THE ROLE OF THE GREEN ECONOMY IN IMPROVING RESOURCE ALLOCATION EFFICIENCY AND ACHIEVING INCLUSIVE GROWTH IN DEVELOPING COUNTRIES: THE CASE OF IRAQ, 2005–2024

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Abstract. The objective of this research is to examine the role of the green economy in improving resource allocation efficiency and promoting inclusive economic development in developing countries, with Iraq examined as a case study during the period 2005–2024. The research uses both descriptive-analytical and econometric methods. Unit root tests were performed to examine the stationarity properties of the time series before multiple linear regression models were estimated using the Ordinary Least Squares (OLS) technique.

The analysis revealed a strong negative and statistically significant relationship between carbon intensity and resource efficiency, while renewable electricity generation did not show a statistically significant relationship with resource efficiency. GDP was positively associated with both resource efficiency and the Human Development Index (HDI). In the HDI model, renewable electricity generation showed a negative statistically significant association, while carbon intensity showed a positive statistically significant association. These findings should be interpreted cautiously in the context of Iraq's oil-dependent economic structure and should not be regarded as evidence of causal relationships. Trade openness did not show a statistically significant relationship with HDI.

The study recommends increasing investment in renewable energy, improving energy efficiency, diversifying sources of income, strengthening governance and anti-corruption measures, and developing a national green economy strategy aligned with the Sustainable Development Goals for 2030.

Keywords: green economy; resource allocation efficiency; inclusive growth; renewable energy; carbon intensity; developing countries; Iraq.

РОЛЬ ЗЕЛЁНОЙ ЭКОНОМИКИ В ПОВЫШЕНИИ ЭФФЕКТИВНОСТИ РАСПРЕДЕЛЕНИЯ РЕСУРСОВ И ДОСТИЖЕНИИ ИНКЛЮЗИВНОГО РОСТА В РАЗВИВАЮЩИХСЯ СТРАНАХ: НА ПРИМЕРЕ ИРАКА, 2005–2024 ГГ.

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Аннотация. Цель данного исследования заключается в изучении роли зелёной экономики в повышении эффективности распределения ресурсов и содействии инклюзивному экономическому развитию в развивающихся странах на примере Ирака в период 2005–2024 гг. В исследовании применяются описательно-аналитический и эконометрический методы. Для проверки стационарности временных рядов были проведены тесты на единичный корень, после чего с использованием метода наименьших квадратов (OLS) были оценены модели множественной линейной регрессии.

Анализ выявил сильную отрицательную и статистически значимую связь между углеродоёмкостью и эффективностью использования ресурсов, тогда как доля возобновляемой электроэнергии не показала статистически значимой связи с эффективностью использования ресурсов. ВВП имел положительную связь как с эффективностью использования ресурсов, так и с Индексом человеческого развития (HDI). В модели HDI доля возобновляемой электроэнергии показала отрицательную статистически значимую связь, тогда как углеродоёмкость — положительную статистически значимую связь. Эти результаты следует интерпретировать с осторожностью с учётом нефтезависимой структуры экономики Ирака и не рассматривать их как доказательство причинно-следственных связей. Открытость торговли не показала статистически значимой связи с HDI.

В исследовании рекомендуется увеличивать инвестиции в возобновляемые источники энергии, повышать энергоэффективность, диверсифицировать источники доходов, укреплять систему государственного управления и меры по борьбе с коррупцией, а также разработать национальную стратегию зелёной экономики, согласованную с Целями устойчивого развития до 2030 года.

Ключевые слова: зелёная экономика; эффективность распределения ресурсов; инклюзивный рост; возобновляемая энергия; углеродоёмкость; развивающиеся страны; Ирак.

Introduction

The world is undergoing a fundamental change in the way economic development models are viewed. This change is driven by increasing awareness of environmental limits and of the consequences of conventional patterns of economic growth. The traditional development model, which relies heavily on natural resources while giving insufficient attention to environmental and social impacts, has proved inadequate for achieving sustainable and inclusive development. This is particularly important for developing countries, many of which face institutional weaknesses, infrastructure limitations, poverty, unemployment, and difficulties in managing natural resources efficiently.

The concept of the green economy is increasingly viewed as an economic approach designed to balance three major dimensions: economic growth, social justice, and environmental protection. The green economy focuses on the efficient use and conservation of resources, waste reduction, and the transition toward more sustainable patterns of production and consumption. It can also contribute to job creation, poverty reduction, and a more equitable distribution of the benefits of development.

International organizations, particularly the United Nations Environment Programme (UNEP), have increasingly emphasized the contribution of the green economy to achieving the Sustainable Development Goals (SDGs). This is especially important for developing countries that possess natural resources that could support a transition toward more sustainable development.

According to *The Sustainable Development Goals Report 2025*, only 35 percent of SDG targets with available trend data are on track or showing moderate progress, highlighting the need for more inclusive and environmentally sustainable development models (United Nations, 2025).

Developing countries have different economic and institutional characteristics, including financial constraints, infrastructure limitations, varying levels of political and institutional support, and differences in access to technology and investment. Therefore, this study provides an analytical framework for examining how green economy indicators are associated with resource allocation efficiency and inclusive growth, using Iraq as a case study of a developing rentier economy.

Research Problem

The green economy has become an increasingly important concept among researchers and policymakers. A substantial theoretical literature supports the transition toward a green economy as a means of promoting sustainable development. However, a gap remains between the expected benefits of the green economy and its practical outcomes, particularly in developing countries.

The transition toward a green economy depends on each country's economic structure, institutional conditions, natural resources, and technological capabilities. Consequently, the experiences of developing countries differ considerably. These differences raise questions about the extent to which green economy indicators are associated with more efficient resource use and whether environmental transition can occur alongside improvements in human development and inclusive growth.

The research problem can therefore be summarized in the following main question:

How does the green economy contribute to improving resource allocation efficiency and supporting inclusive growth in Iraq as a developing country?

To address this question, the study considers the following sub-questions:

1. To what extent are renewable energy and carbon intensity associated with resource allocation efficiency in Iraq?
2. To what extent are green economy indicators associated with inclusive growth, as represented in this study by the Human Development Index?
3. What role may institutional and governance conditions play in the effectiveness of green economy policies in Iraq?
4. What is the current state of Iraq's transition toward a green economy, and what are the main challenges and opportunities associated with this transition?

Research Hypotheses

Based on the research problem and its sub-questions, the following hypotheses are proposed:

First hypothesis: There is a statistically significant relationship between green economy indicators, particularly the share of renewable energy and carbon intensity, and resource allocation efficiency in Iraq.

Second hypothesis: Green economy indicators have a statistically significant relationship with inclusive growth in Iraq, as represented by the Human Development Index.

Third hypothesis: Institutional quality and governance conditions play an important role in determining the effectiveness of green economy policies.

Fourth hypothesis: Iraq faces significant structural and institutional obstacles in its transition toward a green economy despite its natural resources and potential for renewable energy development.

Importance of the Research

The theoretical importance of this study lies in combining two important dimensions of the green economy—resource allocation efficiency and inclusive growth—within a unified analytical framework. The study applies this framework to Iraq as a developing rentier economy, thereby contributing to the literature on the relationship between environmental transition, resource efficiency, and human development.

The practical importance of the study lies in providing evidence that may assist policymakers in Iraq and relevant international organizations in evaluating green economy policies and identifying areas in which investment can contribute to improved resource efficiency, inclusive development, and progress toward the Sustainable Development Goals.

Research Objectives

Based on the research problem and related questions, the study aims to achieve the following objectives:

1. To assess the relationship between selected green economy indicators, particularly renewable energy and carbon intensity, and resource allocation efficiency in Iraq.
2. To examine the relationship between green economy indicators and inclusive growth, using the Human Development Index as the main indicator of inclusive development in the empirical analysis.
3. To analyze the current state of Iraq's transition toward a green economy and identify the main structural and institutional challenges associated with this transition.
4. To develop evidence-based policy recommendations that may support Iraq's transition toward a green economy and improve its developmental benefits while limiting potential economic, social, and environmental challenges.

Research Terms

First: Green Economy. The green economy refers to an economic system that seeks to improve human well-being and social equity while reducing environmental risks and ecological scarcity. According to the United Nations Environment Programme (UNEP), a green economy is low-carbon, resource-efficient, and socially inclusive. For the purposes of the empirical analysis in this study, the transition toward a green economy is represented primarily by the share of renewable energy in electricity production and carbon intensity.

