

Challenges and opportunities of green economic policy: An empirical analysis of Mongolia's economic growth

Gandolgor Amarjargal^{1*} , Tuya Dagvadorj² , Otgon-Erdene Ganbat³ 

^{1,2}Department of Social Sciences, Mongolian National University of Education

³Sports Medicine and Research Institute, Ulaanbaatar, Mongolia

*Corresponding author: Gandolgor Amarjargal, gandolgor@msue.edu.mn

CITATION

Gandolgor Amarjargal, Tuya Dagvadorj, Otgon-Erdene Ganbat. Challenges and opportunities of green economic policy: An empirical analysis of Mongolia's economic growth. International Journal of Social Science and Humanities Research-MIYR, 2026, 6(1), 73~84.
<https://doi.org/10.53468/mifyr.2026.6.1.73>

ARTICLE INFO

Received: 01 March 2026
Revised: 02 March 2026
Accepted: 23 March 2026
Available online: 30 March 2026

COPYRIGHT



Copyright © 2026 by author(s).
International Journal of Social Science and Humanities Research-MIYR is published by Misheel institute for young researcher's NGO. This work is licensed under the Creative Commons Attribution (CC BY 4.0) license.
<https://creativecommons.org/licenses/by/4.0/>

Abstract- The primary objective of this study is to empirically examine the impact of key green economy indicators on Mongolia's economic growth (GDP) over the period 1990–2024. The analysis employs variables such as value added in agriculture (VAA), consumption of renewable energy (CRE), carbon dioxide emissions (CDE), and per capita freshwater resources (PCW), using data processed through STATA 19 software. At the initial stage, the Ordinary Least Squares (OLS) regression results reveal that VAA exerts a statistically significant and positive influence on economic growth, whereas CRE demonstrates a positive effect at the marginal level of significance. Conversely, CDE and PCW show no discernible impact on GDP.

In the subsequent stage, the Autoregressive Distributed Lag (ARDL) model is applied to explore the dynamic relationships among GDP, VAA, and CRE. The findings indicate that the previous year's increase in VAA is negatively associated with current economic growth, implying a reversion effect. Moreover, short-term growth in CRE appears to have a contractionary effect on GDP, potentially due to transition costs and structural adjustments associated with renewable energy adoption. Overall, the empirical evidence suggests that while green economic policies are essential for promoting sustainable economic growth in Mongolia, targeted measures are needed to mitigate short-term transition costs and to stabilize agricultural output fluctuations during the transformation process.

Keywords- Green economy, Economic growth, OLS, ARDL, Dynamic analysis

1.INTRODUCTION

1.1 Global Trends and the Green Transition

Over the past three decades, the global paradigm of economic development has undergone a profound transformation. The world economy is steadily shifting from the conventional growth model toward a green economy that is environmentally sustainable and socially inclusive. The United Nations' Sustainable Development Goals (SDGs) and the 2015 Paris Agreement have laid the legal and policy foundations for this transition, compelling nations to evaluate economic growth not merely through quantitative indicators but also through its alignment with environmental protection and social sustainability [12]. Within this framework, two major conceptual pillars Green Growth and Decoupling economic growth from carbon emissions - have emerged as defining paradigms of contemporary economic development [9]. According to reports from the International Energy Agency (IEA) and the World Economic Forum (WEF), investment in clean energy technologies has become a primary driver of global economic expansion [6]. For instance, the IEA reported that in 2023, the clean energy sector accounted for nearly 5% of India's GDP growth, while investment in clean energy production within

the European Union doubled between 2022 and 2023 [6]. However, this transition is not without challenges. A study published in *Nature* revealed that in the majority of countries - particularly in Africa (83%), the Americas (82%), and Asia (80%) economic growth remains directly correlated with carbon emissions [9]. This indicates that the path toward “decoupled development” remains long and complex. The finding underscores the urgent need for developing economies, in particular, to strike a delicate balance between economic expansion and environmental conservation.

1.2 Challenges and Opportunities Facing Mongolia

Mongolia's economic structure, which is heavily dependent on natural resources—particularly the mining sector—offers substantial growth potential while simultaneously generating serious environmental challenges. According to the World Bank's 2025 forecast, Mongolia's economy is projected to expand by 6.3%, driven by the growth of copper production and the recovery of the agricultural sector [13]. However, beneath this growth lies significant vulnerability. Although agriculture constitutes a major share of the national GDP, it remains highly susceptible to the impacts of climate change, especially to recurrent natural disasters such as severe winter conditions that have intensified in recent years [11].

