SCIENTIFIC CULTURE

www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 1.1, (2026), pp. 1570-1591
Open Access. Online & Print

DOI: 10.5281/zenodo.11425214

NATIONAL GOVERNANCE STRATEGIES FOR ACHIEVING PERFORMANCE TOWARD SUSTAINABILITY IN THAILAND: AN ANALYSIS OF THE INFLUENCE AND RELATIONSHIP BETWEEN GREEN-ECONOMIC, SOCIAL, AND PRO-ENVIRONMENTAL CULTURES

Pruethsan Sutthichaimethee[1], Danupon Ariyasajjakorn[2], Jianhui Luo[3], Supakorn Ukumphan[4], Worawat Sa-Ngiamvibool[5], Buncha Wattana[6], Supannika Wattana[7*]

[1]Faculty of Engineering, Mahasarakham University, Maha Sarakham, 44150, Thailand, Pruethsan.s@kkumail.com, https://orcid.org/0000-0002-7575-4187
[2]Faculty of Economics, Chulalongkorn University, Bangkok 10330, Thailand. danupon.a@chula.ac.th https://orcid.org/0009-0004-4597-9483
[3]Hunan Mechanical and Electrical Polytechnic, Changsha, 410151, China. 65010363001@msu.ac.th, https://orcid.org/0009-0002-7477-9603
[4]Faculty of Engineering, Mahasarakham University, Maha Sarakham, 44150, Thailand. 67010353012@msu.ac.th, https://orcid.org/0009-0000-5377-4892
[5]Faculty of Engineering, Mahasarakham University, Maha Sarakham, 44150, Thailand, Electrical and Computer Engineering Research Unit, Mahasarakham University, Maha Sarakham, 44150, Thailand. wor.nui@gmail.com, https://orcid.org/0000-0001-8580-8962
[6]Faculty of Engineering, Mahasarakham University, Maha Sarakham, 44150, Thailand, Electrical and Computer Engineering Research Unit, Mahasarakham University, Maha Sarakham, 44150, Thailand. buncha.w@msu.ac.th, https://orcid.org/0000-0002-7207-6843
[7]Faculty of Engineering, Mahasarakham University, Maha Sarakham, 44150, Thailand, Electrical and Computer Engineering Research Unit, Mahasarakham University, Maha Sarakham, 44150, Thailand. Email: supannika.w@msu.ac.th, https://orcid.org/0000-0001-9019-3616

Received: 10/10/2025
Accepted: 10/11/2025

Corresponding Author: Supannika Wattana (supannika.w@msu.ac.th)

ABSTRACT

In this study, the researcher developed the Logit-Recursive System Based on Vector Autoregressive with Exogenous Variable Model (Logit-RS-VARX model) with the objective of analyzing the causal influence of key factors on national management strategies to achieve performance aligned with sustainability goals. The study combined quantitative research with qualitative analysis to ensure completeness and robustness. The research findings indicate that the Logit-RS-VARX model can identify the adaptability of sectors toward equilibrium. Specifically, when the government implements a policy, the Social Culture Sector adjusts to equilibrium the fastest, followed by the Green Economy Sector and the Pro-Environmental Sector. Therefore, policy interventions targeting the Social Culture Sector are the most effective choice, as they can transmit

influence to the Pro-Environmental Sector, helping to reduce greenhouse gas emissions efficiently. Based on these insights, the study proposes a new scenario policy that focuses on increasing the electric vehicle rate and solar cell adoption rate to drive changes in social culture. The results show that the long-term growth rate of greenhouse gas emissions from 2025 to 2065 will increase at a reduced rate of 57.01%, remaining below the defined carrying capacity of 650.55 Mt CO_2 Eq. However, for these measures to be effective, it is essential to build societal values and cultural acceptance, particularly within the Social Culture Sector, to ensure successful policy implementation. Previous studies have not addressed this aspect, leading to misguided strategies and failure to achieve sustainability goals in both the short and long term.

KEYWORDS: Social Culture, Sustainability Goal, New Scenario Policy, Pro-Environmental, Green Economy, Electric Vehicle Rate, Solar Cell Rate, Net-Zero Emission.