Second: Resource Allocation Efficiency. Resource efficiency refers to the ability of an economic system to generate greater economic value from available resources while reducing unnecessary resource consumption and environmental impacts. In the empirical part of this study, resource allocation efficiency is represented by energy productivity, measured as economic output per unit of energy consumed.

Third: Inclusive Growth. Inclusive growth refers to economic development that creates opportunities for broad participation in the growth process and allows the benefits of development to be shared across society. Although inclusive growth can be assessed using several social and economic indicators, the empirical analysis in this study uses the Human Development Index (HDI) as its principal proxy.

Research Methodology

The study uses descriptive-analytical and econometric methods to examine the relationships between green economy indicators, resource efficiency, and inclusive growth in Iraq as a case study of a developing country. Annual secondary data covering the period 2005–2024 were obtained primarily from the World Bank's World Development Indicators (WDI), the United Nations Development Programme (UNDP), and Ember Yearly Electricity Data. The resource-efficiency analysis covers 2005–2024, while the econometric analysis based on the internationally comparable UNDP Human Development Index covers 2005–2023.

The stationarity properties of the time-series variables were examined using unit root tests before model estimation. Multiple regression models were then estimated using the Ordinary Least Squares (OLS) method to examine the statistical relationships between the selected variables. Diagnostic tests were also conducted to evaluate the estimated models. In addition, descriptive analysis was used to examine the development of green economy indicators, resource efficiency, and inclusive growth in Iraq during the study period.

Previous Studies

First: Arabic Studies

Al-Jubouri (2022), "The Efficiency of Allocating Alternative Energy Resources and Its Impact on Comprehensive Growth Indicators in Iraq."

The study examined the efficiency of alternative energy resource allocation in Iraq and its relationship with comprehensive growth indicators during the period 2010–2020. It employed descriptive, analytical, and quantitative methods, including multiple regression analysis. The results indicated that the efficiency of alternative energy resource allocation in Iraq remained relatively low because of inadequate infrastructure, limited investment, and the absence of an appropriate legal and regulatory framework. The study also reported a modest positive relationship between resource allocation efficiency and comprehensive growth indicators. It recommended reforming energy policies and increasing investment in renewable energy sources.

Al-Samarrai (2024), "Green Economy Strategies as an Approach to Improving Environmental Efficiency and Distributive Justice in Rentier States."

This study examined the potential role of green economy strategies in improving environmental performance and distributive justice in rentier economies, with particular attention to Iraq. A descriptive-analytical approach was used. The study concluded that rentier economies face specific challenges in transitioning toward a green economy because of their strong dependence on oil revenues. Nevertheless, green economy strategies may contribute to economic diversification, improved resource efficiency, and greater distributive justice when supported by political commitment and appropriate institutional reforms.

Second: Foreign Studies

World Bank (2012), "Inclusive Green Growth: The Pathway to Sustainable Development."

The World Bank examined the relationship between economic growth, environmental sustainability, and social inclusion in developing countries. The report emphasized that green growth should not be considered automatically inclusive and that environmental policies need to be designed in ways that protect poor and vulnerable groups. It also highlighted the importance of resource efficiency, environmental protection, appropriate institutions, and policy design in achieving sustainable development. The report concluded that inclusive green growth can provide a pathway through which developing countries pursue economic development while reducing environmental pressures and promoting social welfare.

Ofori, Gbolonyo, and Ojong (2022), "Towards Inclusive Green Growth in Africa: Critical Energy Efficiency Synergies and Governance Thresholds."

The study examined the relationship between energy efficiency, governance, and inclusive green growth using data from 23 African countries during the period 2000–2020. The authors applied a dynamic Generalized Method of Moments (GMM) approach. The results showed that energy efficiency alone was not sufficient to promote inclusive green growth. However, governance created a positive synergy with energy efficiency and strengthened its contribution to inclusive green growth. In particular, control of corruption, regulatory quality, and government effectiveness were identified as important institutional factors. The study therefore emphasized that improvements in energy efficiency should be accompanied by stronger governance and institutional capacity.

Akpolat and Bakırtaş (2024), "The Nonlinear Impact of Renewable Energy, Fossil Energy and CO_2 Emissions on Human Development Index for the Eight Developing Countries."

The study investigated the relationships between renewable energy consumption, fossil energy consumption, CO_2 emissions, and the Human Development Index in eight developing countries during the period 1990–2021. The authors used panel-data econometric methods. The findings indicated nonlinear relationships between energy variables, carbon emissions, and human development. Renewable energy showed a U-shaped relationship with HDI, whereas fossil energy consumption and CO_2 emissions showed inverted U-shaped relationships. The study also found a positive association between international trade and human development. The authors emphasized the importance of expanding renewable energy use and reducing long-term dependence on fossil fuels as part of sustainable development policies.

Third: Commentary on Previous Studies

The reviewed studies indicate that the transition toward a green economy is closely connected with resource efficiency, human development, and institutional conditions. However, the nature and strength of these relationships differ according to the economic structure, level of development, and institutional environment of individual countries.

Al-Jubouri (2022) showed that the efficient allocation of alternative energy resources may contribute to improved growth indicators in Iraq, while also emphasizing the constraints created by inadequate infrastructure and limited investment. Al-Samarrai (2024) highlighted the specific difficulties faced by rentier economies, particularly their dependence on oil revenues, and emphasized the importance of economic diversification and institutional reform.

At the international level, the World Bank (2012) emphasized that green growth must be accompanied by social inclusion and appropriate policy measures if its benefits are to reach vulnerable groups. Ofori et al. (2022) provided empirical evidence that energy efficiency alone may not be sufficient to achieve inclusive green growth and that the quality of governance can significantly strengthen its contribution to sustainable development. Akpolat and Bakırtaş (2024), in turn, demonstrated that the relationships between renewable energy, fossil energy, carbon emissions, and human development are not necessarily linear, highlighting the complexity of the relationship between environmental transition and socioeconomic development.

The reviewed literature also differs in methodology and geographical scope. Al-Jubouri (2022) focused specifically on Iraq, while Al-Samarrai (2024) examined the broader characteristics of rentier economies. Ofori et al. (2022) used an econometric panel-data approach covering African countries, whereas Akpolat and Bakırtaş (2024) examined a group of developing countries using panel-data methods. The World Bank (2012) provided a broader analytical and policy framework for understanding inclusive green growth in developing economies.

Overall, previous research suggests that improvements in resource and energy efficiency, greater use of renewable energy, and stronger institutional quality can contribute to more sustainable development. At the same time, the findings indicate that the effects of green transition policies depend on the economic and institutional characteristics of each country.

Fourth: Research Gap

The reviewed literature provides important evidence on green growth, energy and resource efficiency, renewable energy, environmental sustainability, and human development. However, these dimensions are frequently examined separately or through cross-country and regional analyses.

Within the literature reviewed in this study, relatively limited attention has been given to examining resource efficiency and inclusive growth within the same empirical framework specifically for Iraq. This issue is particularly relevant because Iraq combines several distinctive characteristics, including high dependence on oil revenues, limited renewable energy penetration, relatively high carbon intensity, and significant institutional and economic constraints.

The present study therefore contributes to the existing literature by examining the relationships between selected green economy indicators, resource efficiency, and inclusive growth within a unified empirical framework for Iraq during the period 2005–2024. In particular, the study uses renewable energy and carbon intensity as key green economy indicators, energy productivity as an indicator of resource efficiency, and the Human Development Index as a proxy for inclusive growth.

Research Boundaries

The research focuses on the role of the green economy in improving resource allocation efficiency and supporting inclusive growth, while other possible effects of the green economy remain outside the scope of the study.

Spatial boundaries: The Iraqi economy.

Time boundaries: The study covers the period 2005–2024, during which interest in the green economy and sustainable development increased significantly.

Theoretical Framework of the Green Economy, Resource Efficiency, and Inclusive Economic Development

Green Economy

First: The Concept of the Green Economy and Its Development

The concept of the green economy began to emerge more clearly at the end of the twentieth century, along with growing international awareness of the environmental risks associated with conventional development models based on excessive use of natural resources and insufficient consideration of environmental impacts (Khanfar, 2014: 54). Several factors contributed to the development of this concept, including climate change, global food-security challenges, and the 2008 global financial crisis, which highlighted the vulnerability of existing economic systems (Al-Maazouzi and Ben Othman, 2018: 132).

