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Research Article

Achieving and Sustaining the Green Economy and It Potential Benefit to the Economic Growth of Sierra Leone: Empirical Analysis

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Abstract

The study examines the possible advantages of establishing and maintaining a green economy in Sierra Leone, focusing on social progress, environmental sustainability, and economic growth. The research aims to provide a scientifically grounded and research-based understanding of the process of transitioning to a green economy and its effects on Sierra Leone's economic development by examining important sectors like aquaculture, fisheries, and agriculture. This empirical study looks at the relationship between fishing, aquaculture, and agriculture and Sierra Leone's economic growth from 1990 to 2018 using regression models and statistical analyses. The study looks at the relationships between green economic practices and economic growth using a number of techniques, including correlation, Granger causality, and unit root tests. According to the findings, Sierra Leone urgently needs a green economy because of its vulnerability to environmental degradation, climate change shocks, and macroeconomics issues. The study accentuates the possible advantages of agriculture, fishing, and aquaculture for economic expansion and upswing. It also emphasizes how important it is to adopt sustainable practices and green technologies to reduce the risks associated with climate change. The recognition of the links between green economic principles and Sierra Leone's economic growth has increased as a result of this study. To facilitate the shift to a green economy, the study suggests implementing economic and fiscal policy tools, stepping up current initiatives, and enforcing regulations. In addition, building a supportive investment climate, encouraging stakeholder engagement, and fostering institutional collaboration are essential to establishing and maintaining a green economy in Sierra Leone. The analysis examines the potential advantages of establishing and maintaining a green economy in Sierra Leone, focusing on social progress, environmental sustainability, and economic growth.

Keywords

Green Economy, Economic Growth, Sierra Leone, Aquaculture, Fishery, Agriculture, Climate Change, Environmental Sustainability, Empirical Analysis

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1. Introduction

The rapid deterioration of the environment and worsening climate situation have increased the necessity of relying upon new and unique policies like the Green Economic policies as effective environmental management tools. A green economy is characterized by resource efficiency, low carbon emissions, environmental preservation, and social inclusivity (ADB) It aims to shift away from traditional economic models that rely heavily on fossil fuels and unsustainable practices, towards a more sustainable and resilient economic system. By embracing green technologies, renewable energy sources, and sustainable agricultural practices, Sierra Leone can reduce its environmental footprint while promoting economic diversification and employment creation. Achieving and sustaining a green economy has become a global priority in recent years, as countries recognize the potential benefits it can bring to economic growth, environmental sustainability, and social well-being. The concept of a sustainable green economy has gained significant attention worldwide. As countries strive to address environmental challenges and promote sustainable development, the role of a green economy in fostering economic growth has become a subject of interest. This study aims to explore the potential benefits of a sustainable green economy to the economic growth of Sierra Leone through empirical analysis. Sierra Leone's economic development has been constrained by concurrent global and domestic shocks, and macroeconomic management remains weak. [6] The country faces macroeconomic management weaknesses, fiscal pressures, and debt sustainability risks, which need to be addressed to create an enabling environment for green investments and sustainable development. However, transitioning towards a green economy can help Sierra Leone address pressing environmental challenges such as deforestation, land degradation, and climate change. By adopting sustainable land management practices, promoting renewable energy sources, and protecting ecosystems, the country can preserve its natural resources for future generations.

2. Review of Literature of the Study

2.1. Theoretical Literature

Neoclassical growth theory is an economic theory that outlines how a steady economic growth rate results from a combination of three driving forces; labor, capital, and technology. The National Bureau of Economic Research names Robert Solow and Trevor Swan as having the credit of developing and introducing the model of long-run economic growth in 1956. The model first considered exogenous population increases to set the growth rate but, in 1957, Solow incorporated technology change into the model [7] The Model is an exogenous model of economic growth that analyzes changes in the level of output in an economy over time as a result of changes in the population growth rate, the savings rate, and the rate of technological progress [11].

Its main aim was to show that in the long run, an economy achieved sustainable growth [1]. The theory states that short-term equilibrium results from varying amounts of labor and capital in the production function. The theory also argues that technological change has a major influence on an economy, and economic growth cannot continue without technological advances [8].

Finally, [9] Solow – Swan model solved the two problems identified by the Harrod – Domar model - instability of the economy and the impossibility of full use of the labor by introducing the assumption of substitution of factors of production, which in turn remo1ved the assumption of a constant ratio of capital/production.

This growth theory posits that the accumulation of capital within an economy, and how people use that capital, is important for economic growth. [11] Further, the relationship between the capital and labor of an economy determines its output. Also, that the economy achieves equilibrium in the long run. In addition, they confirm the existence of convergence, which means faster development of poor countries in comparison with rich ones. Finally, technology is thought to augment labor productivity and increase the output capabilities of labor.

Therefore, the production function of neoclassical growth theory is used to measure the growth and equilibrium of an economy. That function is

$$Y = AF(K, L) \tag{1}$$

Where,

Y denotes an economy's gross domestic product (GDP)

K represents its share of capital

L describes the amount of unskilled labor in an economy

A represents a determinant level of technology

This function specifies that, for a given technology, only so much output (Y) can be produced for given employment levels of the inputs capital (K) and labor (L) (Mixon 2014).

2.2. Environmental Kuznets Curve (EKC)

The EKC concept emerged in the early 1990s with Grossman and Krueger‟s (1991) pathbreaking study of the potential impacts of NAFTA and Shafik and Bandyopadhyay‟s (1992) background study for the 1992 World Development Report. However, the idea that economic growth is necessary in order for environmental quality to be maintained or improved is an essential part of the sustainable development argument promulgated by the World Commission on Environment and Development (1987) in Our Common Future.