1. INTRODUCTION

The global and regional environmental conditions, along with responses to climate change, have emerged as critical global issues due to the continued rise in greenhouse gas emissions. As of 2025, the average global temperature has risen by approximately 1.50 ± 0.12 °C compared to the pre-industrial era (1850–1900) (The World Bank: Energy Use (Kg of Oil Equivalent Per Capita) Home Page, 2025). Moreover, the average global temperature over the past decade marks the highest 10-year average ever recorded. The concentration of greenhouse gases in the atmosphere also continues to increase steadily (Office of the National Economic and Social Development Council (NESDC), 2025). In ASEAN countries, greenhouse gas emissions from fossil fuel combustion are found to be 1.5 times higher than those resulting from land-use changes. Additionally, many parts of the world have been experiencing extreme and unpredictable weather events, such as cyclones in the Mediterranean Peninsula, a heatwave in Italy with record temperatures reaching 48.2°C, widespread wildfires in northern Greece, and prolonged droughts occurring across almost every continent. In the ASEAN region, major natural disasters are primarily typhoons, which have caused severe damage to agricultural crops in the Philippines, Thailand, Laos, Vietnam, and Cambodia. Forest resources, both terrestrial and mangrove, continue to deteriorate, despite their vital role in absorbing carbon dioxide, mitigating climate change, and preserving biodiversity (Office of Natural Resources and Environmental Policy and Planning, 2025). Globally, biodiversity loss remains a critical issue, with many species still at high risk of extinction due to habitat destruction from agricultural expansion, coastal aquaculture, infrastructure development, and the impacts of climate change (NESDC, 2025). The ocean's temperature has reached its warmest level in 67 years, accelerating the melting of ice sheets and causing sea-level rise. These changes have led to coral bleaching and increasingly severe impacts on communities and vulnerable groups who are forced to confront more frequent and intense natural disasters.

Air pollution is another pressing global issue that nations around the world are urgently trying to address. In 2025, it was reported that only seven countries worldwide had PM2.5 levels below the World Health Organization (WHO) standard of 5 micrograms per cubic meter. Meanwhile, the ten countries with the highest PM2.5 concentrations are all located in Asia, with pollution stemming from both domestic sources and transboundary haze. Similarly, nearly all ASEAN countries are facing air quality problems, with Indonesia continuing to record the highest PM2.5 concentration in the region. In terms of cooperation and global efforts, countries continue to pursue the Sustainable Development Goals (SDGs), particularly the seven goals directly related to natural resources and the environment, namely Goals 6, 7, 11, 12, 13, 14, and 15, which concern water resources, energy, urban environment, responsible consumption and production, climate action, marine resources, and terrestrial ecosystems, respectively. In addition, international collaboration and actions under various conventions, agreements, and regional frameworks are being actively promoted, along with environment-related trade conditions (NESDC, 2025). Notably, the European Union's measures on low greenhouse gas emission products and deforestation-free supply chains have become significant factors influencing global trade. Furthermore, many countries, including Thailand, have adopted key United Nations frameworks for natural resource and environmental management to guide their national policies and actions toward sustainability (National Statistical Office Ministry of Information and Communication Technology, 2025).

Thailand's natural resource and environmental management is implemented under various levels of planning frameworks, guided by the National Strategy (2018–2037), which serves as the overarching framework to ensure coherence and integration among all related plans. The country continues to adhere to the Philosophy of Sufficiency Economy and aims to meet the United Nations Sustainable Development Goals (SDGs), as outlined in the 13th National Economic and Social Development Plan (ONEP, 2025). To operationalize these goals, Thailand has developed several strategic plans, including the Five-Year Environmental Quality Management Plan, as well as specific management plans for key thematic areas such as forests, land and soil resources, minerals, water resources, energy, pollution, waste management, and climate change. For the Fiscal Year 2025, the government allocated approximately 150-billion-baht, equivalent to 3.87% of the national budget, to the strategic area of "Creating Growth Based on an Environmentally Friendly Quality of Life." This represents an increase from the previous fiscal year, reflecting stronger national commitment to sustainability. In addition, financial mechanisms have been employed through the Environmental Fund, providing support for projects

initiated by local administrative organizations, the private sector, and environmental NGOs (OECD, 2025). Thailand is also strengthening partnerships with international funds to support climate impact reduction activities, enhance adaptive capacity in the agricultural sector, and promote the adoption of clean technologies. These measures, developed and implemented over the past decade, demonstrate Thailand's ongoing efforts to foster resilience and sustainability in environmental management (The World Bank, 2025; NESDC, 2025).

