori assumptions that increased ecological degradation has a negative effect on health outcomes. The negative correlation with life expectancy indicates that environmental degradation compromises the general health, which is probably caused by the increase in pollution and resource depletion. The positive relationships with maternal and infant mortality reveal that ecological strain increases the vulnerability of populations to health risks, which are associated with increased maternal and infant mortality. The implication of these results is that the ecological footprints need to be reduced through environmental policies in order to offer better health outcomes in these areas.

The results for government health expenditure (logGHE) show a 1% increase in government health expenditure correlates with a 0.015% increase in life expectancy, a 0.395% decrease in maternal mortality, and a 0.059% decrease in infant mortality. Although the impacts on life expectancy and infant mortality are statistically insignificant, the maternal mortality decrease is statistically significant and confirms the a priori hypothesis of improved health outcomes with increased health spending. This implies that maternal deaths can be greatly minimized by investment in health infrastructure and services. Nonetheless, the weaker effect on the life expectancy and infant mortality presents the possibility that other factors, perhaps concerning the effectiveness and distribution of health resources, may affect these outcomes. The point is that, with other supportive measures, there is a possibility that the targeted health expenditure can be more effective.

The impact of urban population (logURPO) on health outcomes shows a 1% increase in urban population results in a 0.006% increase in life expectancy, a 0.695% decrease in maternal mortality, and a 0.896% decrease in infant mortality. These results are significant and fulfill the a priori hypothesis that urbanization has a positive impact on health outcomes because of improved access to healthcare, sanitation, and education. The fact that it is positively influencing life expectancy implies that cities are more beneficial in terms of ensuring people live longer. The high maternal and infant mortality rates are reduced greatly, thus indicating the relevance of infrastructure and services in the city in protecting the health of mothers and children. These findings suggest that urban development policies, as well as the investments into the urban health services, can significantly enhance the population health.

The positive change in life expectancy (logSSE), maternal mortality (not significant) and infant mortality is 0.064 percent, 0.038 percent, and 0.205 percent, respectively, with a positive increase (logSSE) in secondary school enrollment. These are important in terms of life expectancy and infant mortality, which indicates that education has a positive impact on health outcomes as assumed a priori. The increased enrollment in higher secondary school probably leads to improved health awareness and practices, which translate to increased life expectancy and decreased infant mortality. The fact that the impact was not significant on maternal mortality implies that education is important, but other things might be required to tackle the health of mothers holistically. The results stress the importance of educational policies and investments in enhancing overall public health.

The coefficient of GDP per capita (logGDPK) shows that there is little effect of GDP on health with a 1% increase in GDP causing a 0.003% increase in life expectancy, a 0.038 reduction in maternal mortality and a 0.084 reduction in infant mortality but none of these are statistically significant. These results are contrary to the a priori assumption that increased GDP per capita should positively affect health outcomes, which implies that economic growth alone is not adequate to promote health in these nations. This can be attributed to the unequal distribution of income or inefficient use of economic earnings. It suggests that growth in GDP per capita without focusing on inequality and investing in health and education may not lead to major gains on the public health outcomes.

The values of R-squared mean that the model accounts 93% of the variation in life expectancy, 91% of the variation in maternal mortality, and 88% of the variation in infant mortality. The large R-squared values indicate that the variables included are very effective in explaining the level of health in these countries.

Table 4.5: Effect of Ecological Footprints on Health Outcomes

	logLEX	logMMR	logIFM
logECOF	-0.077***	0.519*	0.624***
	(0.001)	(0.097)	(0.000)
logGHE	0.015*	-0.395***	-0.059
	(0.093)	(0.002)	(0.253)
logURPO	0.006***	-0.695*	-0.896***
	(0.004)	(0.073)	(0.000)
logSSE	0.064***	-0.038	-0.205***
	(0.000)	(0.715)	(0.000)
logGDPK	0.003	-0.084	-0.018
	(0.654)	(0.719)	(0.619)
R^2	0.93	0.91	0.88

*Note: *** and * denotes significance at 1% and 10% respectively.*

Source: Computed by Researcher, 2026

Effect of Ecological Footprints components on health Outcomes

Table 4.6 shows the impact of the elements of the ecological footprint on health outcomes. BUL has a positive effect on life expectancy, maternal mortality, and infant mortality. All three health outcomes are greatly influenced by built-up land (BUL). An increase in BUL by 1 percent results in a 0.092 percent increase in life expectancy, a 0.690 percent increase in maternal mortality and a 0.606 percent increase in infant mortality, all of which are highly significant ($\rho < 0.05$). The fact that urban areas have a positive impact on life expectancy implies that they have higher accessibility to healthcare, education and economic opportunities, which leads to longevity. Nevertheless, the high mortality rates among mothers and babies indicate the possible negative aspects of urbanization, including overcrowding, pollution, and the lack of healthcare facilities, which may have a negative impact on vulnerable population.

The effects of carbon (CAB) on health outcomes are mixed. Although a 1% change in CAB is linked to negative, but non-significant, effect on life expectancy (-0.025%, $\rho > 0.1$) with it has a negative effect on maternal mortality (0.090%; $\rho > 0.1$), it has a positive impact on infant mortality (0.193%; $\rho < 0.05$ p = 0.005). This means that the increased emissions of carbon (which may be due to industrial activities) have adverse effects on the health of infants, perhaps in the form of high levels of air pollutants and related breathing problems. The absence of significance in the life expectancy and maternal mortality implies that there are other factors that can counteract the adverse impact of carbon emission in these outcomes.