The Environmental Kuznets Curve (EKC) provides an analytical framework to examine how economies deal with environmental issues. It postulates an inverted-U relationship between pollution and economic development; at early stages of development, environmental quality deteriorates as per capita income increases, while at higher levels of development, environmental degradation is seen to decrease as per capita income increases further [3]. The green economy aims to achieve economic growth and development without an adverse effect on the environment. The EKC hypothesis can be used to understand the relationship between achieving and sustaining the green economy and its potential benefits to the economic growth of Sierra Leone. [2] Sierra Leone is committed to mainstreaming inclusive green economy in the feed Salone Agenda (2023-2030), which involves developing infrastructure, energy, and cities sustainably; managing renewable and nonrenewable natural resources efficiently; and building an inclusive and sustainable economy.

The EKC hypothesis suggests that as societies become wealthier, concerns shift from economic growth to environmental protection. Therefore, achieving and sustaining the green economy in Sierra Leone requires a targeted policy and attitudes to ensure that economic growth is compatible with an improving environment. The EKC hypothesis can be used to model sustainable non-renewable and renewable energy based on the EKC hypothesis for Africa's ten most popular tourist destinations.

2.3. Empirical Review of Literature

The world's fastest-growing good production system is aquaculture, which is also a major ocean-based economic activity sector that is anticipated to increase as a result of the EU's Blue Growth Initiative [10]. Very little study has been done in these fields. Purdue University, for instance, conducted study on the aquaculture industry's economic significance in Indiana in 2012. They gathered information in 2012 from a sample of Indiana aquaculturists, or fish farmers, and utilized it to evaluate the industry's total economic activity. According to the report, the aquaculture sector provides 280 employments, of which 169 are directly related to the sector and other supporting businesses. The industry produces $19,484,193 in added value in addition to $3,731,842 in labor income.

The aquaculture business generates production valued at $23,599,676; the overall value of its output, when combined with that of its supporting industries, is $37,892,895. For every $1.00 sold by the aquaculture sector, the local economy gains $0.61 more in production, and for every direct job created by the sector, there are 0.66 more jobs overall. This is according to the national audit report of (NAR-2022) there is an extra $0.62 rise in added value in the local economy for every $1.00 gain in added value from the aquaculture sector.

According to Jeo Lee et al [6] the economic effects of ocean acidification on shellfish fisheries and aquaculture in the United Kingdom were studied qualitatively and reveal that there is negative relationship between them. The purpose of their study was to calculate the possible financial impacts of ocean acidification on shellfish output in aquaculture and wild capture in the United Kingdom. By using the partial equilibrium (PE) and net present value (NPV) models, they calculated the direct and overall economic losses associated with the production of shellfish by the year 2100. According to their results, the UK economy is negatively impacted by the production of shellfish.

In his research on the Socio-Economic Impact of Aquaculture in Canada, Gardner Pinfold (2013) asserts that the aquaculture sector as a whole produced slightly more than $1.0 billion in GDP in Canada in 2010, with slightly more than $355 million coming from direct GDP and around $710 million from spin-off effects. With an overall employment effect of little over 14,000, the industry generated slightly over 5,800 direct full-time equivalent jobs. With a total revenue effect of over $618 million, it produced roughly $193 million in direct labor income. The demand for fish and fishery products has been rising over time, while fish output from catch fisheries has stalled around 88 to 90 million Tonnes, according to Ababouch's (2015) [5] essay on Fisheries and Aquaculture in the Context of Blue Economy. Since 1973, consumption has increased by over 100%. While the global population expanded at an average rate of 1.6 percent per year between 1970 and 2014, the continuously rising demand has been supplied by a robust increase in aquaculture output, estimated to have grown at an average annual growth rate of 8 percent. As a consequence, from 7% in 1970 to almost 50% in 2014, the average yearly contribution of edible fish from aquaculture for human consumption has grown seven times.

It is anticipated that this trend will continue, with aquaculture's share of the fish food supply reaching 65% by 2030. However, aquaculture's development has been unequal, with Asia accounting for about 90% of world production while Africa, which has significant potential, produces less than 2%, with tilapia grown in Egypt accounting for half of that amount. She also demonstrated how one of the most traded food commodities is fish and seafood. In different forms and formats, almost 38% of global output is traded internationally, with a value of US$ 145 billion in 2014 compared to just $8 billion in 1976. More than half of this commerce comes from developing nations, whose net trade revenue (export-import) exceeded the net trade income of all other agricultural commodities combined in 2014, totaling US$ 39 billion.

In their paper The Economic Impact of the Blue Economy, [8] provided a convincing overview of aquaculture in Europe in 2017. They claim that Europe produced over 1,182 million tonnes of aquaculture, valued at 3.7 million euros, placing the industry in tenth place globally. The nations around the Mediterranean and Black Seas accounted for the majority of this output, contributing significantly: Italy (43.6%), Greece (62.2%), Romania (69.5%), Bulgaria (54.9%), Malta (81.6%), Slovenia, and Cyprus (78.7%). These nations' GDPs have surely increased as a result of this.

Also, Huang & Leung [7] conclude in their article Understanding and measuring the contribution of fisheries and aquaculture to gross domestic product (GDP) in Italy that aquaculture generates USD 111 million in indirect GDP and USD 250 million in direct GDP through its direct GVA.

The evaluated literatures show mixed results. This indicates that fisheries have a beneficial effect on GDP, although Jeo Lee et al. [6] claim that the UK economy is negatively impacted by shellfish output. Most intriguingly, there are both qualitative and quantitative works in the literature. Time series analysis was only used in one quantitative study, however [9]. Due to the difficulty of conducting in-depth interpretation and analysis, the results have been inconsistent. The analysis of the prior research on aquaculture and economic growth that is currently accessible demonstrates a positive correlation between the two. However, these studies are unique in that they were conducted completely outside of Sierra Leone and used a descriptive approach for data analysis.