Among the key measures that Thailand has designated as national priority policies are several fiscal and social mechanisms aimed at promoting sustainability and reducing greenhouse gas emissions. On the fiscal side, Thailand has implemented tax incentives, including income tax exemptions for funds received as government subsidies under the electric vehicle (EV) promotion scheme for both cars and motorcycles. Additionally, income tax exemptions are provided for investments made in the Thailand Sustainability Fund, as well as corporate income tax exemptions for three years under specific investment promotion measures to encourage environmentally friendly businesses. On the social front, Thailand has fostered multi-sector collaboration to accelerate the reduction of greenhouse gas emissions through a range of urgent and high-impact initiatives across the country. These include the promotion of biomass energy, renewable energy, electric vehicles, waste-to-energy biomass, biofuel consumption, biofertilizers, solar energy, ecotourism, and income redistribution programs. These measures are considered crucial in driving social transformation nationwide, with the Thai government aiming to achieve both short-term and long-term progress toward the Sustainable Development Goals (SDGs) and to ensure a transition toward a low-carbon, inclusive, and sustainable society (Office of Natural Resources and Environmental Policy and Planning, 2025).

Thailand's pursuit of the Sustainable Development Goals (SDGs) has long been a key component of its national strategy, aiming to foster balanced growth across the economic, social, and environmental dimensions. The country's strategic vision focuses on achieving prosperity while ensuring sustainability for future generations. Historically, Thailand has achieved significant success in economic development, consistently maintaining growth even amid various crises (Sutthichaimethee et al., 2025). Economic indicators have shown continuous improvement, particularly in areas such as industrial growth, which remains the highest, followed by increases in the export rate and urbanization rate. This economic expansion has, in turn, contributed to social advancement: per capita income has steadily increased, educational attainment has improved, and the public health system has become more robust. However, when viewed from an environmental perspective, the trend has been the opposite. Environmental growth and ecosystem health have declined continuously, with rising pollution levels, the deterioration of community ecosystems, and a sharp rise in greenhouse gas emissions (ONEP, 2025; Sutthichaimethee et al., 2025).

Thailand's implementation of the Sustainable Development Goals (SDGs) from 1995 to 2025 demonstrates that the country has achieved remarkable success in economic and social development, with steady and continuous growth in both areas. However, environmental progress has moved in the opposite direction, reflecting a persistent challenge in balancing development with sustainability. Over the years, the Thai government has continuously implemented various measures, adopted successful international practices while also developed new policies tailored to Thailand's context, both directly and indirectly. These measures include the Principal Payment Puller (PPP), the Principle of Prevention, as well as initiatives promoting biomass energy, renewable energy, electric vehicles, waste-to-energy biomass, biofuel consumption, biofertilizers, solar energy, ecotourism, and income distribution programs. Despite these ongoing efforts, Thailand has yet to achieve meaningful environmental improvement. While CO_2 emissions continue to rise, albeit at a slower rate compared to the period between 1995 and 2020, both methane (CH_4) and nitrous oxide (N_2O) emissions have been increasing rapidly and continuously. This trend is closely linked to the fact that a large portion of Thailand's population is engaged in agricultural activities, which remain a major source of pollution. Consequently, despite the government's continued efforts and growing awareness, greenhouse gas emissions in the agricultural sector have continued to rise sharply, posing an ongoing challenge to Thailand's path toward genuine environmental sustainability (NESDC, 2025; Thailand Greenhouse Gas Management Organization (Public Organization), 2025).

Due to these contributing factors, Thailand's greenhouse gas (GHG) emissions have been rising

consistently, making it unlikely that the nation will meet its net-zero emissions target by 2065. Reaching this goal demands not only cutting overall emissions but also enhancing carbon absorption capacity, mainly through expanding forest areas. However, current trends show that GHG emissions are still rising continuously, leading to severe ecosystem degradation over the past decade. In contrast, economic growth has surged rapidly, and social development has grown proportionally, both reinforcing each other. Given this situation, the government must redefine its national development strategy to ensure that economic, social, and environmental progress advance in parallel. This involves carefully analyzing the key factors driving growth, followed by determining how to establish a new policy scenario that effectively addresses these interconnected dimensions. Next, it is essential to identify whether economic or social factors currently exert the greatest impact on Thailand's environment, as well as to recognize the overlooked elements in past strategic planning, particularly the lack of genuine public participation. The government has placed strong emphasis on transforming the economy into a green economy, yet insufficient attention has been given to inclusive social engagement, which is critical for achieving long-term sustainability. Therefore, the government must develop essential policy tools and mechanisms to guide national administration toward a truly sustainable future, ensuring that environmental preservation, economic prosperity, and social well-being are all equally prioritized in Thailand's long-term development trajectory (ONEP, 2025; Sutthichaimethee et al., 2025).