The United Nations Environment Programme (UNEP) defines a green economy as one that improves human well-being and social equity while reducing environmental risks and ecological scarcities (UNEP, 2011: 9). This concept combines three major dimensions: the economic dimension, represented by improved well-being; the social dimension, represented by social equity; and the environmental dimension, represented by reduced environmental risks. A green economy also encourages public and private investment in activities that improve resource efficiency, reduce greenhouse-gas emissions, waste, and pollution, and protect ecosystems and biodiversity (UNEP, 2011: 9).

The World Bank describes a green economy as one that uses natural resources efficiently, reduces pollution and adverse environmental impacts, and takes environmental and natural risks into account while supporting inclusive economic development (World Bank, 2012). The Organisation for Economic Co-operation and Development (OECD) defines green growth as economic growth that preserves the natural assets required to sustain human well-being while limiting environmental degradation (OECD, 2011: 11).

Second: Dimensions of the Green Economy

The green economy consists of three main and interrelated dimensions:

The economic dimension: This refers to achieving sustainable economic growth through the efficient use of resources, reduction of waste and pollution, and improvement of productivity. It is concerned with transforming economic activities so that they become more resource-efficient and less environmentally harmful (Abdel Latif, 2020: 205).

The social dimension: This includes promoting social equity, reducing poverty, creating environmentally sustainable employment opportunities, and ensuring a more equitable distribution of the benefits of economic growth. It aims to improve living standards, particularly for disadvantaged and economically vulnerable groups (World Bank, 2012; UNEP, 2011).

The environmental dimension: This involves protecting ecosystems, reducing pollution, preserving biodiversity, and addressing climate change. Its objective is to ensure the sustainable use of natural resources for present and future generations (Al-Samarrai, 2024: 60).

Third: Objectives of the Green Economy

The green economy has several interrelated objectives (UNEP, 2011: 12–15).

Achieving sustainable development: The green economy provides an important mechanism for achieving sustainable development across its economic, social, and environmental dimensions by promoting development pathways that are more resource-efficient and environmentally sustainable.

Supporting environmentally friendly industries and business practices: This involves transforming environmentally harmful production activities into cleaner and more sustainable forms of production and encouraging the development of environmentally responsible goods and services.

Reducing poverty: The green economy can contribute to poverty reduction through more efficient use of natural resources, job creation, and improved access to essential services.

Creating green jobs: Green jobs include employment opportunities that contribute to maintaining or improving environmental quality across agriculture, manufacturing, services, and

other sectors. Such jobs may reduce energy and raw-material consumption, limit greenhouse-gas emissions, reduce waste and pollution, and contribute to the protection or restoration of ecosystems (UNEP et al., 2008: 30).

Improving resource efficiency: One of the major objectives of the green economy is to increase the efficiency of resource use while reducing pollution and waste and promoting sustainable management of natural resources.

Fourth: Green Economy Indicators

The OECD and UNEP have proposed several indicators for assessing progress toward a green economy, particularly in the areas of resource efficiency, waste management, and environmental protection (OECD, 2011; UNEP, 2011: 15). These indicators include:

Economic indicators: These may include the share of investment directed toward projects that improve resource and energy efficiency and reduce waste and pollution, as well as the proportion of production or employment associated with environmentally sustainable activities.

Environmental indicators: These reflect the relationship between economic performance and environmental pressure. At either the sectoral or macroeconomic level, they may include energy consumption, water use, emissions, or other resource inputs per unit of economic output.

Social indicators: These reflect the social outcomes associated with sustainable development, including aspects of human well-being, access to services, employment, and other dimensions of social welfare.

Overall, the green economy can be understood as an approach that links environmental protection with economic and social development, aiming to manage natural resources efficiently while preserving opportunities for future generations.

The Concept of Resource Allocation Efficiency

Resource allocation efficiency refers to the ability of an economy to generate economic value from available resources while minimizing waste and negative environmental impacts. It reflects the extent to which natural resources, energy, and raw materials are transformed into goods and services efficiently. In green-economy literature, resource efficiency is closely associated with the concept of decoupling economic growth from increasing resource consumption.

The economic literature suggests several approaches to measuring resource efficiency, including resource productivity, energy intensity, material intensity, and carbon productivity (OECD, 2011; UNEP, 2017).

Resource efficiency may also be understood as obtaining maximum economic value from natural resources while minimizing negative environmental impacts through improved production efficiency, recycling, and reduction of losses and waste (Al-Samarrai, 2024: 62).

Dimensions of Resource Allocation Efficiency

Resource allocation efficiency includes several interrelated dimensions (Al-Jubouri, 2022: 93–95; UNEP, 2017):

Energy efficiency: This refers to achieving a higher level of economic output with lower energy consumption. It can be improved through more efficient production technologies and greater use of cleaner energy sources. Higher energy efficiency can reduce dependence on fossil fuels and lower greenhouse-gas emissions.

Material efficiency: This refers to reducing the amount of virgin raw materials used in production, increasing recycling and reuse, and promoting circular-economy practices. Its objective is to reduce pressure on finite natural resources and decrease waste generation.

Water-use efficiency: This refers to obtaining greater economic value from available water resources while minimizing losses and improving water management. It is particularly important in water-scarce countries such as Iraq and other Arab states.

Land-use efficiency: This involves increasing the productive use of land while protecting biodiversity and ecosystem services. Measures may include improving agricultural productivity, combating desertification, and protecting forests and other natural areas.

The Relationship Between Resource Efficiency and the Green Economy

Previous research indicates that improvements in energy and resource efficiency are important components of the transition toward greener and more sustainable economic development. The effectiveness of such improvements may also depend on institutional and governance conditions (OECD, 2011; UNEP, 2017; Ofori et al., 2022). Several mechanisms may contribute to this relationship:

Investment in clean technology: The green economy encourages investment in cleaner and more resource-efficient production technologies, which can reduce environmental pressures while improving the productivity of available resources.

Improved energy efficiency: Renewable energy development and energy-efficiency measures can reduce dependence on fossil fuels and improve the efficiency of energy use in production and service sectors.

Recycling and the circular economy: Effective recycling programs, longer product lifecycles, material reuse, and circular production models can reduce demand for virgin resources and limit waste generation.

Waste reduction: More effective resource management can reduce losses throughout production and supply processes and contribute to more efficient use of natural resources.

Overall, improvements in resource and energy efficiency are widely recognized as important elements of green economic development. However, evidence also suggests that stronger governance and institutional quality can enhance the contribution of energy efficiency to inclusive and sustainable green growth (OECD, 2011; UNEP, 2017; Ofori et al., 2022).

Theoretical Framework: The Concept of Inclusive Growth

First: The Concept of Inclusive Growth

Inclusive growth refers to a development process in which economic opportunities and the benefits of growth are broadly shared across society, including among poor and vulnerable groups (World Bank, 2012). Unlike traditional approaches that focus mainly on the rate of economic growth, inclusive growth also considers the quality of growth, access to economic opportunities, and the distribution of development benefits among different groups in society.

Inclusive growth therefore seeks to combine sustained economic development with broader participation in economic activity and a more equitable distribution of its benefits. Particular attention is given to disadvantaged and marginalized groups that may otherwise have limited access to employment, education, healthcare, and other development opportunities (World Bank, 2012; Abdel Latif, 2020: 210).

From this perspective, inclusive growth is not limited to increasing national income. It also involves improving human well-being, expanding economic opportunities, and reducing social and economic disparities. The Human Development Index (HDI) is therefore commonly used as one of the indicators that can reflect broader changes in human development, particularly in the areas of health, education, and income (UNDP, 2022).

Second: Dimensions of Inclusive Growth

Inclusive growth consists of several closely related economic, social, institutional, and environmental dimensions (World Bank, 2012; Ofori et al., 2022).

The economic dimension: This includes achieving sustainable economic growth, increasing productivity, diversifying the economy, and improving market efficiency. It requires policies that encourage investment, production, innovation, and competitiveness.

The social dimension: This focuses on reducing poverty and unemployment, improving income distribution, promoting equal opportunities, and expanding access to essential services such as education, healthcare, and housing. Its main objective is to ensure that the benefits of economic development are shared more broadly across society.