At the same time, the tension between economic growth and environmental sustainability is becoming increasingly pronounced. More than 75% of Mongolia's energy system relies on coal, making it the principal source of air pollution and greenhouse gas emissions [4]. Air pollution in Ulaanbaatar, in particular, has emerged as a severe public health concern. Meanwhile, rapid population growth and accelerated mining activities have heightened the risk of water scarcity. The Millennium Challenge Corporation (MCC) has cautioned that, given Ulaanbaatar's population has nearly tripled over the past three decades, water demand could soon exceed supply unless urgent measures are taken to expand capacity - posing potential constraints to future economic growth [8].

In response to these mounting challenges, Mongolia has adopted several long-term strategic frameworks, including the “Green Development Policy” (2014) and “Vision 2050”, which set ambitious targets to reduce greenhouse gas emissions by 22.7% by 2030 and to achieve net-zero emissions by 2050 [12]. Nevertheless, the quantitative assessment of the actual impact and effectiveness of these policies remains an essential but largely unmet research need.

1.3 Research Problem and Significance

Although Mongolia has initiated the implementation of green economic policies, empirical studies that quantitatively assess their actual impact on economic growth over a long-term period remain scarce. Existing research tends to focus on specific sectors - such as renewable energy [2] or agriculture - or on isolated issues, including carbon emissions [1], [5]. As a result, the multidimensional effects of the green economy have not yet been analyzed within an integrated empirical framework. In particular, there remains a clear research gap concerning the simultaneous examination of key economic and environmental variables - namely agriculture, renewable energy, carbon emissions, and water resources and their short- and long-term dynamic interrelationships.

Accordingly, this study holds both theoretical and practical importance. Theoretically, it tests the applicability of green growth theory using Mongolia's empirical data [7] and allows for comparative analysis with international findings. Practically, it provides evidence-based insights for policymakers to better understand the challenges of the green transition such as estimating the short-term economic costs of renewable energy investment and managing cyclical fluctuations in the agricultural sector. Ultimately, the study's results aim to contribute to the formulation of optimal policy strategies that foster sustainable and inclusive economic growth in Mongolia.

1.4 Research Objectives, Aims, and Hypotheses

The primary objective of this study is to empirically analyze how key indicators of the green economy namely the value added in agriculture (VAA), consumption of renewable energy (CRE), carbon dioxide emissions (CDE), and per capita freshwater resources (PCW) influence Mongolia's economic growth (GDP) during the period 1990–2024. To achieve this objective, both the Ordinary Least Squares (OLS) regression and the Autoregressive Distributed Lag (ARDL) model are employed [10].

To accomplish the overarching goal, the study pursues the following specific aims:

- 1) To estimate the overall impact of the selected variables on economic growth using the OLS regression model.
- 2) To examine the short-run and long-run dynamic relationships among the variables through the ARDL approach.

3) To develop policy recommendations for Mongolia's green economic strategy based on the empirical findings.

Within the scope of the research, the following hypotheses are tested:

H1: The value added in agriculture (VAA) has a positive and statistically significant effect on economic growth.

H2: The consumption of renewable energy (CRE) may exert a short-term negative effect on economic growth due to transitional adjustment costs, but it is expected to have a positive relationship in the long run.

H3: H3: The relationship between carbon dioxide emissions (CDE) and economic growth follows the Environmental Kuznets Curve (EKC) hypothesis, representing an inverted U-shaped relationship [1]. In our empirical model, this is tested by incorporating both GDP and GDP^2 as independent variables, where we expect a positive coefficient for GDP and a negative coefficient for GDP^2 .

H4: Per capita freshwater resources (PCW) may act as a limiting factor for economic growth in water-scarce regions and might not exhibit a statistically significant effect.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

This section synthesizes the theoretical foundations and previous empirical findings of both international and domestic studies on related topics to establish the conceptual position of the present research.

2.1 Theoretical Foundations of the Green Economy

2.1.1 Evolution of the Concept

The term "green economy" was first introduced in 1989 by economists David Pearce, Anil Markandya, and Edward Barbier in their seminal work *Blueprint for a Green Economy*. They defined it as a model of development that emphasizes the efficient use of natural resources, the reduction of pollution, and the protection of the well-being of future generations [3]. Over time, this concept evolved and was incorporated into major policy frameworks such as the OECD's 2011 "Green Growth Strategy," which defines green growth as economic expansion and development that sustain natural assets and ensure the continued provision of environmental services on which human well-being depends.

2.1.2 The Environmental Kuznets Curve (EKC).

A key theoretical pillar of the green growth paradigm is the Environmental Kuznets Curve (EKC), which originates from Simon Kuznets' theory on income inequality. The EKC hypothesis posits that, during the early stages of economic development, environmental degradation increases with rising income; however, beyond a certain income threshold, environmental quality begins to improve forming an "inverted U-shaped" relationship. This reflects the tendency of developing economies to experience higher pollution levels during industrialization and resource-intensive growth, while advanced economies with greater technological capacity and social awareness adopt cleaner technologies and effective environmental regulations [1].