Therefore, this research recognizes the aforementioned issues and has been conducted within the framework of the Sustainable Development Goals (SDGs). It introduces a new analytical model called the Logit-Recursive System Based on Vector Autoregressive with Exogenous Variable Model (Logit-RS-VARX Model). This model addresses significant research gaps previously found in both Thai and international studies, as it is capable of analyzing panel data and can be utilized as a strategic tool for formulating new policy scenarios to guide national administration effectively. In this study, the primary focus is placed on social participation, particularly on the influence of social and cultural factors within the Thai societal context, and how these factors impact both the environmental and economic sectors. The findings from this study are anticipated to become an essential foundation for guiding Thailand's national management strategies with greater accuracy, efficiency, and effectiveness, supporting progress toward the 2065 net-zero emissions target. In contrast to earlier research that mainly relied on social science methodologies to explore social aspects, this study employs a scientific approach to analyze social phenomena. Additionally, a focus group discussion was conducted with nine key national policymakers representing three major government bodies: the Ministry of Natural Resources and Environment (3 participants), the Ministry of Energy (3 participants), and the Office of the National Economic and Social Development Council (NESDC) (3 participants) (Office of Natural Resources and Environmental Policy and Planning, 2025; Sutthichaimethee et al., 2025; Sutthichaimethee et al., 2025, ONEP, 2025). The purpose of this discussion was to validate the quantitative analysis, strengthen the credibility and comprehensiveness of the results, and ensure that the findings can be effectively applied to future policy dialogues and recommendations aimed at advancing Thailand's sustainable development and environmental governance.

2. LITERATURE REVIEW

Environmental management has become an urgent global concern as human activities, economic growth, and climate change interact in increasingly complex ways. Addressing these challenges requires an integrated understanding of how energy use, industrial production, agriculture, urban development, institutional practices, and social culture shape ecological, economic, and social systems. This review synthesizes recent research on renewable energy transitions, climate adaptation, sustainable agriculture and industry, institutional and corporate sustainability, urban planning, and socio-cultural dimensions of environmental behaviour. Together, these perspectives provide a comprehensive foundation for exploring the interconnections vital to effective and sustainable environmental management.

2.1. Renewable Energy Transition and Economic Growth Link

The link between renewable energy adoption and economic growth has increasingly become a central topic in contemporary energy and environmental studies. Studies have emphasized that transitioning from fossil fuels to renewable energy can foster sustainable economic development, particularly in resource-rich, energy-exporting nations. For example, studies on ASEAN net energy exporters, Indonesia, Malaysia, and Brunei, show that

increasing renewable energy output positively influences GDP per capita, while energy net imports have limited impact, highlighting the importance of technological investments and equitable energy policies (Setiawan et al., 2025). Similar insights emerge from Thailand, where low-carbon society scenarios indicate that adopting cost-effective demand-side measures in residential, industrial, and transport sectors can substantially reduce CO_2 emissions compared to business-as-usual projections (Winyuchakrit et al., 2021). Taiwan's policy initiatives further illustrate the role of green finance, carbon pricing, and emissions trading systems in facilitating net-zero transitions, although challenges such as reliance on fossil fuels and underdeveloped carbon markets persist (Cheng, 2025). Collectively, these studies underscore that sustainable energy transitions depend on a combination of technological innovation, policy coherence, and strategic investment. Beyond energy systems, climate change impacts extend to environmental and cultural domains, underscoring the multidimensional nature of adaptation strategies. For instance, the management of Egyptian museum collections demonstrates the necessity of integrating heritage preservation with climate mitigation to address threats from extreme weather, temperature fluctuations, and humidity (Elkhial, 2025). Likewise, hydrological studies of the Danube River reveal climate-driven alterations in seasonal flow patterns, compounded by human activities such as land use changes and water regulation, signalling potential reductions in water availability with implications for agriculture and energy generation (Laghari et al., 2018).

2.2. Climate Variability, Water Resources, And Agricultural Resilience

Climate variability and its impacts on natural and agricultural systems have been extensively examined, particularly in sensitive mountainous and tropical regions. In the Hindu Kush-Himalaya region, hydrological modeling of the Hunza catchment reveals that rising temperatures increase glacier melt and alter seasonal runoff patterns, with pronounced effects in spring and summer, while winter and autumn flows remain relatively stable (Laghari et al., 2018). Similarly, tropical agriculture faces significant vulnerability, as demonstrated in potato cultivation, where irregular rainfall, temperature fluctuations, and higher humidity negatively affect growth, yield, and disease susceptibility (Hasanuddin et al., 2025). Adaptation strategies, including climate-resilient crop varieties, optimized irrigation, and soil conservation, have been proposed to enhance resilience and ensure long-term food security in such climates. These studies collectively emphasize that climate adaptation requires an integrated approach, addressing both water resource management and agricultural engineering.