Fisheries and aquaculture are important sources of food and livelihoods for people along the world's seashores and waterways, and they influence the livelihoods of more than one billion people. However, the production practices of these industries can lead to environmental degradation if they are not sustainable. [11] Achieving and sustaining a green economy in fisheries and aquaculture can have a positive impact on the economy and the environment. The potential for green growth in fisheries and aquaculture can be enhanced through the supply chain, and policies that address different challenges and opportunities can be implemented WHO Development green growth. A systematic review on the application of general equilibrium and input-output methods showed that sustainable fisheries models can have positive economic, social, and environmental impacts. Sustainable fishing practices are necessary to ensure that populations of ocean and freshwater wildlife remain for the future. The State of World Fisheries and Aquaculture 2020 report by the Food and Agriculture Organization of the United Nations highlights the importance of sustainability in fisheries and aqua Fisheries have a significant impact on the economy, and several studies have been conducted to analyze this impact.
A Systematic Review on the Application of General Equilibrium and Input-Output Methods, the paper provides a systematic literature review on the impact of fisheries on the economy and the application of the computable general equilibrium [12] and input-output methods. The authors reviewed several studies that used these methods to analyze the impact of fisheries on the economy. They found that fisheries have a significant impact on the economy, and the impact varies depending on the region and the type of fishery. The authors also found that the CGE and input-output methods are useful tools for analyzing the impact of fisheries on the economy.
The studied the effects and paths of regional industrial structure transformation on marine fishery economic growth: [5] this study analyzed the impact of industrial structure adjustment on fishery economic growth. The authors used stochastic frontier, mixed data, shift share analysis, and panel threshold models to empirically analyze the impact of industrial structure adjustment on fishery economic growth. They found that this adjustment is important for marine fishery's economic growth and an important way to promote the fishery economy's transformative development. The authors also found that the current fishery industry's economic growth mainly depends on the primary industry, whereas the contribution of secondary and tertiary industries is not high. This industrial structure may not be conducive to the fishery economy's growth and the improvement of the industry's technical efficiency and international competitiveness. Commercial fisheries & local economies: This study provides empirical evidence demonstrating that commercial fisheries contribute to local economies. The authors found that commercially exploited fish stocks have positive effects on local economies, including increased employment, income, and tax revenue. The authors also found that the positive effects of commercial fisheries on local economies are more significant in rural areas than in urban areas. Does fish production influence the GDP and food security? Evidence from Nigeria: This study investigates the model of the long-run connection between marine fish production, economic growth, and food security. The study applies an annual time series data from 1981 to 2017 and uses the autoregressive distributed lag (ARDL) model to estimate the long-run relationship between fish production, GDP, and food security. The authors found that fish production has a significant positive impact on GDP and food security in Nigeria [12].

Bio-economic indicators of fisheries: impact of variations in fish price dynamics: This study addresses the factors affecting fish price dynamics and examines their drivers as prices often dictate target fisheries. The authors found that variations in fish price dynamics have a significant impact on the bio-economic indicators of fisheries. The authors also found that the drivers of fish price dynamics are complex and include factors such as supply and demand, market structure, and government policies. [6]

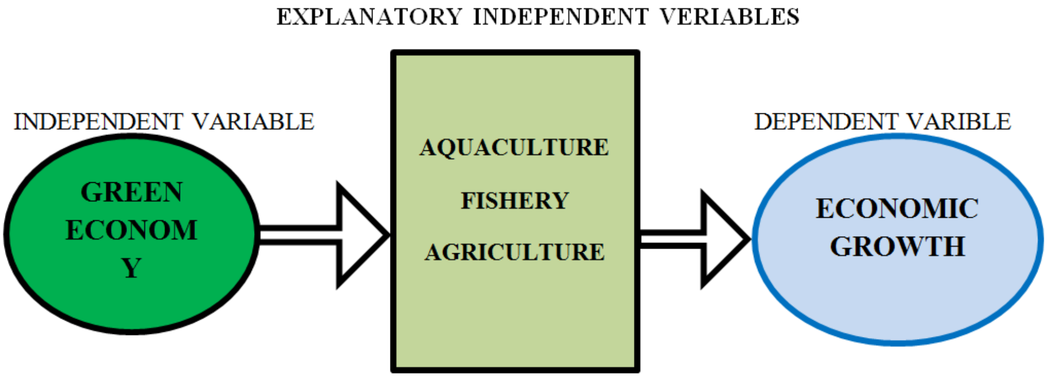
Fisheries have a significant impact on the economy, and several studies have been conducted to analyze this impact. These studies have used different methods and models to analyze the impact of fisheries on the economy, and they have found that fisheries have a positive impact on the economy. The impact varies depending on the region, the type of fishery, and other factors such as industrial structure and fish price dynamics.

Agriculture, as the backbone of many developing economies, plays a central role in the pursuit of a green economy by ensuring sustainable food production, preserving natural resources, and supporting economic growth. Sierra Leone, an agrarian nation with significant agricultural potential, can benefit greatly from sustainable agricultural practices. [4]
A dynamic panel data analysis with a Case Study of Pakistan, [11] the study aimed to measure the impact of agriculture

sector productivity on economic growth in Pakistan during the period 1972-2012. The authors used empirical evidence to support the role of private and public resource allocation to agriculture and infrastructure development. They found that agriculture is an important factor for economic growth, like an engine for economic development. The study suggested that trade openness impact is positive and favorable on GDP per capita. [12] Agriculture and development, the literature review discusses the role played by agriculture in the development process and the interactions between agriculture and other economic sectors. The authors also found that agriculture contributes to both income growth and poverty reduction in developing countries by generating income and employment in rural areas and providing food security. The review also highlights the need for investment in agricultural research and development to improve productivity and sustainability. Unraveling the links between agriculture and economic growth: a panel time series approach for post-WW II Africa [8]: This study explored the interaction between agricultural development and economic growth for 52 African countries in the period 1961-2010. The authors used a panel time series approach to analyze the relationship between agriculture and economic growth. They found that growth in agricultural productivity causes significant aggregate effects and will therefore also influence the general economic growth within a country. The study also found that agricultural modernization has an impact on the long-run economic growth.