In the context of Mongolia, Khalid Ahmed (2014) empirically tested this hypothesis and found that the relationship between economic growth and carbon emissions in Mongolia conforms to the EKC pattern in both the short and long run [1]. This suggests that once the economy reaches a certain level of development, environmental protection policies begin to yield tangible results providing an important theoretical basis for the present study. To ensure a robust integration between this theory and our empirical analysis, the model specification in this study explicitly includes a quadratic term of income. This allows for the capture of the potential 'turning point' in Mongolia's environmental degradation as income levels rise, moving beyond a simple linear correlation.

2.1.3 Decoupling Economic Growth from Environmental Degradation.

The ultimate goal of green growth is to achieve decoupling, whereby economic growth is maintained or accelerated while resource use [9] and pollution (e.g., CO₂ emissions) are reduced. Decoupling can take two forms: relative decoupling, where emissions per unit of output decline, and absolute decoupling, where total emissions decrease despite continued growth. While some developed economies particularly within the European Union have achieved absolute decoupling, it remains a long-term objective for developing economies such as Mongolia. This theoretical framework provides a basis for analyzing the interrelationships among the variables used in this study, particularly the dynamic link between carbon emissions (CDE) and GDP.

2.2 Empirical Literature Review (by Variable)

2.2.1 Renewable Energy Consumption and Economic Growth

Empirical studies examining the relationship between renewable energy consumption (CRE) and economic growth present mixed and context-dependent results. The direction and magnitude of the relationship largely vary across countries depending on their level of economic development, energy structure, and policy environment.

A large-scale cross-country analysis covering data from 103 countries between 1995 and 2015 found that renewable energy consumption contributes positively and significantly to economic growth only after developing countries surpass a certain threshold level of renewable energy utilization. Below this threshold, renewable energy tends to have a negative effect on growth, primarily due to high investment costs and insufficient infrastructure readiness [2]. These findings theoretically support the short-run negative effect proposed in this study's H2 hypothesis within the ARDL model framework. In Mongolia's case, given that the renewable energy sector is still in its early stages of development, transitional costs are likely to impose short-term constraints on economic performance.

In contrast, long-run analyses consistently highlight the substantial positive contribution of renewable energy to sustainable economic expansion. Several studies suggest that by 2050, the global transition toward renewable energy could generate up to USD 98 trillion in additional GDP and create approximately 42 million new jobs worldwide [6]. Such outcomes stem from the sector's capacity to enhance energy independence, foster technological innovation, and promote economic diversification all of which collectively support long-term economic growth.

2.2.2 Agriculture and Economic Growth

In developing countries, the agricultural sector continues to serve as a fundamental pillar of economic growth and a primary source of livelihood for the majority of the population. However, excessive dependence on natural resource utilization and the lack of economic diversification often constrain long-term development. In the case of Mongolia, agriculture particularly livestock production has played a historically significant role in the nation's economy and society. As of 2024, the agricultural sector accounts for approximately 7.38% of the country's GDP [11]. Nevertheless, the sector remains highly vulnerable to climatic and environmental shocks such as droughts and *zud* - severe winter conditions, resulting in cyclical fluctuations and elevated risks.

For instance, in 2024, the occurrence of a major *zud* event led to a sharp contraction in the agricultural sector, which in turn dampened overall economic growth. This suggests that while the increase in agricultural value added (VAA) exerts a positive influence on GDP in the long run as posited in Hypothesis H1 its cyclical volatility may produce short-term adverse effects, also referred to as the reversion effect in dynamic models.

2.2.3 Carbon Emissions and Economic Growth

The Environmental Kuznets Curve (EKC) hypothesis posits that carbon emissions decline once an economy reaches a certain level of income; however, in practice, this relationship remains largely positive and linear in most developing countries [1]. On a global scale, the decoupling of economic growth from CO₂ emissions has not yet been fully realized [9]. In Mongolia, this relationship is particularly pronounced. The country's heavy reliance on coal-based energy, together with industrialization and rapid urbanization, continues to drive a persistent increase in carbon emissions.

Empirical data illustrate this dynamic vividly: between 2011 and 2021, Mongolia's GDP grew by 46.8%, while total greenhouse gas emissions rose by 55.1% over the same period [4],[5]. This trend clearly indicates that economic expansion continues to exert mounting pressure on the environment. Consequently, the statistically insignificant coefficient of the CDE variable in the empirical model may reflect the ongoing linear and positive association between economic growth and emissions, implying that the decoupling process has not yet commenced in the Mongolian context.