2.3. Institutional And Corporate Approaches to Sustainability

Sustainability considerations extend beyond natural systems into human and institutional domains. Higher Education Institutions (HEIs) in Thailand illustrate the challenges and opportunities in implementing sustainable development practices, where institutional size and participation in frameworks such as UI Green Metric significantly influence sustainability performance across administration, environment, and education dimensions (Tabucanon et al., 2021). In the corporate sector, sustainability reporting has been shown to correlate positively with firm performance, demonstrating that transparency in social, economic, environmental, and governance practices can drive financial outcomes (Mohanty et al., 2023). Urban planning and landscape design also offer critical pathways for sustainability, as evidenced in the application of environmentally conscious landscape design to replace slum areas in Cairo, enhancing human well-being while managing resources such as water, soil, and energy (Ali et al., 2023).

2.4. Integrating Environmental Accounting, Governance, And Policy Frameworks

In fact, sustainable development and environmental management increasingly rely on the integration of accounting, corporate behaviour, and public sector strategies. Environmental accounting has been shown to enhance firms' environmental performance and productivity, demonstrating its potential as a tool for achieving the Sustainable Development Goals (Alakkas et al., 2023). Similarly, studies in China reveal that corporate environmental disclosure is influenced by public attention and government incentives, highlighting how transparency and policy mechanisms can encourage proactive environmental behaviour among enterprises (Wang, 2020). In the public sector, multi-criteria assessment approaches incorporating fuzzy logic have been applied to evaluate environmental factors affecting sustainable development, providing a systematic and objective framework to guide policy and administrative decisions

(Kryshtanovych et al., 2024). Collectively, these studies underscore the importance of embedding environmental considerations into institutional practices, both in private and public domains, to drive sustainability outcomes. Environmental degradation, climate change, and socioeconomic factors are closely interlinked, influencing both inequality and ecological resilience. Research in lower middle-income ASEAN countries indicates that environmental degradation exacerbates income inequality, while renewable energy consumption and human capital development mitigate its effects (Kryshtanovych et al., 2024). At a broader level, high-resolution remote sensing data allows for an in-depth examination of climate change impacts across European nations, highlighting spatial and temporal variations in temperature, precipitation, vegetation health, and evapotranspiration patterns (Yilmaz, 2025). These findings emphasize the interconnected nature of environmental, economic, and social systems, suggesting that effective sustainability strategies must integrate environmental monitoring, policy interventions, and technological adaptation to enhance resilience and equitable development.

2.5. Sectoral Contributions to Environmental Degradation and Low-Carbon Strategies

When it comes to agricultural production, industrial processes, and urban development, they, indeed, are significant contributors to environmental degradation and greenhouse gas emissions. In Brazil, multi-purpose crops such as sugarcane, soybean, and corn exhibit substantial state-level variability in emissions, particularly when direct land use changes are considered, highlighting the need for localized strategies in decarbonization and biofuel production (Pereira et al., 2025). Similarly, ASEAN economies show that economic growth, agriculture, and trade openness significantly drive CO_2 emissions, while renewable energy adoption and climate-smart policies can mitigate these effects, suggesting the importance of sector-specific and regional interventions for low-carbon development (Sobirov et al., 2025). In Europe, detailed climatic analysis using historical records and deep learning techniques reveals rapid warming, shifting precipitation patterns, and variable solar radiation in Odesa, Ukraine, emphasizing the value of high-resolution data for urban climate adaptation and energy planning (Melnyk et al., 2025). Industrial and urban systems also present opportunities for emissions reduction and ecological sustainability through technological and planning innovations. The use of Limestone Calcined Clay Cement (LC3) in Germany demonstrates significant reductions in CO_2 and particulate matter compared to traditional cement, while also addressing social risks such as workers' rights and corruption, highlighting the need for region-specific environmental and social assessments in industrial applications (Haverkamp et al., 2025). Urban land use transformation in the Yangtze River Delta shows that shifts in residential, industrial, and ecological land directly affect environmental quality, with topography, climate, and greening improving ecological outcomes, while economic development and urban expansion exert adverse effects (Ren et al., 2025).