The institutional dimension: This includes strengthening good governance, improving institutional quality, combating corruption, enforcing the rule of law, and increasing transparency and accountability. Strong institutions are important for ensuring that economic and environmental policies contribute effectively to inclusive development (Ofori et al., 2022).

The environmental dimension: This concerns the long-term sustainability of development through the protection of natural resources, reduction of pollution, and integration of environmental considerations into economic policy. Inclusive development should therefore be pursued in a way that does not compromise the resources and environmental conditions required by future generations (World Bank, 2012).

Third: Indicators for Measuring Inclusive Growth

Inclusive growth can be assessed using a range of economic and social indicators that reflect not only economic performance but also the distribution of development benefits and improvements in human well-being.

Human Development Index (HDI): The HDI is a composite indicator developed by the United Nations Development Programme (UNDP) to measure human development across three main dimensions: a long and healthy life, measured by life expectancy at birth; access to knowledge, measured by mean years of schooling and expected years of schooling; and a decent standard of living, measured by gross national income (GNI) per capita. The HDI provides a broader measure of development than income alone and is therefore widely used to assess changes in human well-being (UNDP, 2022).

Poverty Rate: The poverty rate represents the proportion of the population living below a specified national or international poverty line. A decline in poverty can indicate that the benefits of economic development are reaching lower-income and vulnerable groups, while persistently high poverty may indicate limited inclusiveness of economic growth.

Unemployment Rate: The unemployment rate represents the proportion of the labor force that is without employment but is available for and seeking work. Lower unemployment may indicate broader participation in economic activity and greater access to employment opportunities.

Gini Index: The Gini Index measures inequality in the distribution of income or consumption within a population. It generally ranges from 0 to 1, where a value of 0 represents perfect equality and a value closer to 1 indicates greater inequality. A lower Gini Index therefore reflects a more equal distribution of income or consumption.

Multidimensional Poverty Index (MPI): The MPI measures poverty through multiple overlapping deprivations in areas such as health, education, and living standards. Unlike income-based poverty measures, it provides a broader assessment of the different forms of deprivation experienced by individuals and households.

Employment Rate: The employment rate measures the proportion of the working-age population that is employed. Higher employment levels may indicate greater participation in economic activity and broader access to productive employment opportunities.

Although several indicators can be used to assess inclusive growth, the empirical analysis in the present study uses the **Human Development Index (HDI) as the principal proxy for inclusive growth**, as it incorporates the key dimensions of health, education, and income and provides consistent annual data for evaluating changes in human development in Iraq.

Fourth: The Relationship Between Inclusive Growth and the Green Economy

The green economy can contribute to inclusive growth through several economic, social, and environmental channels. By promoting cleaner production, greater resource efficiency, renewable energy, and sustainable employment, green-economy policies can support improvements in human well-being while reducing environmental pressures (World Bank, 2012; UNEP, 2011).

Creation of Green Employment Opportunities: Investment in renewable energy, sustainable agriculture, waste management, energy efficiency, and clean transportation can create new employment opportunities and support improvements in household income and living standards. Green jobs can therefore contribute to reducing unemployment and increasing participation in economic activity (UNEP, ILO, IOE, & ITUC, 2008).

Improved Access to Basic Services: Green-economy policies can contribute to better access to essential services such as clean energy, safe water, sanitation, and sustainable

transportation. Improved access to these services can support better health, education, and living conditions, particularly among vulnerable and marginalized groups (Abdel Latif, 2020: 220; World Bank, 2012).

Poverty Reduction: Green growth can contribute to poverty reduction by expanding sustainable livelihood opportunities, improving access to economic resources and essential services, and creating employment in environmentally sustainable sectors. However, appropriate social and institutional policies are necessary to ensure that the benefits of green growth reach poor and vulnerable groups (World Bank, 2012; UNEP, 2011).

Improved Income Distribution: Inclusive green-growth policies may contribute to a more equitable distribution of development benefits by creating employment opportunities, improving access to productive activities, and supporting disadvantaged groups. Nevertheless, the distributional effects of green policies depend on the design of public policies and the quality of institutions (World Bank, 2012; Ofori et al., 2022).

Improved Human Development: Investments in clean energy, environmental quality, resource efficiency, and sustainable infrastructure may also contribute to broader human-development outcomes. Improvements in health, education, income opportunities, and access to basic services can support higher levels of human development over time (UNDP, 2022).

Overall, the relationship between the green economy and inclusive growth is not automatic. The extent to which green-economy policies contribute to inclusive development depends on the structure of the economy, the quality of institutions, access to financing and technology, and the ability of public policies to ensure that the benefits of green transformation are broadly shared across society (World Bank, 2012; Ofori et al., 2022).

Analytical Framework of the Research Variables

The analytical framework of this study examines the relationship between green economy indicators and two main outcome dimensions: resource allocation efficiency and inclusive growth. It also provides an initial descriptive assessment of the development of green economy indicators in Iraq during the period 2005–2024 before proceeding to the econometric analysis.

The framework is based on data obtained from recognized international and national statistical sources and is intended to reflect the development of the Iraqi economy within the broader context of the global transition toward a green economy and sustainable development.

In the empirical analysis, renewable energy and carbon intensity are used as the principal green economy indicators, energy productivity is used as an indicator of resource allocation efficiency, and the Human Development Index is used as the principal proxy for inclusive growth.

Table 1. Development of Green Economy, Resource Efficiency, and Inclusive Growth Indicators in Iraq, 2005–2024

Year	Renewable Electricity Generation Share (%)	Carbon Intensity of GDP (kg CO_2e per constant 2015 US$ of GDP)	Resource Efficiency: GDP per Unit of Energy Use (constant 2021 PPP $ per kg of oil equivalent)	Human Development Index (HDI)	GDP (constant 2015 US$, billion)	Inflation, Annual (%)	Trade Openness (% of GDP)
2005	19.74	0.928	10.62	0.609	94.05	36.96	115.74
2006	18.03	0.854	11.54	0.611	99.36	53.23	89.65
2007	17.27	0.775	11.94	0.618	101.23	−10.07	74.09
2008	9.44	0.828	11.96	0.634	109.56	12.66	81.06
2009	8.53	0.855	11.52	0.644	113.26	6.87	78.69
2010	9.75	0.925	11.10	0.650	120.52	2.43	73.50
2011	6.31	0.894	10.90	0.656	129.61	5.60	72.17
2012	9.54	0.901	11.22	0.664	147.67	6.09	73.61
2013	8.16	0.909	11.66	0.668	158.94	1.88	67.41
2014	4.33	0.851	12.50	0.671	162.54	2.24	68.98
2015	3.69	0.827	13.54	0.675	166.77	1.39	69.59
2016	4.18	0.817	13.95	0.676	189.77	0.56	54.59
2017	2.39	0.898	12.16	0.681	186.31	0.18	59.78
2018	1.91	0.946	11.23	0.689	191.22	0.37	65.80
2019	4.36	0.960	11.30	0.693	201.77	−0.20	68.99

2020	3.87	1.040	11.22	0.680	177.48	0.57	57.74
2021	3.10	1.110	9.98	0.687	180.15	6.04	61.50
2022	2.26	1.140	9.49	0.695	194.48	4.99	68.76
2023	1.21	1.190	8.77	0.695	195.49	4.36	69.46
2024	1.63	1.240	8.30	0.712*	192.47	2.61	77.14

Source: Prepared by the author based on data from the World Bank's *World Development Indicators (WDI)*, Ember *Yearly Electricity Data*, and the United Nations Development Programme (UNDP), including the *Human Development Report 2025* and the *Iraq National Human Development Report 2025*.

Notes: Renewable electricity generation data are based on Ember *Yearly Electricity Data*. Carbon intensity of GDP, GDP per unit of energy use, GDP, inflation, and trade openness are based on World Bank *World Development Indicators (WDI)*. HDI values for 2005–2023 are based on the internationally comparable UNDP Human Development Index time series; the *Human Development Report 2025* reports an HDI value of 0.695 for Iraq in 2023.

* The value of 0.712 for 2024 is reported in the *Iraq National Human Development Report 2025*. It is included in Table 1 for descriptive purposes only. Because the 2024 observation is not part of the same international UNDP HDI time series used for the econometric analysis covering 2005–2023, it is excluded from the HDI descriptive statistics, unit-root test, and regression model.