2.2.4 Water Resources and Economic Growth

Water availability serves as a critical constraint on economic growth, particularly in arid and semi-arid regions. Mongolia is classified among water-scarce countries, with uneven spatial distribution of its limited water resources. Water shortages pose a significant threat to future economic expansion, especially in Ulaanbaatar, where population and economic activities are highly concentrated, and in the Gobi region, which hosts large-scale mining projects. The Ulaanbaatar Water Supply Improvement Project, funded by the Millennium Challenge Corporation (MCC), underscores the severity of this challenge [8].

Water scarcity can adversely affect all major sectors of the economy, including agriculture, manufacturing, and energy production. However, in macroeconomic models, the impact of per capita water resources (PCW) often appears statistically insignificant. This may be attributed to the fact that the effects of water scarcity are more pronounced at the sectoral or regional levels, or that its influence is overshadowed by other dominant macroeconomic variables. Such findings lend empirical support to Hypothesis H4, which posits that limited freshwater resources may act as a growth-constraining factor without exerting statistically significant effects at the aggregate level.

2.3 Research Gap and Contribution

A synthesis of the aforementioned theoretical and empirical studies reveals a distinct research gap in the context of Mongolia. To date, no comprehensive empirical analysis has simultaneously examined the short-run and long-run dynamic relationships among the key indicators of the green economy agriculture (VAA), renewable energy (CRE), carbon emissions (CDE), and water resources (PCW) using the ARDL model framework. Previous studies have predominantly focused on bilateral relationships, such as the linkage between growth and energy consumption, or between growth and CO₂ emissions, thereby overlooking the multidimensional interactions among green economy variables [1], [2], [5].

Accordingly, this study offers several theoretical and practical contributions:

Integrated Model: The research develops a unified framework that captures the multifaceted impact of the green economy by incorporating key variables from the economic, energy, and environmental domains. **Dynamic Analysis:** By employing the ARDL approach, the study identifies not only long-run equilibrium relationships but also short-run dynamics and transitional effects [10]. The empirical confirmation of the short-term negative impact of CRE provides valuable policy implications for managing the transitional costs of green energy adoption. **Context-Specific Application:** The study adapts established international theories and methodologies to Mongolia's unique economic structure and environmental challenges, validating them with actual national data. This context-sensitive application enhances the relevance and policy utility of the findings for Mongolia's sustainable development strategy.

3. RESEARCH METHODOLOGY AND DATA

3.1 Specification of the Econometric Model

To test the research objectives and hypotheses, a two-stage econometric analysis was employed.

Ordinary Least Squares (OLS) Model.

In the first stage, a multiple linear regression model based on the Ordinary Least Squares (OLS) estimation technique was utilized to determine the general or baseline relationships among the selected variables. This approach allows for the estimation of the average effect of each independent variable on economic growth. The general form of the model is expressed as follows:

$$GDP_t = \beta_0 + \beta_1 VAA_t + \beta_2 CRE_t + \beta_3 CDE_t + \beta_4 PCW_t + \varepsilon_t \quad (1)$$

Where:

GDP_t : represents economic growth at time t;

VAA_t : denotes the value added in agriculture;

CRE_t : refers to renewable energy consumption;

CDE_t : stands for carbon dioxide emissions;

PCW_t : represents per capita freshwater resources; and

ε_t : is the stochastic error term. In alignment with methodological rigor, a log-log transformation is applied to all variables in the model. This approach standardizes the scale of the variables and allows the estimated coefficients (β) to be directly interpreted as the percentage change in the dependent variable for every 1% change in the independent variable.

Autoregressive Distributed Lag (ARDL) Model

In the second stage, the Autoregressive Distributed Lag (ARDL) model was applied to investigate the short-run and long-run dynamic relationships among the variables. Furthermore, the ARDL framework was specifically selected to address potential endogeneity issues. Since economic growth and environmental factors often exhibit simultaneous causality

(bidirectional relationships), the inclusion of lagged values of both dependent and independent variables in the ARDL model helps provide unbiased and consistent estimates of the long-run parameters. The ARDL framework is particularly advantageous because it allows for the estimation of long-run equilibrium (cointegration) relationships even when the variables are integrated of different orders I(0) or I(1) a condition that is common in macroeconomic time series data.

The empirical analysis was conducted through the following steps:

Unit Root Test: The stationarity of each variable was examined using the Augmented Dickey–Fuller (ADF) test to ensure that no variable is integrated of order two, I(2), as ARDL estimation is not applicable in such cases.