2.6. Social And Cultural Dimensions of Environmental Sustainability

Environmental sustainability is not only a technological or policy challenge but also a deeply social and cultural process shaped by human behavior, collective values, and institutional identity. Recent scholarship highlights that cultural heritage preservation is increasingly threatened by climate change, calling for adaptive and context-specific conservation strategies that replace energy-intensive, outdated climate control systems with data-driven, locally grounded approaches (Manti and Henderson, 2025; Villanueva, 2025). At the same time, behavioural studies show that environmental responsibility is strongly influenced by social identity and contextual framing, when individuals view themselves as active citizens rather than passive consumers, they tend to make more sustainable choices, and reward-based communication is often more effective than penalty framing in promoting pro-environmental behaviour (Pavlova et al., 2025; Liashenko and Demianiuk, 2025). Research further reveals that social psychology plays a crucial role in advancing the Sustainable Development Goals, providing insights into how collective norms, moral values, and self-identity shape environmental action across societies (Prandelli et al., 2025; Prandelli et al., 2013; Milinski, et al., 2008). Cross-cultural environmental psychology extends this understanding by emphasizing that human–environment interactions are culturally bound, and that diverse perspectives are essential for meaningful, globally relevant sustainability research (Tam and Milfont, 2020). These insights also connect with gendered and organizational dimensions of sustainability, as seen in studies showing how emotional, safety, and

aesthetic values influence women's sustainable consumption patterns, and how green leadership and talent management foster pro-environmental behaviors in the workplace (Zhu and Bao, 2025; Sánchez-Rodríguez et al., 2025; Kanwal et al., 2024). Finally, policy-oriented studies in the cultural and tourism sectors demonstrate that sustainability-linked initiatives can improve environmental, social, and governance (ESG) performance, particularly when supported by transparent governance and innovation-driven frameworks (Chen et al., 2025).

The literature makes clear that sustainable environmental management is not a single-policy solution but a complex process that relies on cooperation across many sectors and levels of society. Previous studies have provided valuable knowledge on renewable energy transitions, climate adaptation, sustainable agriculture, and institutional reforms, yet much of this work tends to treat environmental, economic, and social dimensions separately. What remains less understood is how cultural values, social behavior, and institutional practices interact to influence environmental outcomes, especially in developing regions such as Thailand and the broader ASEAN context. This gap highlights the need for research that brings these elements together to understand sustainability as both a technical and social process. Building on this recognition, the present study comes into play.

3. THE MATERIAL AND METHOD

For this study, a model called the Logit-Recursive System Based on Vector Autoregressive with Exogenous Variable Model (Logit-RS-VARX model) was developed. An important component in the analysis, which forms part of the simultaneous equation system, is the recursive system. In this system, the dependent variable of one equation is determined by both exogenous factors and the lagged endogenous variables from another equation. In other words, the dependent variables occur at different time sequences. It has been observed that the supply of goods in the current period is not determined by the current price but by the price of the previous year. This is because increases or decreases in the production of goods and services are primarily influenced by market components, government policies, and the economic system. Therefore, past prices can be considered predetermined endogenous variables.

On the demand side, the level of demand depends on how buyers respond to the market at the time of purchase. This relationship can be expressed as follows:

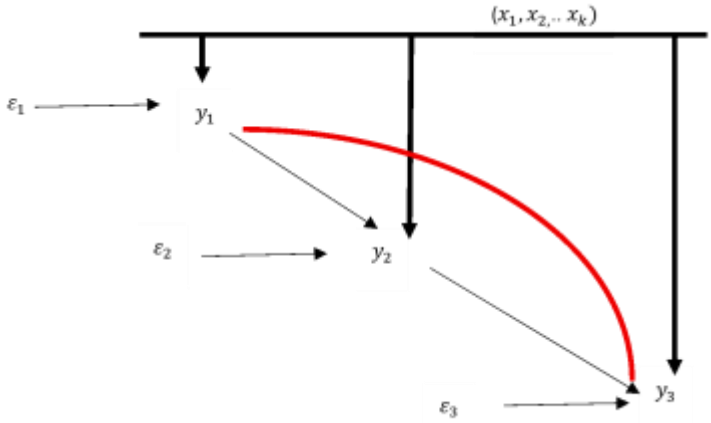

Figure 1: Direction Of Relationships in the Logit-RS-VARX Model.

Figure 1 illustrates the relationship among demand, supply, and price in the Logit-RS-VARX Model, showing a unidirectional determination or effect. Specifically, the first dependent variable (y_1) is influenced by the independent variables

It can be observed that the endogenous variable in each equation is influenced by its own disturbance term, and the disturbance terms do not exert cross-equation effects through the endogenous variables of other equations. That is, the endogenous variable of the second equation (y_2) has y_1 as a

$(x_1, \ldots, x_3)$ along with its associated disturbance term, e_1 . In the second equation, the second dependent variable (y_2) is determined by the same set of independent variables ($x_1, \ldots, x_3$), and its own disturbance term, e_2 .

predetermined variable. Therefore, each equation in the Logit-RS-VARX Model is independent in terms of its disturbance term, which implies that the covariance between the equations is zero, satisfying one of the conditions of the Logit-RS-VARX Model. Another condition of this model is that the structural

equations do not contain endogenous variables from subsequent equations, i.e., y_1, y_2, and y_3, in order. This condition ensures that the structural parameter matrix (Γ) has a triangular form. However, this condition alone is insufficient to define the Logit-RS-VARX Model.