First: Development of Green Economy Indicators (Independent Variables)

Table 1 shows a substantial decline in the share of renewable energy in Iraq's electricity generation during the study period. The share decreased from 19.74% in 2005 to 1.63% in 2024. The highest value was recorded in 2005, while the lowest value was 1.21% in 2023.

Although the overall trend was downward, several temporary increases occurred during the study period, particularly in 2010, 2012, 2019, and 2024. Nevertheless, the long-term pattern indicates a considerable reduction in the contribution of renewable sources to electricity generation and continued dependence on fossil fuels.

Carbon intensity followed a different pattern. It decreased from 0.928 kg CO_2e per constant 2015 US dollar of GDP in 2005 to its lowest value of 0.775 in 2007. After several years of fluctuation, carbon intensity began to increase more noticeably in the later part of the study period. It reached 1.040 in 2020, 1.110 in 2021, 1.140 in 2022, 1.190 in 2023, and 1.240 in 2024.

The simultaneous decline in the renewable electricity share and increase in carbon intensity in recent years indicate that Iraq continued to face substantial challenges in reducing the carbon intensity of economic activity and advancing its transition toward a greener energy system.

Second: Development of Resource Efficiency (First Dependent Variable)

Energy productivity, used in this study as a proxy for resource efficiency, showed considerable fluctuations during the study period. It increased from 10.62 constant 2021 PPP dollars per kilogram of oil equivalent in 2005 to 11.96 in 2008.

After some fluctuations, energy productivity improved further and reached its highest value of 13.95 in 2016. This indicates that, during this period, the Iraqi economy generated greater economic output per unit of energy consumed.

However, this improvement was not sustained. Energy productivity subsequently declined from 12.16 in 2017 to 11.23 in 2018 and continued to decrease in the following years. It fell to 9.98 in 2021, 9.49 in 2022, 8.77 in 2023, and 8.30 in 2024.

Therefore, the data indicate that Iraq experienced an improvement in energy productivity during the earlier and middle parts of the study period, followed by a clear deterioration in resource efficiency during the later years.

Third: Development of Inclusive Growth (Second Dependent Variable)

The Human Development Index (HDI), used in this study as a proxy for inclusive growth, showed a general upward trend during the study period. The index increased from 0.609 in 2005 to 0.693 in 2019.

A temporary decline occurred in 2020, when the HDI fell to 0.680. It subsequently increased to 0.687 in 2021 and 0.695 in both 2022 and 2023.

The value of 0.712 reported for 2024 is based on Iraq's National Human Development Report 2025 and is included in Table 1 for descriptive purposes only. It should be distinguished from the internationally comparable UNDP HDI time series used in the econometric analysis, which covers the period 2005–2023. Therefore, the 2024 value is excluded from the HDI descriptive statistics, unit-root test, and regression model.

Overall, the HDI data indicate substantial improvement in human development over the study period. However, this improvement occurred alongside declining renewable electricity generation and rising carbon intensity in the later years. This suggests that improvements in human development were not necessarily accompanied by equivalent progress in environmental sustainability.

Fourth: Preliminary Relationships Among the Variables

The descriptive trends indicate several possible relationships among the study variables. Renewable electricity generation declined substantially during the study period, while carbon intensity generally increased during the later years. This pattern suggests a possible inverse relationship between renewable energy use and carbon intensity, although descriptive evidence alone cannot establish statistical significance.

Resource efficiency, measured by energy productivity, improved until the middle of the study period and reached its highest level in 2016. It subsequently declined, particularly after 2020. In contrast, the Human Development Index generally continued to improve. These differing trends indicate that changes in resource efficiency and human development did not always move in the same direction.

GDP generally increased during the study period, rising from US$94.05 billion in 2005 to more than US$190 billion in several recent years. The increase in GDP was accompanied by an overall improvement in HDI, suggesting a possible positive association between economic activity and human development.

Inflation showed substantial fluctuations, with particularly high values in the early years of the study period. Trade openness also varied considerably, declining from 115.74% of GDP in 2005 to its lowest value of 54.59% in 2016 before increasing to 77.14% in 2024.

These descriptive relationships provide an initial understanding of the behavior of the study variables but do not establish causality or statistical significance. Econometric analysis is therefore required to examine the magnitude, direction, and statistical significance of the relationships among green economy indicators, resource efficiency, inclusive growth, and the control variables.

Empirical Framework of the Research

The empirical analysis examines the relationships among green economy indicators, resource efficiency, and inclusive growth in Iraq using annual data covering the period 2005–2024. The resource-efficiency model is estimated for the full period 2005–2024. However, the inclusive-growth model based on the internationally comparable UNDP Human Development Index (HDI) is estimated for the period 2005–2023, because the 2024 national HDI value is included for descriptive purposes only and is not part of the same international HDI time series.

The empirical analysis includes descriptive statistics, unit-root tests, regression model estimation, and diagnostic tests. The estimated results are subsequently interpreted in relation to the theoretical framework and previous empirical studies.

First: Descriptive Statistics of the Variables

Table 2 presents the descriptive statistics for the variables included in the study based on the revised dataset.

Table 2. Descriptive Statistics of the Study Variables

Statistics	RENEWABLE	CARBON	RESOURCE_EFF	HDI	GDP	INF	TRADE
Mean	6.985	0.9444	11.245	0	155.633	6.938	72.413
Median	4.345	0.9050	11.265	0	164.655	2.520	69.525
Maximum	19.740	1.2400	13.950	0	201.770	53.230	115.740
Minimum	1.210	0.7750	8.300	0.6090	94.050	−10.070	54.590

Standard Deviation	5.636	0.1315	1.383	0	37.716	13.990	13.079
Skewness	1.117	0.969	−0.265	−0.719	−0.400	2.356	1.804
Kurtosis	3.120	2.830	3.180	2	1.602	7.958	7.213
Jarque–Bera	4.174	3.156	0.261	. 7	2.162	38.987	25.638
Probability	0.124	0.206	0.878	0	0.339	<0.001	<0.001

Source: Prepared by the author based on calculations using the revised study dataset.

The average share of renewable energy in electricity generation was 6.985% during the study period. The variable showed considerable variation, ranging from 1.21% to 19.74%, with a standard deviation of 5.636. The positive skewness coefficient of 1.117 indicates that the distribution is skewed toward higher values. However, the Jarque–Bera test does not reject the null hypothesis of normality at the 5% significance level (JB = 4.174, p = 0.124).

Carbon intensity had a mean value of 0.9444 and a standard deviation of 0.1315. Values ranged from 0.775 to 1.240. The Jarque–Bera probability of 0.206 indicates no statistically significant departure from normality.

Resource efficiency, measured by energy productivity, had an average value of 11.245 constant 2021 PPP dollars per kilogram of oil equivalent. The minimum value was 8.30 and the maximum was 13.95, with a standard deviation of 1.383. The Jarque–Bera test does not indicate a significant departure from normality (JB = 0.261, p = 0.878).

The Human Development Index had a mean value of 0.6629 during the period 2005–2023, with a standard deviation of 0.0282. Its values ranged from 0.609 to 0.695. The Jarque–Bera test does not reject the null hypothesis of normality (JB = 2.027, p = 0.363). The 2024 national HDI value is excluded from these descriptive statistics to maintain consistency with the internationally comparable UNDP HDI series used in the econometric analysis.

GDP averaged approximately US$155.633 billion in constant 2015 prices, with values ranging from US$94.05 billion to US$201.77 billion. The standard deviation was US$37.716 billion. The Jarque–Bera probability of 0.339 indicates no statistically significant departure from normality.

Inflation showed considerable volatility. The average annual inflation rate was 6.938%, while values ranged from −10.07% to 53.23%. Inflation was strongly positively skewed (skewness = 2.356) and had high kurtosis (7.958). The Jarque–Bera test strongly rejects the null hypothesis of normality (JB = 38.987, p < 0.001).

Trade openness averaged 72.413% of GDP, with a minimum of 54.59% and a maximum of 115.74%. The variable was positively skewed (skewness = 1.804) and had relatively high kurtosis (7.213). The Jarque–Bera test also rejects the null hypothesis of normality (JB = 25.638, p < 0.001).