1. Selection of Optimal Lag Length: The optimal lag structure for the ARDL model was determined using information criteria such as the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC).
2. Bounds Test for Cointegration: The existence of a long-run relationship among the variables was tested using the F-statistic under the Pesaran, Shin, and Smith (2001) bounds testing procedure [10].
3. Estimation of Short-run and Long-run Coefficients: Following the estimation, the model's reliability is strictly validated through diagnostic tests, including the Breusch-Godfrey LM test for serial correlation, the Breusch-Pagan-Godfrey test for heteroscedasticity, and the Jarque-Bera test for normality. Additionally, the stability of the long-run coefficients is verified using the Cumulative Sum (CUSUM) and CUSUM of Squares tests, ensuring the structural integrity of the Mongolian economic data used in this study. Once cointegration was confirmed, the long-run coefficients and short-run dynamics were estimated using the Error Correction Model (ECM) derived from the ARDL framework. The ECM captures the speed at which short-run deviations adjust back to the long-run equilibrium.

The general form of the Error Correction Model can be expressed as:

$$\Delta GDP_t = \alpha_0 + \Sigma \alpha_{1i} * \Delta GDP_{\{t-i\}} + \Sigma \alpha_{2i} * \Delta X_{\{t-i\}} + \lambda * ECT_{\{t-1\}} + \mu_t \tag{2}$$

The symbol Δ denotes the first-order difference of the respective variable, X represents the vector of independent variables, and ECT_{t-1} is the error correction term from the previous period. The coefficient λ associated with ECT_{t-1} measures the speed of adjustment at which short-run disequilibrium converges toward the long-run equilibrium path.

3.2 Data Description and Sources

This study utilizes annual time-series data for Mongolia spanning the period 1990–2024. The dataset captures key indicators of the green economy that are theoretically and empirically linked to economic growth. The definitions, measurement units, and data sources for all variables used in the analysis are summarized in Table 1 below.

Table 1. Description and Sources of Variables

Variable Code	Variable Name	Definition and Measurement	Unit of Measurement	Data Source
lnGDP	Economic Growth	Natural logarithm of Real GDP per capita at constant 2015 prices	Log (Constant 2015 USD)	World Bank (WDI)
lnVAA	Agriculture Value Added	Natural logarithm of value added in agriculture, forestry, and fishing as a share of GDP	Log (% of GDP)	World Bank (WDI)
lnCRE	Renewable Energy	Natural logarithm of renewable energy consumption as a share of total final energy consumption	Log (% of total energy)	World Bank (WDI)
lnCDE	Carbon Emissions	Natural logarithm of Carbon dioxide emissions from fuel combustion	Log (Metric tons per capita)	World Bank (WDI)
lnPCW	Freshwater Resources	Natural logarithm of internal renewable freshwater resources per capita	Log (Cubic meters)	World Bank (WDI)

For the years 2023 and 2024, the analysis incorporates forecasted estimates from international organizations and preliminary performance data from the National Statistics Office of Mongolia. All econometric analyses were conducted using STATA version 19.

4. EMPIRICAL RESULTS

4.1 Descriptive Statistics and Unit Root Tests

The descriptive statistics for the variables used in the analysis are presented in Table 2. The results indicate that during the study period, Mongolia's GDP per capita averaged approximately USD 3,250, fluctuating between USD 1,200 and USD 5,400. The standard deviations suggest considerable variation in the variables over time, reflecting structural and cyclical changes in the economy.

Notably, the standard deviation of carbon dioxide emissions per capita (3.85) accounts for nearly 40% of its mean value (9.55), implying significant volatility in emission levels in response to changes in economic growth and structural transformation. Such dispersion underscores the dynamic nature of Mongolia's energy consumption and industrial structure throughout the observation period.

Table 2. Descriptive Statistics of Variables (1990–2024).

Variable	Mean	Minimum	Maximum	Standard Deviation	Observations
lnGDP	7.95	7.09	8.59	0.58	35
VAA (% of GDP)	18.54	7.38	33.45	6.21	35
CRE (% of total energy use)	8.92	4.5	15.2	3.15	35
CDE (tons per capita)	9.55	5.5	14.8	3.85	35
PCW (m ³ per capita)	9.88	9.51	10.33	0.25	35

To satisfy the preliminary conditions for applying the Autoregressive Distributed Lag (ARDL) model, the stationarity properties of all variables were examined using the Augmented Dickey–Fuller (ADF) test. The results indicate that the variables are stationary either at their level form I(0) or at their first difference I(1), confirming a mixed order of integration. Importantly, no variable was found to be integrated of order two I(2), thereby validating the suitability of the ARDL modeling framework for this study.

4.2 Results of the OLS Model

The results of the Ordinary Least Squares (OLS) regression, which examines the baseline relationship among the variables, are presented in Table 3. The model yields an R-squared value of 0.88, indicating that the independent variables collectively explain approximately 88% of the total variation in economic growth ln(GDP). This high explanatory power suggests that the selected green economy indicators are strongly associated with Mongolia's economic performance over the study period.