Therefore, the disturbance term condition, which ensures that the variance-covariance matrix of the disturbances is diagonal, is also crucial. In the structural form of the Logit-RS-VARX Model, the endogenous variables are arranged such that the Γ parameter matrix is triangular, and the variance-covariance matrix of the disturbances is a diagonal matrix, as follows (Raj and Ullah, 1981; Harvey, 1980):

$$\Gamma = \begin{bmatrix} \gamma_{11} & \cdots & \gamma_{1g} \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \gamma_{gg} \end{bmatrix} \quad (1)$$

$$\sum = \begin{bmatrix} \sigma_1^2 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sigma_E^2 \end{bmatrix} \quad (2)$$

From equations (1) and (2), the general system of equations can be expressed, incorporating the exogenous variables (x) and the parameter values β, as follows:

□1=□=1□□□1□□−□1, ….,□□=□=1□−1□□□+□=1□□□□□□−□□ (3)

From equation (3), it is observed that the Logit-RS-VARX Model is always exactly identified. The number of parameters to be estimated in the Γ matrix is $g[(g+1)/2] - g$, and there are g variance terms in the Σ matrix.

In the reduced form equations, the number of parameters is typically $gk + g[(g+1)/2]$, and the number of variables in G and U is the same, as follows (Sutthichaimethee et al., 2025; Baltagi, 2021):

$$G = U = \frac{g(g+1)}{2} + gk \quad (4)$$

For the model in this study, to enhance understanding, the variance-covariance matrix Σ is presented, where $\Sigma = \Gamma' \Omega \Gamma$, as follows (Sutthichaimethee et al., 2025; Dickey and Fuller, 1981):

$$\begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ \gamma_{12} & \sigma_2^2 \end{pmatrix} \begin{pmatrix} \omega_1^2 & \omega_{12} \\ \omega_{21} & \omega_2^2 \end{pmatrix} \begin{pmatrix} -1 & \gamma_{12} \\ 0 & -1 \end{pmatrix} \quad (5)$$

From equation (5), let ω denote the elements of Ω. If Ω is known, it can be further expressed as:

$$\sigma_1^2 = \omega_1^2, \sigma_2^2 = \omega_2^2 - \frac{\omega_{12}^2}{\omega_1^2} \quad (6)$$

From equation (6), if ω_1^2 and ω_2^2 are the variances of the disturbance terms in the reduced-form equations, the parameter β can then be calculated as follows:

$$\begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \\ \pi_{31} & \pi_{32} \end{bmatrix} \begin{bmatrix} -1 & \gamma_{12} \\ 0 & -1 \end{bmatrix} = - \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \\ \beta_{31} & \beta_{32} \end{bmatrix} \quad (7)$$

$$\beta_{11} = \pi_{11}, \beta_{12} = \pi_{12} - \gamma_{12}\pi_{11}, \beta_{21} = \pi_{21}, \beta_{22} = \pi_{22} - \gamma_{12}\pi_{21}, \beta_{31} = \pi_{31}, \beta_{32} = \pi_{32} - \gamma_{12}\pi_{31} \quad (8)$$

From equations (7)-(8), letting γ_{12} represent the value estimated using the indirect least squares (ILS) method, it is found that the parameter of the first equation y_1 corresponds to its reduced-form parameter.

In the second equation y_2, the parameters are obtained from the coefficients of the first equation combined with the reduced-form parameters of the second equation, as follows (Sutthichaimethee et al., 2025):

$$y_t = \beta_{11}x_1 + \beta_{21}x_2 + \beta_{31}x_3 - \varepsilon_1 \quad (9)$$

From equation (9), let β be expressed in terms of reduced-form coefficients as:

$$\beta_{11} = \pi_{11},\ \beta_{21} = \pi_{21},\ \beta_{31} = \pi_{31} \quad (10)$$

From equation (10), the second equation y_2 can be written as:

$$y_2 = \gamma_{12}y_1 + \beta_{12}x_1 + \beta_{22}x_2 + \beta_{32}x_3 - \varepsilon_2 \quad (11)$$

By substituting y_1 from equations (9) and (10) into equation (11), we obtain:

$$y_2 = (\gamma_{12}\pi_{11} + \beta_{12})x_1 + (\gamma_{12}\pi_{21} + \beta_{22})x_2 + (\gamma_{12}\pi_{31} + \beta_{32})x_3 - \varepsilon_{2-}\gamma_{12}\,\varepsilon_1 \quad (12)$$