Overall, the descriptive statistics indicate substantial variation in renewable electricity generation, GDP, inflation, and trade openness during the study period. Carbon intensity and HDI showed comparatively lower variability, while resource efficiency experienced important changes over time despite a relatively moderate overall standard deviation.

Second: Unit Root Tests

The Augmented Dickey–Fuller (ADF) test was used to examine the stationarity properties of the time-series variables. Given the relatively small annual sample, the test was estimated with an intercept and one lag. Table 3 presents the results.

Table 3. Results of the Augmented Dickey–Fuller (ADF) Unit Root Test

Variable	Level t-statistic	Prob.	First Difference t-statistic	Prob.	Order of Integration
RENEWABLE	−2.672	0.0790	−3.506	0.0078	I(0), at the 10% level

CARBON	0.183	0.9713	−3.218	0.0190	I(1)
GDP	−1.459	0.5539	−3.489	0.0083	I(1)
HDI	−2.757	0	–		I
INF	−16.310	<0.001	—	—	I(0)
RESOURCE_EFF	−1.171	0.6859	−2.906	0.0447	I(1)
TRADE	−2.796	0.0588	−5.467	<0.001	I(0), at the 10% level

Source: Prepared by the author based on ADF calculations using the revised study dataset.

The ADF test results indicate that the study variables have mixed orders of integration. Inflation is stationary at level at conventional significance levels, while renewable energy, trade openness, and HDI are stationary at level at the 10% significance level. Carbon intensity, GDP, and resource efficiency are non-stationary at level but become stationary after first differencing and are therefore classified as I(1).

Overall, the results indicate a mixture of I(0) and I(1) variables. None of the variables is integrated of order two, I(2), under the reported test specification.

Third: Estimation of the Multiple Regression Models

First: Model of the Relationship Between Green Economy Indicators and Resource Efficiency

Table 4. Estimation Results for the Resource Efficiency Model Dependent Variable: RESOURCE_EFF (Energy Productivity)

Variable	Coefficient	Standard Error	t-statistic	Prob.
C	21.301	1.567	13.594	<0.001
RENEWABLE	−0.012	0.045	−0.271	0.790
CARBON	−11.929	1.092	−10.926	<0.001
GDP	0.014	0.006	2.236	0.042
INF	0.014	0.011	1.352	0.198
TRADE	−0.014	0.015	−0.934	0.366

Model Statistic	Value	Model Statistic	Value
R-squared	0.929	Mean dependent variable	11.245
Adjusted R-squared	0.903	SD dependent variable	1.383
F-statistic	36.380	Durbin–Watson statistic	1.586
Prob. (F-statistic)	<0.001		

Source: Prepared by the author based on OLS calculations using the revised study dataset.

The coefficient of determination ($R^2 = 0.929$) indicates that the explanatory variables included in the model account for approximately 92.9% of the variation in resource efficiency during the study period. The adjusted R^2 is 0.903, while the overall regression model is statistically significant ($F = 36.380$, $p < 0.001$).

Carbon intensity has a strong negative and statistically significant relationship with resource efficiency (coefficient = −11.929, $p < 0.001$). Holding the other variables constant, higher carbon intensity is associated with lower energy productivity. This result is broadly consistent with the literature emphasizing the importance of energy efficiency and reduced environmental pressure in the transition toward greener economic development (Ofori et al., 2022).

GDP has a positive and statistically significant coefficient (coefficient = 0.014, $p = 0.042$). This finding indicates a positive association between economic output and resource efficiency during the study period, holding the other explanatory variables constant.

Renewable energy has a small negative coefficient, but the relationship is not statistically significant (coefficient = −0.012, $p = 0.790$). Therefore, the model does not provide sufficient

statistical evidence that changes in the share of renewable electricity generation were independently associated with resource efficiency during the study period.

Inflation has a positive but statistically insignificant coefficient (coefficient = 0.014, p = 0.198). Trade openness also has a negative but statistically insignificant coefficient (coefficient = −0.014, p = 0.366). Consequently, neither variable shows a statistically significant relationship with resource efficiency in this model.

The Durbin–Watson statistic is 1.586. Although this value does not by itself provide conclusive evidence of residual autocorrelation, it indicates the need to evaluate serial correlation more formally using the diagnostic tests reported subsequently.

Because the unit-root analysis indicates that RESOURCE_EFF, CARBON, and GDP are non-stationary at level and become stationary after first differencing, the coefficients of this level-form OLS regression should be interpreted cautiously. The results are therefore treated as statistical associations rather than evidence of causal relationships.

Second: Model of the Relationship Between Green Economy Indicators and Inclusive Growth

Table 5. Estimation Results for the Inclusive Growth Model
Dependent Variable: HDI (Human Development Index)
Estimation period: 2005–2023

Variable	Coefficient	Standard Error	t-statistic	Prob.
C	0.5884	0.0162	36.293	<0.001
RENEWABLE	−0.00195	0.00043	−4.492	0.001
CARBON	0.02804	0.01131	2.479	0.028
GDP	0.00039	0.00006	6.369	<0.001
INF	−0.00020	0.00010	−1.973	0.070
TRADE	0.00006	0.00015	0.371	0.716

Model Statistic	Value	Model Statistic	Value
R-squared	0.985	Mean dependent variable	0.663
Adjusted R-squared	0.979	SD dependent variable	0.028
F-statistic	165.364	Durbin–Watson statistic	1.316
Prob. (F-statistic)	<0.001	Number of observations	19

Source: Prepared by the author based on OLS calculations using the revised study dataset.

The coefficient of determination (R^2 = 0.985) indicates that the explanatory variables included in the model account for approximately 98.5% of the variation in the Human Development Index during the estimation period. The adjusted R^2 is 0.979, and the overall regression model is statistically significant (F = 165.364, p < 0.001).

GDP has a positive and statistically significant coefficient (coefficient = 0.00039, p < 0.001), indicating a positive association between economic output and the Human Development Index, holding the other variables constant.

Renewable electricity generation has a negative and statistically significant coefficient (coefficient = −0.00195, p = 0.001). This result indicates a negative statistical association between the renewable electricity share and HDI during the study period. However, it should not be interpreted as evidence that renewable energy reduces human development. The result may reflect the specific historical development of Iraq's electricity sector, in which the renewable share declined substantially while HDI generally increased over time.

Carbon intensity has a positive and statistically significant coefficient (coefficient = 0.02804, p = 0.028). In the context of Iraq, this positive association may reflect the structure of an oil-dependent economy in which carbon-intensive economic activity is closely connected with oil

production, government revenues, and public expenditure. Therefore, the result should not be interpreted as evidence that higher carbon intensity itself improves human development.

Inflation has a negative coefficient and is statistically significant only at the 10% level (coefficient = −0.00020, p = 0.070). This suggests a weak negative association between inflation and HDI, although the result should be interpreted cautiously.

Trade openness has a small positive coefficient but is not statistically significant (coefficient = 0.00006, p = 0.716). Therefore, the model does not provide sufficient statistical evidence of an independent relationship between trade openness and the Human Development Index during the estimation period.

The Durbin–Watson statistic is 1.316. This value suggests that possible positive serial correlation should be evaluated using a formal diagnostic test rather than relying on the Durbin–Watson statistic alone. The subsequent Breusch–Godfrey test does not indicate statistically significant first-order serial correlation in the residuals.

The unit-root analysis indicates that HDI is stationary at level at the 10% significance level, whereas carbon intensity and GDP are non-stationary at level and become stationary after first differencing. Because the model therefore contains variables with mixed orders of integration, the level-form OLS coefficients should be interpreted cautiously. The estimated relationships are treated as statistical associations and should not be interpreted as evidence of causality.

Fourth: Diagnostic Tests

Diagnostic tests were conducted for both regression models to assess the validity of the main OLS assumptions. The Breusch–Godfrey LM test with one lag was used to examine serial correlation, while the Breusch–Pagan–Godfrey test was used to assess heteroskedasticity. The results are presented in Table 6.

Table 6. Diagnostic Test Results

Test	**Resource Efficiency Model (RESOURCE_EFF)**	**Inclusive Growth Model (HDI)**
Serial Correlation LM Test	F-statistic = 0.594 (p = 0.455)	F-statistic = 1.414 (p = 0.257)
Heteroskedasticity Test	F-statistic = 0.607 (p = 0.696)	F-statistic = 0.552 (p = 0.734)

Source: Prepared by the author based on diagnostic calculations using the revised regression models.