2.4. Conceptual Framework

The study will focus on Sierra Leone's Gross Domestic Product (GDP) as a representative indicator of the output generated by key green economy sectors, including Aquaculture, fishery and agriculture. [5] The research framework encompasses three exogenous variables, namely Aquaculture, fishery and agriculture, which are integral components of the green economy and are expected to contribute significantly to the economic development of Sierra Leone. The study will employ Sierra Leone's GDP as the endogenous variable, serving as a reliable measure of the country's overall economic performance and growth. The research aims to contribute to policy development and aiding in informed decision-making and strategies aimed at fostering a sustainable and prosperous future for Sierra Leone. The study will address the research gaps in past studies on the impact of forestry, fisheries and agriculture in achieving and sustaining the green economy and its potential benefits to the economic growth of Sierra Leone, including limited local context, interdisciplinary research, social and equity aspects, policy and implementation, and long-term impact assessment.



Source: Author’s construction

Figure 1. *Showing the conceptual framework.*

3. Research Methodology

3.1. Specification of the Regression Model

The theoretical foundation for modeling the economic growth is derived from the neo-classical growth theory as reviewed in the literature. In this theory, the production function is used as a measure of growth and equilibrium of an economy. The function is specified as;

$$Y = f(AK, L) \tag{2}$$

Where, Y denotes an economy's Gross Domestic Product (GDP); K represents its share of capital, L describes the amount of unskilled labor in an economy and A represents a determinant level of technology. If we assume that the technology is determined by Aquaculture, Fishery and Agriculture then;

$$A = f(A, F, \text{and } Ag) \tag{3}$$

Where A represents Aquaculture, F is fishery and Ag for agriculture;

Substituting (2) into (3) yields;

$$Y = f(A, F, Ag, K, L) \quad (4)$$

Expressing the functional form of the model in mathematical form gives;

$$Y_{it} = \beta_0 + \beta_1 Ag_{it} + \beta_2 Aqit + \beta_3 F_{it} + \varepsilon_{it} \quad (5)$$

Taking logarithm on both sides of the model yield;

$$InY_t = \beta_0 + \beta_1 InA_t + \beta_2 InF_t + \beta_3 InAg_t + \beta_4 InK_t + \beta_5 InL_t + \varepsilon_t \quad (6)$$

3.2. Estimation Procedures

This section of this research work follows the following methods as seen below in order to achieve the objectives of this paper.

3.2.1. Unit Root Test

The stationary of the variables used in the study is tested at this step of the estimate process. The Augmented Dickey-Fuller (ADF) unit root test, proposed by Dickey & Fuller (1981), aids in determining the sequence of integration of the data series. This test is used to determine the variables in the study's long-term characteristics. The time series' variance, mean, and covariance remain constant across time if they are determined to be stationary. This indicates that the analysis's findings are trustworthy and can be utilized to forecast the economy's future economic activity.

The following models are used to administer the ADF test.

$$\Delta y_t = \alpha_1 y_{t-1} + \sum_{n=1} \alpha\alpha\Delta y;\ + e_t \quad (7)$$

$$\Delta y_t = \alpha_1 y_{t-1} + \sum_{n=1} \alpha\alpha\Delta y;\ + \delta_t + e_t \quad (8)$$

Where Y is a data series, t denotes a linear time trend, et is a stochastic variable, n is the ideal number of delays in the development variable, Δ is the first difference operator, and α0 is a constant. The series has one unit root and is of integrated order one if the ADF result rejects the test in the first difference but fails to reject the test in the levels. It also suggests that the series has two unit roots and is of integrated order two if the test fails to reject the test in levels and at first difference but rejects it in second differences.

$$\lambda\ \text{trace}(r) = -T \sum_{i=r+1}^{n} In(1 - \lambda_t) \quad (9)$$

3.2.2. Vector Error Correction Model (VECM)

If the Cointegration test findings shown evidence of a long-term link between the variables, then this phase of the estimating process is feasible. The Cointegration equation and short run dynamics between the series are investigated using the traditional vector error correction model (VECM). When the series fails to Cointegrate, the short run model is used as the next estimation technique since the term "error correction term" is estimated for the coefficients. The link between the data series' long-term equilibrium relationship and short-term dynamics is explained by the idea of VECM. Since VECM is used to rectify transient short-term deviations of series from the long-term equilibrium relationship, its application is essential.

The VECM model is displayed as follows:

$$[\Delta X]t + a_2\ U\ (t\text{-}1) = a_0 + a_1 + t \quad (10)$$

Where a_1 and a_2 are $Y_t = Y_t\text{-}Y\ (t\text{-}1)$ represent the dynamic adjustment coefficients of the variables. The random error term is represented by ε_t, and the residual lag, or Ut-1, is the short run departure from the equilibrium position that is predicted to be corrected for the long run equilibrium error.

The fact that the study included several explanatory variables supported the choice to use VECM, which is based on ordinary least square (OLS). Therefore, the procedure must be used in the research. Below is an illustration of the model.