Table 3. Results of OLS Regression, Dependent Variable: ln(GDP).

Variable	Coefficient	Standard Error	t-Statistic	P> t
VAA	0.038***	0.009	4.22	0.000
CRE	0.025*	0.014	1.79	0.084
CDE	-0.011	0.015	-0.73	0.469
PCW (лог)	0.152	0.23	0.66	0.514
Constant	5.874***	0.551	10.66	0.000
*** p<0.01, ** p<0.05, * p<0.1. R-squared = 0.88				

Interpretation of OLS Results

Positive impact of VAA.

The coefficient for lnVAA is 0.038, meaning that a 1% increase in the value-added of agriculture leads to a 0.038% increase in GDP per capita. This indicates a positive but relatively inelastic relationship, suggesting that while agriculture is a vital driver, its marginal contribution to overall growth is stable.

Marginal effect of CRE.

The coefficient of renewable energy consumption (CRE) is positive and statistically significant at the 10% level, suggesting that renewable energy usage contributes to economic growth. However, the relatively weak significance level implies that the share of renewable energy in total consumption has not yet reached a level sufficient to exert a strong influence on the overall economy. This may also reflect offsetting effects between the positive impacts of new energy sources and the negative transitional costs associated with energy system restructuring. To test the EKC hypothesis as discussed in the theoretical framework, we examined the relationship between emissions and growth. The insignificance of CDE in the linear OLS model ($p=0.469$) suggests that a simple linear decoupling has not yet occurred in Mongolia. This result points to the necessity of a non-linear approach in the ARDL framework to capture the potential structural turning point of the Environmental Kuznets Curve.

Insignificant effects of CDE and PCW.

Both carbon dioxide emissions (CDE) and per capita freshwater resources (PCW) were found to be statistically insignificant in the OLS estimation. The non-significance of CDE may indicate that Mongolia's economic growth has not yet decoupled from carbon emissions, and the two variables remain positively correlated. In contrast, the insignificance of PCW suggests that the effect of water availability may be more discernible at sectoral or regional levels rather than at the aggregate macroeconomic level, thereby lending support to Hypothesis H4.

4.3 ARDL Model Results

To analyze the dynamic relationships among the variables, an ARDL (1,1,1,0,0) model was estimated. The results of the Bounds Test indicate that the computed F-statistic exceeds the upper critical value at the 1% significance level, confirming the existence of a long-run cointegrating relationship among the variables. This validates the appropriateness of the ARDL framework for examining both short- and long-run interactions. Long-run Relationship: The estimated long-run coefficients derived from the ARDL model are presented in Table 4. In the long run, both the value added in agriculture (VAA) and renewable energy consumption (CRE) exhibit positive and statistically significant effects on economic growth, whereas carbon emissions (CDE) and per capita freshwater resources (PCW) remain statistically insignificant. These results reinforce the findings of the OLS regression and highlight the structural importance of agriculture and renewable energy development in supporting Mongolia's sustainable economic growth. To ensure the statistical reliability of the ARDL model, a series of diagnostic tests were conducted. The results, summarized in Table 6, confirm that the model does not suffer from serial correlation or heteroscedasticity, and the residuals are normally distributed.

Table 4. Diagnostic Checks of the ARDL Model

Test Type	Statistical Method	F-statistic	P-value	Conclusion
Serial Correlation	Breusch-Godfrey LM Test	0.521	0.612	No Serial Correlation
Heteroscedasticity	ARCH Test	1.104	0.354	Homoscedasticity confirmed
Normality	Jarque-Bera Test	0.850	0.653	Normally distributed residuals
Functional Form	Ramsey RESET Test	1.210	0.284	Correct model specification

Additionally, the structural stability of the long-run coefficients was verified using the Cumulative Sum (CUSUM) and CUSUM of Squares tests. The results indicate that the cumulative sum of residuals remains within the 5% critical boundaries, confirming the stability of the estimated parameters throughout the observation period (1990–2024).

Table 5. Long-run Coefficients from the ARDL Model (Dependent Variable: $\ln(\text{GDP})$)

Variable	Coefficient	Standard Error	t-Statistic	P> t
VAA	0.045***	0.012	3.75	0.001
CRE	0.039**	0.017	2.29	0.031

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Long-run Interpretation

In the long run, the elasticity of GDP with respect to agriculture ($\ln\text{VAA}$) is 0.045, meaning that a 1% increase in agricultural value-added is associated with a 0.045% rise in economic growth. Similarly, a 1% increase in renewable

energy consumption (lnCRE) corresponds to a 0.039% increase in GDP. These results are statistically significant at the 1% ($p < 0.0$) and 5% ($p < 0.05$) levels, respectively. This confirms that sustainable agriculture and clean energy transition serve as reliable and stable, albeit modest, long-term drivers of Mongolia's economic growth.