For the resource-efficiency model, the Breusch–Godfrey Serial Correlation LM Test produced an F-statistic of 0.594 with a probability value of 0.455. Since the probability value is greater than 0.05, the null hypothesis of no serial correlation cannot be rejected. Therefore, there is no statistically significant evidence of first-order serial correlation in the residuals.

For the inclusive-growth model, the corresponding LM test produced an F-statistic of 1.414 with a probability value of 0.257. This result also indicates no statistically significant evidence of first-order serial correlation in the residuals.

The Breusch–Pagan–Godfrey heteroskedasticity test produced an F-statistic of 0.607 with a probability value of 0.696 for the resource-efficiency model. Since the probability value is greater than 0.05, there is no statistically significant evidence of heteroskedasticity.

For the HDI model, the heteroskedasticity test produced an F-statistic of 0.552 with a probability value of 0.734. Therefore, the null hypothesis of homoskedastic residuals cannot be rejected, indicating no statistically significant evidence of heteroskedasticity in the inclusive-growth model.

Overall, the diagnostic tests do not indicate significant serial correlation or heteroskedasticity in either regression model.

Normality Test

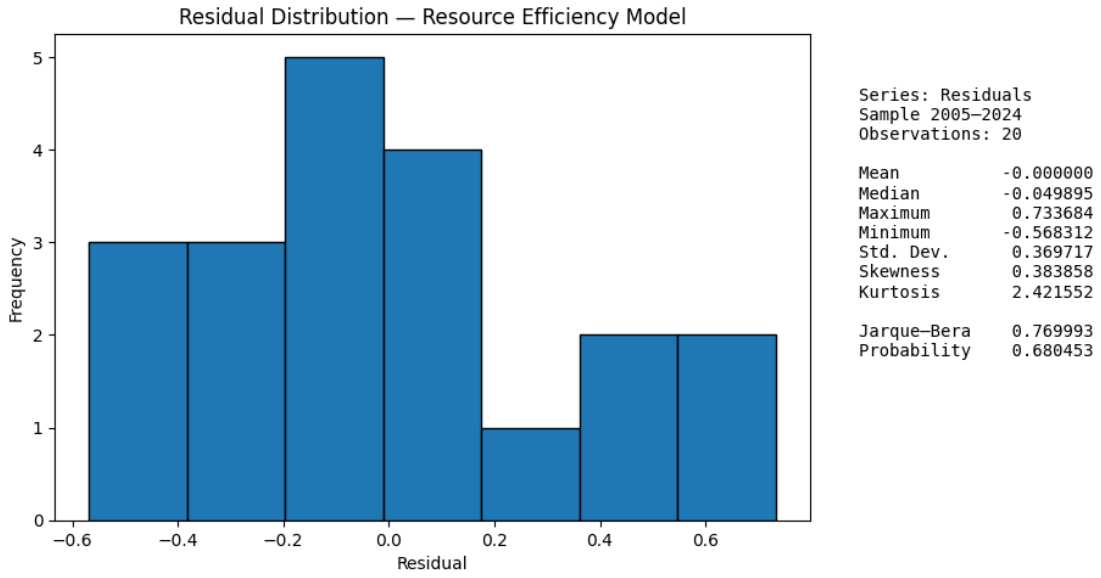
The normality of the regression residuals was evaluated using the Jarque–Bera test.

For the resource-efficiency model, the Jarque–Bera statistic was 0.770 with a probability value of 0.680. Since the probability value is greater than 0.05, the null hypothesis of normally distributed residuals cannot be rejected. The residuals therefore do not show a statistically significant departure from normality.

For the inclusive-growth model, the Jarque–Bera statistic was 0.912 with a probability value of 0.634. Again, the null hypothesis of normality cannot be rejected, indicating no statistically significant departure from normality in the residuals.

The normality results therefore support the residual-normality assumption for both estimated models.

Figure 1. Normality Test of the Residuals for the Resource Efficiency Model



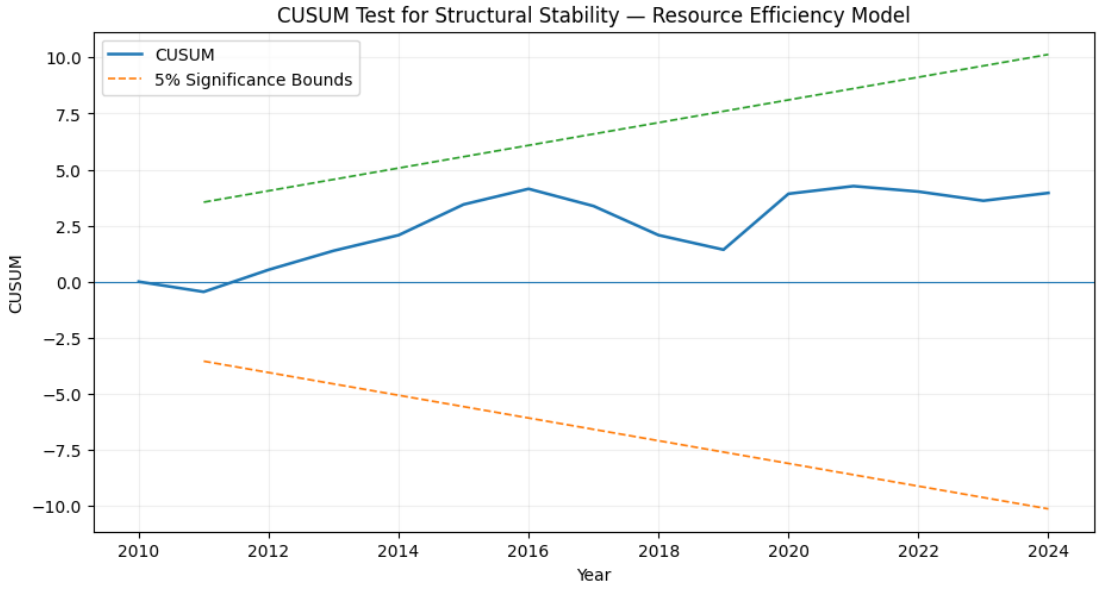
Source: Prepared by the author based on calculations using the revised regression model.

Figure 1 presents the distribution of the residuals for the resource-efficiency model. The Jarque–Bera statistic is 0.770 with a probability value of 0.680. Since the probability value is greater than 0.05, the null hypothesis of normally distributed residuals cannot be rejected.

Therefore, there is no statistically significant evidence of a departure from normality in the residuals of the resource-efficiency model.

Structural Stability Test (CUSUM Test)

Figure 2. CUSUM Test for Model Stability



Source: Prepared by the author based on calculations using the revised regression model.

Figure 2 presents the CUSUM test for the resource-efficiency model. The cumulative sum of recursive residuals remains within the 5% significance boundaries throughout the estimation period. Therefore, there is no statistically significant evidence of structural instability in the estimated model. The result suggests that the regression coefficients remain relatively stable over the study period.

Discussion of the Results in Light of the Hypotheses

First Hypothesis: The Relationship Between the Green Economy and Resource Efficiency

The first hypothesis proposed a statistically significant relationship between green economy indicators and resource efficiency in Iraq.

The empirical results show that carbon intensity has a strong negative and statistically significant relationship with resource efficiency (coefficient = −11.929, $p < 0.001$). This indicates that higher carbon intensity is associated with lower energy productivity, holding the other variables in the model constant. The finding is broadly consistent with the literature emphasizing the importance of energy efficiency and reduced environmental pressure in achieving greener and more sustainable economic development (Ofori et al., 2022).

GDP also has a positive and statistically significant relationship with resource efficiency (coefficient = 0.014, $p = 0.042$). This suggests that higher levels of economic activity may be associated with greater energy productivity.

In contrast, the share of renewable electricity generation does not show a statistically significant relationship with resource efficiency (coefficient = −0.012, $p = 0.790$). Inflation and trade openness are also statistically insignificant in this model.

Therefore, the first hypothesis is partially supported. Carbon intensity shows a statistically significant relationship with resource efficiency, whereas renewable electricity generation does not. However, because carbon intensity, GDP, and resource efficiency are non-stationary at level and become stationary after first differencing, the regression results should be interpreted cautiously as statistical associations rather than evidence of causal relationships.