ΔInY_t=β_0+(β_1 ΔInOT)_(t-1)+(β_2 ΔInF)_(t-1)+(β_3 ΔInA)_(t-1)+(β_4 ΔInAg)_(t-1)+(β_5 ΔInK)_(t-1)+(β_6 ΔInL)_(t-1)+ECM_(t-1)+U_(t) (11)

Where ΔL denotes the variation in the variable's natural logarithm; for example, ΔInY_t denotes a change in the total domestic output, the error term of the long run equilibrium error is Ut, the error correction model is ECM, the constant term is β0, and the parameters of the explanatory variables are βi's. After confirming the long-run equilibrium connection, the vector error correction model approach is calculated to explore the dynamic behavior of the study's pertinent variables.

3.2.3. Granger Causality Examination

In the third step of the estimating process, the Granger causality test, developed by Engle & Granger (1989), is used to investigate the causal relationship between unemployment and economic growth. Its main goal was to ascertain the type of link that existed between the two variables—that is, if there was any causation between them or if the relationship was only unidirectional, bidirectional, or feedback.

Thus, the model is specified as:

$$InY_t = \beta_0 + \sum \beta_{1t} InOT_{t-1} + \sum \beta_{2t} InF_{t-1} + \sum \beta_{3t} InA_{t-1} + \sum \beta_4 InAg_{t-1} + \sum \beta_5 InK_{t-1} + \sum \beta_6 InL_{t-1} + \varepsilon_{1t} \quad (12)$$

$$InOT_t = \beta_0 + \sum \beta_{1t} InY_{t-1} + \sum \beta_{2t} InF_{t-1} + \sum \beta_{3t} InA_{t-1} + \sum \beta_4 InAg_{t-1} + \sum \beta_5 InK_{t-1} + \sum \beta_6 InL_{t-1} + \varepsilon_{1t} \quad (13)$$

Where ε_t the error term, t is the current and t-1 is the lag period.

3.3. Diagnostic Testing

To ensure the robustness, functionality, and sustainability of the mathematical model, diagnostic testing will be conducted. These tests include serial correlation (LM test), Ramsey's RESET Test, and Heteroscedasticity (ARCH Test).

3.4. Source of Data

This study will use time series data ranging from 1990-2020 which includes the targeted variable of interest the dependent variable the Gross domestic Product, and the independent variable green economy and the explanatory independent variables Agriculture, Fishery and Agriculture. The study draws upon a rich dataset sourced from reputable sources such as the World Development Indicators and the World Bank Open Data platform. These datasets offer a detail repository of economic and environmental indicators, ensuring the robustness and reliability of the analysis conducted.

The preliminary analysis reveals significant trends in both GDP and green economy indicators, with notable fluctuations observed over the study period. Correlation tests indicate a positive relationship between certain aspects of the green economy and GDP, suggesting a potential synergistic effect on economic growth. Unit root tests confirm the stationary of the time series data, validating the subsequent analyses.

4. Results and Discussions

This section presents the findings of the study. Its division is split into six components. The preliminary assessment comprised of the statistical data that is descriptive. The second analysis is the correlation test. The third technique for analysis is the unit root test. Ultimately, the results of the tests and diagnostic tests have been touched, respectively. The fourth analysis is the estimation of the Granger causality test.

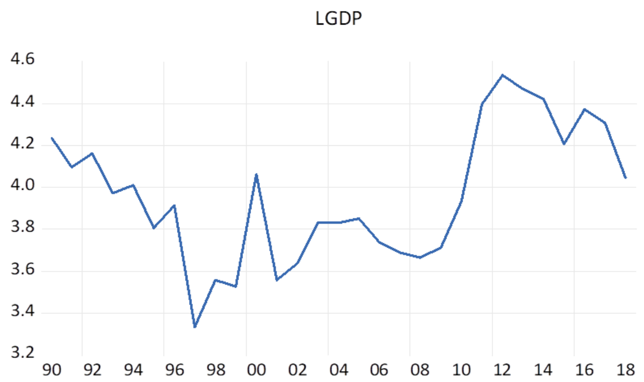


Figure 2. *Log of Gross Domestic Product.*

The distribution of the study's variables is shown in this part of the paper. It provides an explanation of the characteristics that define the variables. The mean, for instance, to shows the series' average value, log of gross Domestic Product, Aquaculture production, fishery and Agriculture in detail description.

The gross domestic product (GDP) of Sierra Leone has experienced various fluctuations from 1990 to 2018. According to the World Bank, the GDP growth rate has been quite volatile, with both positive and negative growth rates in different years. The GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included. The GDP in Sierra Leone was estimated to be $4.000 billion US dollars at the end of 2019, and $4 billion US dollars at the end of 2022, with an average annual growth rate of 2.5% in the last four years. In 2018, the GDP per capita was estimated to be USD 515.9, and the GDP composition by sector was agriculture 60.3%, industry 5.2%, and services 32.4%.