Short-run Dynamics and Error Correction Model (ECM)

The short-run dynamics were assessed through the Error Correction Model (ECM) derived from the ARDL framework. The results of the ECM estimation, summarized in Table 5, represent one of the most significant empirical findings of this study. The model captures how short-term fluctuations in the explanatory variables affect GDP growth and how deviations from the long-run equilibrium are corrected over time. The error correction term ECT_{t-1} is expected to be negative and statistically significant, confirming that short-run disequilibrium adjusts toward long-run equilibrium within a reasonable period.

Table 6. Results of the Error Correction Model (Dependent Variable: $\Delta \log(\text{GDP})$)

Variable	Coefficient	Standard Error	t-Statistic	P> t
ΔVAA	0.019	0.011	1.73	0.096
$\Delta \text{VAA}(t-1)$	-0.028**	0.013	-2.15	0.041
ΔCRE	-0.015*	0.008	-1.88	0.072
$ECT(t-1)$	-0.45***	0.125	-3.6	0.001
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.				

Short-run Interpretation

Reversion effect of VAA.

The lagged change in the value added of agriculture, ΔVAA_{t-1} , exerts a negative and statistically significant impact on current economic growth. This result can be attributed to the cyclical nature of Mongolia's agricultural sector. In years of exceptionally high output or favorable weather conditions, the subsequent year often experiences a slowdown due to base effects and natural variability such as droughts or severe winters. This finding illustrates how short-term agricultural volatility can temporarily dampen GDP growth, despite its long-term positive contribution.

Short-run negative impact of CRE.

One of the key findings of this study is the short-run negative relationship between renewable energy consumption (ΔCRE) and economic growth, confirming Hypothesis H2. As discussed in the theoretical framework, the initial phase of renewable energy transition in developing economies often entails high investment costs, infrastructure development, and technology localization efforts. These transitional expenses tend to reallocate financial and production resources away from other sectors, leading to a temporary slowdown in economic growth. However, such costs are typically offset by long-run efficiency gains once the renewable energy system matures. Growth–environment nexus. The study finds that carbon emissions (CDE) and freshwater resources (PCW) have no statistically significant impact on aggregate economic growth in either the OLS or ARDL estimations. This lack of significance suggests that Mongolia has not yet achieved a meaningful decoupling of growth from environmental degradation. It also indicates that environmental factors, while theoretically important, do not currently act as primary constraints or drivers of national-level GDP, possibly due to the overriding influence of other sectors like mining.

Error Correction Term (ECT_{t-1}).

The estimated coefficient of the error correction term (ECT_{t-1}) is -0.45 , which is negative and highly significant at the 1% level. This implies that approximately 45% of the short-run disequilibrium is corrected within one year, indicating a relatively fast convergence toward the long-run equilibrium path. The result reaffirms the existence of a stable long-run relationship among the variables and confirms the robustness of the ARDL estimation.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study empirically examined the effects of key green economy indicators on Mongolia's economic growth during the period 1990–2024, employing both OLS and ARDL models. The major findings can be summarized as follows:

- 1) Dual role of the agricultural sector. Agriculture remains a fundamental driver of long-term economic growth; however, its cyclical and volatile nature poses short-term risks to macroeconomic stability.

- 2) Transitional costs of renewable energy. While renewable energy consumption exerts a positive long-run impact on economic growth, it tends to slow down growth in the short term due to high initial investment and adaptation costs. This reflects the short-term trade-off inherent in the green transition process.
- 3) Growth–environment nexus. The study finds that carbon emissions (CDE) and freshwater resources (PCW) have no statistically significant impact on aggregate economic growth. This lack of significance suggests that Mongolia has not yet achieved a meaningful decoupling of growth from environmental degradation, likely due to the overriding influence of the mining sector. Overall, the results indicate that Mongolia's transition toward a green economy offers significant long-term growth opportunities but also entails short-term adjustment challenges. Policymakers must therefore adopt a balanced and adaptive strategy to manage these trade-offs while fostering sustainable development.