Crop land (CRL) significantly affects life expectancy (-0.026%, $\rho > 0.1$), infant mortality (-0.019%; $\rho > 0.1$), but in the opposite direction. These findings indicate that agricultural growth does not always positively affect the health outcomes and can actually reduce life expectancy and infant mortality. The beneficial impact on maternal mortality, although not significant, might be related to better nourishment in terms of agricultural products**.**

CRL has a small negative effect on life expectancy (-0.026%; $\rho > 0.1$) and infant mortality (-0.019%; $\rho > 0.1$) and a positive but insignificant effect on maternal mortality (0.056% p = 0.651). These findings indicate that agricultural growth is not always associated with better health outcomes and can even have a negative impact on life expectancy and infant mortality. The improvement in the maternal mortality rate, though not significant, may be because of better nutrition through the agricultural produce, but the net effect of crop land on health outcomes would seem to be small.

Table 4.6: Effect of components of ecological footprint on health outcomes

	LEX	MMR	IFM
BUL	0.092***	0.690***	0.606***
	(0.000)	(0.000)	(0.000)
CAB	-0.025	0.090	0.193***
	(0.251)	(0.439)	(0.005)
CRL	-0.026	0.056	-0.019
	(0.268)	(0.651)	(0.779)
FGS	-0.004	-0.000002	0.057***
	(0.438)	(0.999)	(0.000)
FPD	-0.114**	0.438*	0.492***
	(0.010)	(0.063)	(0.000)
GRL	0.014	0.112	-0.991
	(0.784)	(0.678)	(0.553)

*Note: ***, ** and * denotes significance at 1%, 5% and 10% respectively.*

Source: Computed by Researcher, 2026

4.2 Discussion of Findings

This paper explores the relationship between ecological footprints and health outcomes in lower-middle-income West African countries between 1990 and 2024. The results present some insightful insights into the effects of environmental degradation and resource exploitation on the health of the population in these areas. To begin with, the paper provides a strong negative correlation between the ecological footprints and the life expectancy that indicates the negative health impacts related to environmental degradation. The nations that have higher ecological footprints have shorter life expectancies, which highlights the pressing necessity of having sustainable environmental practices in order to alleviate these impacts. These results were in line with the results of Iqbal et al. (2023) as well as the findings by as well as the findings by Jarallah (2026).

Secondly, the analysis shows that ecological footprints lead to maternal and infant mortality rates in the countries studied. This observation underscores how the well-being of mothers and children is susceptible to environmental alterations like deforestation, land degradation, and pollution. The research also finds particular elements of ecological footprints to be especially important in the increase of maternal mortality namely forest products and fishing grounds due to their effects on food security and environmental sustainability. The findings supported the outcomes by Samara et al. (2025) which highlight the paramount overlap between environmental sustainability and population health, and calls on policy makers to focus on sustainable development practices that will protect maternal and child health.

Individual component analyses also explain the different effects of the different components of ecological footprint on health. The urbanized land turns out to be a contradictory factor since it has a positive impact on life expectancy due to better infrastructure and other urban amenities but also contributes to environmental degradation. On the other hand, the most negative effect on life expectancy is seen in forest products, which are indicative of the larger effects of deforestation on ecosystem services that are important to human health. This highlights the complexity of the environmental health interactions and points out that integrated policy responses that can balance economic development and environmental sustainability are necessary.

Finally, the paper concludes that the ecological footprints have a high level of variations in the proportion of health outcomes in specific nations. The variability is determined by different socio-economic settings, environmental policies and the capacity of health infrastructure. The results indicate that interventions should be unique in response to particular environmental issues that each country is encountering. Nation states dependent on the extraction of natural resources can gain advantages in the strict conservation policies and sustainable resource management actions, but urbanizing states need to focus on green infrastructure and pollution prevention programs to reduce the health risks of the high rate of urbanization.

5.0 Conclusion and Policy Recommendations

This paper offers solid empirical data that ecological degradation in the form of ecological footprint has a considerable negative impact on health outcomes in the lower-middle-income West African nations. The results validate that the increase in ecological footprints lowers life expectancy and increases maternal and infant mortality and depletion of forest products and overexploitation of fishing grounds have been found to be especially detrimental factors. The impact of built-up land is mixed: on the one hand, it positively affects the life expectancy, improving access to basic services related to urban development, but on the other hand, it has a negative effect on maternal and infant mortality, which is manifested through the negative effects of unplanned urbanization, overcrowding, pollution, and the lack of infrastructure. It is important to note that GDP per capita has not resulted in any meaningful health outcome improvements and this implies that economic growth in the area has not translated into widespread welfare improvement, probably because of structural disparities and inefficient resource allocation.

Conversely, government health spending and education are found to be important positive contributors to health and increases the argument that specific social investments are more efficient in promoting the well-being of the population, as opposed to increasing income. It is on these findings that the policy makers in the sub-region are advised to incorporate environmental sustainability in the mainstream development planning through imposing stiffer policies against deforestation, land utilization, and sustainable management of forest and marine resources. It is also necessary to enhance regional collaboration within the ECOWAS framework as there is cross-sectional interdependence of these economies. Besides that, more should be done in terms of investing in maternal and child health services especially those in the ecologically vulnerable and rural regions and the urban planning policies should focus on green infrastructure, sanitation and pollution management to reduce the health risks of the rapid urbanization.

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