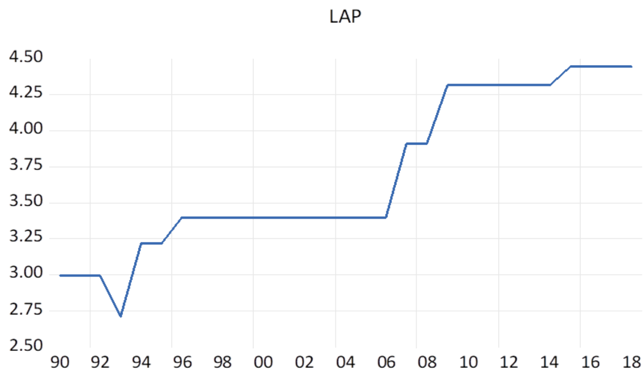


Figure 3. *Log of Aquaculture production.*

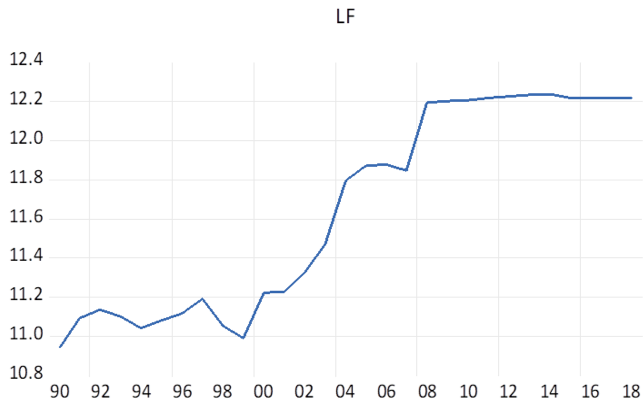


Figure 4. *Log of Labour force.*

Aquaculture production in Sierra Leone has grown over the years, providing fresh fish to a significant portion of the population. The country has diverse aquaculture production systems, and the integration of fish and rice farming has the potential to further boost production. However, the pace of development has been slow, and efforts to improve and expand aquaculture production are essential to meet the growing demand for fish in the country.

Fisheries in Sierra Leone have faced various challenges and opportunities from 1990-2018. The country's total fish production from marine waters was estimated at about 83,000 Tonnes, with aquaculture providing fresh fish to a significant number of people.

The management of fisheries in Sierra Leone has been challenging, especially in data-deficient situations, and the country has been described as a failed state for fishing. Despite these challenges, various organizations have provided interventions and support for aquaculture development and production in the country.

Agriculture has been an important sector in Sierra Leone's economy, providing employment and sustenance for the majority of the population. However, the sector has faced challenges such as low technology and input use, as well as the pressure on land and ecosystems due to unsustainable practices. Efforts to improve and modernize agriculture in the country are essential to ensure future growth and food security.

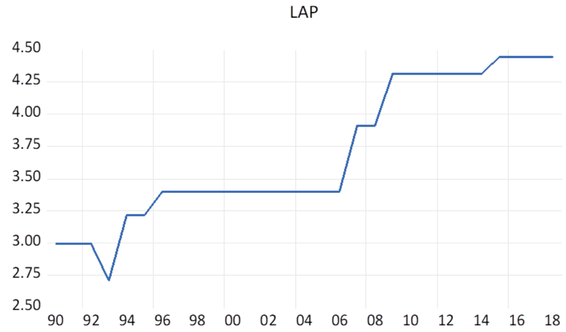


Figure 5. *Log of Agriculture.*

The descriptive statistics for the variables that used to conduct inquiry as shown in Table 1. It gives a measure of central tendency (mean) and a measure of variance (standard deviation) in addition to the variables and the lowest and highest values. The variables that are being examined have values ranging from 2.71 to 22.3 at their lowest and maximum, respectively. The values are correlated with the production of aquaculture. These characteristics also had the highest and lowest averages in this analysis.

Table 1. *Descriptive summary statistics.*

Variables	Obs.	Mean	Median	Std. Dev.	Minimum	Maximum
Gross domestic product	29	3.959549	3.931826	0.318445	3.332205	4.532599
Aquaculture production	29	3.691233	3.401197	0.550927	2.708050	4.442651
Fishery production	29	11.64728	11.79411	0.518797	10.94299	12.23831
Agriculture	29	3.901416	3.931826	0.155375	3.583519	4.110874

Source: Author 2023

4.1. Test of Correlation

Administering a correlation analysis, the degree and direction of the relationship between two variables was determined. Accordingly, table 2 demonstrates that the log of aquaculture production have a substantial positive connection of 0.98 and 0.92, respectively, with respect to fishing. Furthermore, there is a 0.96 significant positive association with fishing. This suggests that there's a high chance the model won't achieve first-degree serial correlation if the variable are put into a single equation and run.

Table 2. *Correlations output.*

Variables	Gross Domestic product	Agriculture production	Aquiculture production	Fishery production
Gross DomesticProduction	1			
Agriculture	-0.05	1		
Aquacultureproduction	0.44	0.69	1	
Fisheryproduction	0.52	0.50	0.92	1

Author 2023

4.2. Root Unit Test

The unit root test was conducted using the PP (Phillips-Perron) and ADF (Augmented Dickey-Fuller) criteria. At first difference, every variable seemed to be stationary. This validates the Granger Causality Test's application in this investigation. Table 3 below displays the results of the Unit Root Test.

Table 3. *Root of Unit Test.*

Augmented Dickey Fuller Test

Variables	Level		First difference		Order of Integration
	Constant	Constant & Linear Trend	Constant	Constant & Linear Trend	
Log of Gross Domestic Product	-0.75	-2.39	-4.356***	-4.273**	I(1)
Log of Aquaculture Production	-0.69	-2.52	-6.837***	-6.697***	I(1)
Log of Fisheries	-0.84	-1.35	-4.776***	-4.677***	I(1)
Log of Agricultural Output	-2.68	-3.45	-5.155***	-4.722***	I(1)
PHILLIPS - PERRON TEST					
Log of Gross Domestic Product	-2.15	-2.506	-6.525***	-6.472***	I(1)
Log of Aquaculture Production	-0.624	-2.484	-6.700***	-6.571***	I(1)
Log of Fisheries	-0.857	-1.464	-4.778***	-4.68***	I(1)
Log of Agricultural Output	-1.581	-2.196	-4.434***	-4.315**	I(1)

Note: ***1% level of significance ** 5% level of significance

4.3. Granger Causality Test Estimation

4.3.1. Maximum Lag Length Determination Standards

Selecting the variables' maximum lag order is a prerequisite for using the Granger Causality Test method, which comes after determining if the variables are stationary. Using the Akaike Information Criterion, the maximum lag length was chosen. Due to its greater power characteristic over the other criteria, this is derived from the unconstrained VAR. Therefore, two is the maximum VAR length. The maximum VAR length determined by the Akaike Information Criterion (AIC) is shown in table 4 below.