Second Hypothesis: The Relationship Between the Green Economy and Inclusive Growth

The second hypothesis proposed a statistically significant relationship between green economy indicators and inclusive growth, represented in the empirical analysis by the Human Development Index (HDI).

The results show that GDP has a positive and statistically significant relationship with HDI (coefficient = 0.00039, $p < 0.001$). This finding suggests that higher levels of economic activity are associated with higher levels of human development in Iraq.

Carbon intensity also has a positive and statistically significant coefficient (coefficient = 0.02804, $p = 0.028$). In the context of Iraq, this result may reflect the structure of an oil-dependent rentier economy in which carbon-intensive economic activity is closely associated with oil production, government revenues, and public expenditure. This finding should not be interpreted as evidence that environmental degradation itself improves human development.

Renewable electricity generation has a negative and statistically significant relationship with HDI (coefficient = −0.00195, $p = 0.001$). This result should also be interpreted cautiously. It does not imply that renewable energy reduces human development. Rather, it may reflect the historical pattern observed in Iraq, where the renewable share of electricity generation declined substantially while HDI generally increased over time. The relationship between renewable energy, environmental performance, and human development may therefore depend on the economic structure and stage of the energy transition, as also suggested by previous research (Akpolat & Bakırtaş, 2024).

Inflation has a weak negative relationship with HDI that is statistically significant only at the 10% level (coefficient = −0.00020, $p = 0.070$). Trade openness, however, does not show a statistically significant relationship with HDI (coefficient = 0.00006, $p = 0.716$).

Within the estimated model, the second hypothesis receives statistical support because both principal green economy indicators—renewable electricity generation and carbon intensity—show

statistically significant relationships with HDI. Nevertheless, the direction of these relationships should be interpreted cautiously. The unit-root analysis indicates that HDI is stationary at level at the 10% significance level, whereas carbon intensity and GDP become stationary after first differencing. Given these mixed orders of integration, the estimated level-form OLS relationships should be interpreted as statistical associations rather than evidence of causality.

Third Hypothesis: The Role of Institutional Quality

The third hypothesis proposed that institutional quality and governance conditions play an important role in determining the effectiveness of green economy policies.

Institutional quality was not directly included as a variable in the econometric models because a sufficiently consistent annual series was not incorporated into the study dataset. Therefore, this hypothesis cannot be statistically tested using the estimated regression models.

Nevertheless, previous research indicates that governance quality, regulatory effectiveness, institutional capacity, and control of corruption can influence the effectiveness of energy-efficiency and green-growth policies. Ofori et al. (2022), for example, found that governance can strengthen the contribution of energy efficiency to inclusive green growth.

In the case of Iraq, institutional weaknesses, regulatory limitations, and administrative constraints may therefore reduce the effectiveness of environmental and energy reforms.

Accordingly, the third hypothesis is supported theoretically by the existing literature but is not empirically tested in the present study.

Fourth Hypothesis: Challenges of the Transition Toward a Green Economy in Iraq

The fourth hypothesis proposed that Iraq faces significant structural and institutional challenges in its transition toward a green economy.

The descriptive evidence provides support for this hypothesis. The share of renewable electricity generation declined substantially from 19.74% in 2005 to only 1.63% in 2024. At the same time, carbon intensity increased during the later part of the study period and reached 1.240 kg CO_2e per constant 2015 US dollar of GDP in 2024.

Resource efficiency also deteriorated in recent years. Energy productivity declined from its maximum value of 13.95 constant 2021 PPP dollars per kilogram of oil equivalent in 2016 to 8.30 in 2024.

These developments, together with Iraq's continuing dependence on oil revenues, infrastructure limitations, institutional weaknesses, and economic instability, indicate that the transition toward a green economy remains challenging. Therefore, the fourth hypothesis is supported by the descriptive evidence presented in the study.

Conclusions and Recommendations

First: Conclusions

The study examined the relationships between selected green economy indicators, resource efficiency, and inclusive growth in Iraq using annual data covering the period 2005–2024. The resource-efficiency model covers the full period 2005–2024, while the HDI model is estimated for 2005–2023 to maintain consistency with the internationally comparable UNDP HDI series. The main conclusions are as follows:

1. **Iraq has experienced a substantial decline in the share of renewable electricity generation.**

The renewable share declined from 19.74% in 2005 to 1.63% in 2024. This trend indicates that the relative contribution of renewable sources to electricity generation decreased considerably during the study period.

2. **Carbon intensity increased considerably during the later years of the study period.**

Carbon intensity increased from 0.928 kg CO_2e per constant 2015 US dollar of GDP in 2005 to 1.240 in 2024. The increase was particularly evident after 2019, indicating continuing dependence on carbon-intensive economic activity.

3. **Resource efficiency improved during part of the study period but subsequently deteriorated.**

Energy productivity increased and reached its maximum value of 13.95 constant 2021 PPP dollars per kilogram of oil equivalent in 2016. It then declined substantially, reaching 8.30 in 2024. This indicates that earlier improvements in energy productivity were not sustained.

4. **Carbon intensity is negatively associated with resource efficiency.**

The resource-efficiency regression showed a strong negative and statistically significant relationship between carbon intensity and energy productivity (coefficient = −11.929, $p < 0.001$). This result indicates that higher carbon intensity is associated with lower resource efficiency.

5. **GDP is positively associated with resource efficiency.**

GDP showed a positive and statistically significant relationship with resource efficiency (coefficient = 0.014, $p = 0.042$), suggesting that higher economic output may be associated with improved energy productivity.

6. **Renewable electricity generation does not show a statistically significant relationship with resource efficiency.**

The coefficient of renewable electricity generation was statistically insignificant ($p = 0.790$). Therefore, the model does not provide sufficient evidence of an independent relationship between renewable electricity generation and resource efficiency during the study period.

7. **Human development improved substantially despite limited environmental progress.**

The internationally comparable HDI series increased from 0.609 in 2005 to 0.695 in 2023. However, this improvement occurred while renewable electricity generation generally declined and carbon intensity increased during the later years.

8. **GDP has a strong positive relationship with human development.**

In the HDI model for 2005–2023, GDP showed a positive and statistically significant relationship with the Human Development Index (coefficient = 0.00039, $p < 0.001$).

9. **Carbon intensity has a positive statistical association with HDI, but this result should not be interpreted as an environmental benefit.**

Carbon intensity showed a positive and statistically significant coefficient in the HDI model (coefficient = 0.02804, $p = 0.028$). In Iraq's oil-dependent economy, this result may reflect the relationship between carbon-intensive production, oil revenues, public expenditure, and human development rather than a beneficial effect of environmental degradation.

10. **Renewable electricity generation has a negative statistical association with HDI in the estimated model.**

Renewable electricity generation showed a negative and statistically significant coefficient (coefficient = −0.00195, $p = 0.001$). This result should not be interpreted causally. It likely reflects the historical coexistence of declining renewable electricity shares and improving human-development indicators during much of the study period.

11. **Trade openness does not show a statistically significant relationship with HDI.**

Trade openness has a small positive but statistically insignificant coefficient ($p = 0.716$). Therefore, the study does not provide sufficient statistical evidence of an independent relationship between trade openness and HDI.

12. **Inflation shows only a weak negative relationship with human development.**

Inflation has a negative coefficient in the HDI model and is statistically significant only at the 10% level ($p = 0.070$). The result should therefore be interpreted cautiously.

13. **The econometric results require cautious interpretation because of the time-series properties of the variables.**

The ADF tests indicate that carbon intensity, GDP, and resource efficiency are non-stationary at level and become stationary after first differencing. Renewable electricity generation, trade openness, and HDI are stationary at level at the 10% significance level, while inflation is stationary at level at conventional significance levels. Consequently, the dataset contains a mixture of I(0) and I(1) variables, and the level-form OLS results should be interpreted as statistical associations rather than definitive evidence of causal relationships.

14. **Iraq continues to face significant structural and institutional barriers to green transition.**

Continued dependence on fossil fuels, declining renewable electricity shares, increasing carbon intensity, deterioration in energy productivity during recent years, infrastructure constraints, and institutional limitations remain major obstacles to the development of a greener and more resource-efficient economy.

Overall, the results indicate that improvements in human development in Iraq have not been accompanied by equivalent progress in environmental sustainability. The country therefore faces the challenge of maintaining economic and social development while reducing carbon intensity, improving energy productivity, and substantially expanding the role of renewable energy.

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