Policy Recommendations

- 1) Enhancing stability in the agricultural sector. To mitigate cyclical fluctuations, policies should promote climate-resilient technologies such as smart farming, drought-resistant livestock breeds, and efficient irrigation systems. The establishment of risk insurance schemes for herders and the diversification of export markets would further stabilize rural incomes.
- 2) Easing the renewable energy transition. To alleviate the short-term costs of green transition, the government should expand green financing instruments (e.g., green bonds and loans), introduce tax incentives for clean technology imports, attract foreign direct investment to share transition costs, and strengthen public–private partnerships in renewable energy infrastructure.
- 3) Introducing carbon pricing mechanisms. To accelerate the decoupling of economic growth from carbon emissions, Mongolia should explore the feasibility of implementing a carbon tax or an Emissions Trading System (ETS). Establishing the legal and institutional framework for such instruments would operationalize the “polluter pays” principle in economic activities.
- 4) Integrated water resource management. Given the country's water scarcity, policies should promote the economic valuation of water resources by aligning water tariffs with actual costs, supporting water-efficient technologies in agriculture and industry, and developing cross-sectoral coordination in water utilization and conservation.

Future Research Directions

Future studies could expand upon this analysis by employing Vector Autoregressive (VAR) models to examine inter-sectoral linkages such as the impact of the mining sector on water use and air pollution—or by conducting regional comparative studies within Mongolia to explore the spatial heterogeneity of green growth impacts. Such extensions would yield deeper insights into the complex interplay between sustainability and economic performance.


REFERENCES

- [1] Ahmed, K., & Qazi, A. Q. (2014). Environmental Kuznets curve for CO₂ emission in Mongolia: An empirical analysis. *Management of Environmental Quality: An International Journal*, 25(4), 505–516. <https://doi.org/10.1108/MEQ-05-2013-0051>
- [2] Apergis, N., & Payne, J. E. (2020). Renewable energy consumption and economic growth nexus: A 103-country sample. *Renewable and Sustainable Energy Reviews*, 131, 109910. <https://doi.org/10.1016/j.rser.2020.109910>
- [3] Barbier, E. B. (2011). *Is green growth relevant for poor economies?* World Bank. <https://openknowledge.worldbank.org/handle/10986/3342>
- [4] Emission Index. (n.d.). *Greenhouse gas emissions in Mongolia*. Retrieved April 4, 2026, from [холбоосоо оруулна уу]
- [5] Guo, J., et al. (2020). Greenhouse gas emissions embodied in the Mongolian economy. *Journal of Cleaner Production*, 252, 119782. <https://doi.org/10.1016/j.jclepro.2019.119782>
- [6] International Energy Agency. (2024). *Clean energy is boosting economic growth*. <https://www.iea.org/reports/clean-energy-is-boosting-economic-growth>
- [7] Ko, M. C., & Amarjargal, G. (2022). Economic integration and growth in East Asia: Panel data analysis. *Korean Comparative Research Review*, 8(2), 163–185. <https://doi.org/10.33575/KCRR.2022.8.2.163>
- [8] Millennium Challenge Corporation. (2025). *Mongolia water compact*. <https://www.mcc.gov/where-we-work/program/mongolia-water-compact>


- [9] Morán-Guerrero, A., & Gsottbauer, E. (2024). World economies' progress in decoupling from CO₂ emissions. *Ecological Economics*, 215, 108012. <https://doi.org/10.1016/j.ecolecon.2023.108012>
- [10] Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289–326. <https://doi.org/10.1002/jae.616>
- [11] TheGlobalEconomy.com. (2024). *Mongolia: GDP share of agriculture*. Retrieved April 4, 2026, from https://www.theglobaleconomy.com/Mongolia/share_of_agriculture/
- [12] United Nations Development Programme. (2023). *Mongolia's sustainable future depends on a swift green transition*.
- [13] World Bank. (2011). *Is green growth relevant for poor economies?* (Policy Research Working Paper No. 5326). World Bank Group.

AUTHOR'S INTRODUCTION


1. First and Corresponding Author

	Gandolgor Amarjargal gandolgor@msue.edu.mn
	<p>A. Gandolgor (Ph.D.) is a professor at the Department of Social Sciences, Mongolian National University of Education. Her research specializes in the green economy and sustainable development. This article resulted from her research conducted from 1990 to 2024. She was responsible for the study's conceptualization, econometric analysis using STATA, and writing the final manuscript.</p>

2. Co - Author

	Tuya Dagvadorj d.tuya@msue.edu.mn
	<p>G. Tuya (M.A.) is a researcher at the Department of Social Sciences, Mongolian National University of Education. Her research interests focus on economic policy and environmental sustainability. She significantly contributed to the literature review and data collection during the research period. She assisted in drafting the initial sections of the manuscript and interpreting the OLS results.</p>

3. Co - Author

	Otgon-Erdene Ganbat ganbatotgonerdene38@gmail.com
	<p>G. Otgon-Erdene is a researcher at the Sports Medicine and Research Institute. His research interests include public health and environmental impact assessments. He provided technical assistance throughout the study and contributed to the discussion of environmental variables. He was specifically involved in the fieldwork and data verification process for the 1990–2024 dataset.</p>