Table 4.*VAR Lag Oder Selection Criteria.*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	16.27144	NA	2.99e-07	-0.834921	-0.594952	-0.763566
1	113.1990	150.7763*	1.50e-09	-6.162891	-4.723073*	-5.734758
2	144.0902	36.61174	1.20e-09*	-6.599273*	-3.959606	-5.814362*

Source: Computed by the Researcher * indicates lag order selected by the criterion

4.3.2. Test of Johansen Cointegration

The next stage was to determine whether there was any long-term trend between the Green Economy factors and economic development once it was established that all of the series were integrated of the same order I (1). For each set of variables employed, the maximum likelihood testing techniques for Johansen (1988) and Johansen and Juselius (1990) on the number of co-integrating vectors include testing procedures for linear limits on the co-integrating parameters. Maximum Eigen value test statistics are employed.

In accordance to the studies, the probability value of 0.0102, as indicated in Table 5, led to the rejection of the null hypothesis that there was no co-integrating equation at 5%. This suggests that there is at least one long-term or co-integration relationship between green economic growth and various factors.

Table 5. *Unrestricted Cointegration Rank Test (Maximum Eigenvalue).*

Hypothesized			**Max-Eigen**	**0.05**
No. of CE(s)	**Eigenvalue**	**Statistics**	**Critical Value**	**Prob.****
None*	0.0102	0.766874	39.31673	33.87687
At most 1	0.573841	23.02944	27.58434	0.1722
At most 2	0.325060	10.61455	21.13162	0.6856
At most 3	0.228411	7.001179	14.26460	0.4890
At most 4	0.052775	1.463893	3.841466	0.2263

Max-eigenvalue test indicate 1 Cointegration eqn(s) at 0.05 level
*denotes rejection of hypothesis is at the 0.05 level
**Mackinnon-Haug-Michelis (1999) p-values

4.3.3. Causality Test Granger

An econometric test called Granger causality is used to confirm if one variable may accurately predict another. If a variable helps predict another variable, it is said to Granger-cause the other variable; if it does not assist forecast the other variable, it is said to fail to Granger-cause the other variable. The Granger Causality Test is displayed in Table 6 below.

Table 6. *Granger Causality Test.*

Null Hypothesis	**Obs**	**F. stat**	**Prob.**	**Conclusion**
Aquaculture Production does not Granger Cause Gross Domestic Product	28	3.719	0.065	Accepted
Gross Domestic Product does not Granger Cause Aquaculture		0.411	0.527	Rejected
Fisheries does not Granger Cause Gross Domestic Product	28	3.719	0.086	Accepted
Gross Domestic Product does not Granger Cause Fisheries		2.350	0.138	Rejected
Agriculture does not Granger Cause Gross Domestic Product	28	1.174	0.289	Rejected Re
Gross Domestic Product does not Granger Cause Agriculture		0.288	0.597	jected

Source: Computed by researcher 2023 P value > 0.01 1% level of significance P value > 0.05, 5% level of significance P value > 0.1 10% level of significance.
Source: Computed by researcher 2023

4.3.4. Regression Analysis

This study seeks to explore the achieving and sustaining the green economy and it potential benefit to the economic growth of Sierra Leone, therefore the regression model is fitted as:

$$Y_{it} = \beta_0 + \beta_1 Ag_{it} + \beta_2 Apit + \beta_3 F_{it} + \varepsilon_{it} \quad (14)$$

Where β_0 represents the constant, $\beta_1, \beta_2 and \beta_3$ are the coefficients of Agriculture, Aquaculture and fishery respectively and μ_t is the error term of the model.

Table 7. Regression analysis outcomes.

VARIABLES	COEFFICIENT	STD. ERROR	T-STATISTICS	PROB
LAgit	-1.39668	0.435104	-3.209962	0.0036
LApit	0.512517	0.234989	2.181024	0.0388
LFit	0.016609	0.216919	0.076567	0.9396
C	7.323267	2.554022	2.8667347	0.0083
R-squared	0.438544	Mean dependent		3.9595549
Adjusted R-squared	0.371169	S.D dependent var.		0.318445
S.E of Regression	0.252523	Akaika info. Criterion		0.212812
Sum. Of squared R.	1.5941222	Schwarz criterion		0.401405
Log of livelihood	0.914222	Hannan-Quinn criterion		0.271877
F-Statistics	6.509024	Durbin-Watson Stata		1.14 1845
Pro.(Statistics)	0.002091			

Source: Computed by researcher 2023

$$GDP_{it} = 7.323267 - 1.396668\mathrm{Ag}_{it} + 0.512517\mathrm{Apit} + 0.016609\mathrm{F}_{it} \quad (15)$$

The results from table 7 reveal that all the independent variables (Agriculture and Aquaculture) used in this model are statistically significant at 5% since their p-values are less than 5% (0.05), while Fishery Is not significant because the p-value of 0.93. This simply implies that the results show 95% confidence that the coefficients for these independent variables (Agriculture and Aquaculture) are significantly different from zero and thus have a significant influence on the dependent variable (GDP). The R-squared value for this model is 0.438 and this implies that the independent variables account for about 43.8% of variations in the Gross domestic product (GDP). The p-value of F-statistics (0.002) indicates that the entire model is not statistically significant at 5% level. The Durbin Watson statistic value (1.1418) which is approximately two thus indicates that there is first-order serial correlation, and the model is slightly positively skewed. The contribution of agriculture, aquaculture, and fisheries to the gross domestic product (GDP) is considered one of the most widely used indicators of economic performance in an economy. Agriculture is significant for economic growth, but there is an indirect relationship. In other words, an increase in agriculture will lead to an increase in economic productivity. Aquaculture has a direct relationship with gross domestic product (GDP), meaning that a 1% increase in aquaculture will lead to a 1.25% increase in GDP. The study has also shown a direct relationship between fishery production and GDP, indicating that an increase in fishery production will lead to a considerable increase in GDP. Fish production's influence on GDP and food security in the economy: fish exports can significantly impact GDP and are a significant contributor to a country's economic growth through generating income from trade balance.

4.4. Diagnostic Test

Table 8. Showing results of Diagnostics Test.

Residual Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistics	3.449898	Prob. F(1,23)	0.0761
Obs*R-squared	3.782511	Prob. Chi-Squared(1)	0.0518

Normality Test			
Jarque-Bera	0.800752	Probability	0.670068
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	1.016848	Prob. F(4,24)	0.4185
Obs*R-squared	4.202540	Prob. Chi-Squared (4)	0.3793
Heteroscedasticity Test: ARCH			
F-statistics	0.807651	Prob. F(1,26)	0.3771
Obs*R-squared	0.843573	Prob. Chi-Squared (1)	0.3584
Stability Test			
Ramsey RESET Test			
	Value	**Df**	**Probability**
t-statistics	1.730985	23	0.0969
F-statistics	2.996308	(1,23)	0.0969

Source: Computed by the researcher Note: Significant level at 1, 5 and 10%
Critical level at 1, 5, and 10%, please take note

The Breusch-Godfrey Serial Correlation LM Test, a diagnostic tool, indicated that there is no second-degree autocorrelation based on Table 7. Also, as indicated by the ARCH statistics and Breusch-Pagan-Godfrey, there is no autoregressive conditional heteroscedasticity. Additionally, the Jarque-Bera test for normalcy reveals that the error term is regularly distributed at the five percent level, and the Ramsey RESET test reveals that there is no functional misspecification in the model. It shows how the assumptions of ordinary least squares are accurate.

5. Conclusion

This study investigates and primarily focuses on the imperative need for Sierra Leone to transition to a green economy as a strategic response to environmental degradation and the global climate change crisis. The introduction establishes the urgency and defines a green economy as one characterized by resource efficiency, low carbon emissions, environmental preservation, and social inclusivity. The study emphasizes the advantages of adopting sustainable practices, renewable energy, and green technologies, including how they can lessen their negative effects on the environment, diversify the economy, and generate jobs. Fiscal strains, risks associated with debt sustainability, and macroeconomic weaknesses are some of the obstacles Sierra Leone must overcome to advance its economy. On the other hand, the shift to a green economy is viewed as a response to environmental problems like climate change and deforestation. A green economy can promote creativity and competitiveness while boosting economic growth, jobs, investments, and poverty reduction. Several reviews of the literature on the green economy are included in the study, with an emphasis on how it might help Sierra Leone's economy grow.

Investigating green growth strategies, the role of technology and legislative measures, and alternative theories such as ecological economics, it focus attention on the interdependence of the economy and the environment. Information on the regression model, definitions of terms, assumptions, scope, estimation procedure, and diagnostic tests are all included in the study's methodology. Six components make up Chapter Four's analysis and interpretation of the findings. Descriptive statistics, Granger causality testing, unit root testing, and correlation testing, regression analysis geared towards addressing the research objectives and questions are all covered. The results make provision and dispense scientific information about how implementing a green economy may affect Sierra Leone's economic expansion and growth.

6. Recommendation

Agriculture:

1) Key Challenges: Over-reliance on traditional and rain-fed farming, indiscriminate land clearing, and excessive use of inorganic fertilizers
2) Recommended Policies: Intensification of organic ferti-

lizer use, expansion of irrigable areas, promotion of high-yield crop varieties, and enhancement of post-harvesting technologies.

3) Socio-economic Benefits: Increased long-term employment, improved nutrition, enhanced health, higher school enrolment, reduced poverty, increased income, and strong economic development.
4) Environmental Benefits: Improved soil quality, enhanced soil biodiversity, reduced greenhouse gas emissions, and decline in soil erosion.

Forestry:

Key Challenges: Ecological destruction, high rates of deforestation, and reduced carbon sink capacity.

1) Recommended Policies: Sustainable forest management (SFM) and forest expansion.
2) Socio-economic Benefits: Increased short and long-term forestry employment, higher revenue from forest resources, and improved health of forest communities.
3) Environmental Benefits: Decreased deforestation rates, expanded forest cover, increased carbon sinks, improved soil quality, and enhanced water availability.

Aquaculture:

1) Key Challenges: Ensuring sustainability and minimizing environmental impacts.
2) Recommended Policies: Promoting sustainable and responsible aquaculture practices through policy implementation and supporting research and development in the country.
3) Socio-economic Benefits: Aligned with Sustainable Development Goals (SDGs) on poverty alleviation and food security, creation of employment opportunities, and reduced carbon footprint compared to other protein sources.

Priority Actions and Practical Roadmap:

1) Aquaculture: Invest in research and development, implement policies promoting sustainable aquaculture, and support fish processing and marketing facilities.
2) Agriculture: Promote large-scale adoption of organic farming, scientific irrigation, value addition, sustainable agriculture research, and green finance.
3) Forestry: Implement and scale up Sustainable Forest Management (SFM) programs, invest in research and capacity development, and develop fiscal policies for SFM.

Author Contributions

Emmanuel Bongay: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft

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Conflicts of Interest

The authors declare no conflicts of interest.

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