From equation (12), it is evident that the structural form can be derived from the reduced-form equations as follows (Sutthichaimethee et al., 2025; MacKinnon, 1991):

$$\beta_{12} = \pi_{12-}\gamma_{12}\pi_{11},\ \beta_{22} = \pi_{22-}\gamma_{12}\pi_{21},\ \beta_{32} = \pi_{32-}\gamma_{12}\pi_{31} \quad (13)$$

However, regarding the estimation methods, there are several approaches available. For this study, a method was selected that avoids issues arising from estimation, preventing the occurrence of spurious results. The estimation outcomes must not exhibit heteroscedasticity, multicollinearity, or autocorrelation.

Therefore, this study adopts the vector autoregressive (VAR) method. Based on the equations above, it can be described how the dependent and independent variables are connected as follows (MacKinnon, 1991; Raj and Ullah, 1981):

$$y_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} y_{t-i} + \beta_{2i} x_{t-i} + \varepsilon_{1t},\ x_t = \alpha_2 + \sum_{i=1}^{p} \beta_{3i} y_{t-i} + \beta_{4i} x_{t-i} + \varepsilon_{2t} \quad (14)$$

From equation (14), let y_{t-i} denote the value of y_t lagged by i periods, and let x_{t-i} denote the value of x_t lagged by i periods. It is also possible to determine the VAR order as follows.

$$\Delta y_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} \Delta y_{t-i} + \beta_{2i} \Delta x_{t-i} + \varepsilon_{1t},\ \Delta x_t = \alpha_2 + \sum_{i=1}^{p} \beta_{3i} \Delta y_{t-i} + \beta_{4i} \Delta x_{t-i} + \varepsilon_{2t} \quad (15)$$

From equation (15), let Δy_t denote the first-differenced value of y_t ($\Delta y_t = y_t - y_{t-1}$), all variables on the right-hand side are predetermined, meaning there are no endogenous variables influencing each other directly within the model. However, the reduced-form error terms in the VAR capture a mix of underlying structural shocks: $e_t = B_0^{-1}\varepsilon_t$.

Thus, a structural shock $\varepsilon_{i,t}$ can spread throughout the system, affecting all other error terms $\varepsilon_{j,t}$ and causing all endogenous variables to move simultaneously.

As a result, the variance-covariance matrix of the reduced-form VAR is (Sutthichaimethee et al., 2025; MacKinnon, 1991; Baltagi, 2021):

$$\Omega = E(e_t e_t') = E(B_0^{-1}\varepsilon_t \varepsilon_t' (B_0^{-1})') = B_0^{-1}\Sigma(B_0^{-1})' \quad (16)$$

From equation (16), the matrix represents the covariance matrix of the reduced-form VAR. This matrix can have off-diagonal elements, allowing for non-zero correlations between the error terms elements that are non-zero, allowing for non-zero correlations between the error terms.

For the Logit-RS-VARX model in this research, it is an innovative and novel model that has not been previously introduced in either Thailand or abroad. This model offers substantial benefits for application in various other contexts beyond this study and can be used across all sectors under analysis. In addition, it can appropriately eliminate spurious results, preventing misleading interpretations that could otherwise lead to incorrect policy or planning decisions. Furthermore, the model demonstrates strong suitability for long-term forecasting, with high performance values that indicate a high degree of accuracy in long-term predictions. Therefore, applying this model for further studies or for formulating long-term national plans is highly appropriate, as it can support sustainable and well-informed strategic direction for any country in the future.

A review of both domestic and international literature reveals that no prior research has developed a model comparable to the one introduced in this study. Moreover, studies employing this type of analysis are very limited worldwide. Most previous analyses have not adopted a mixed-method research approach, and typically focused only on proposing new policy scenarios, without conducting a strategic prioritization analysis necessary for long-term national management. As a result, such studies were unable to establish an accurate and effective future strategic framework. Furthermore, prior analyses have generally excluded social participation as a key analytical component, which has led to an incomplete understanding of social and cultural factors that influence the development of pro-environmental behaviour. This lack of integration has contributed to the continued increase in greenhouse gas emissions despite ongoing policy interventions. Given that Thailand is primarily an agricultural country, it is crucial that, once the government formulates new scenario policies, it must also analyze the dynamic relationships and influence patterns among key factors. This will enable policymakers to define a long-term national management direction that is both accurate and contextually appropriate, ultimately guiding Thailand toward achieving net-zero emissions within the sustainability framework.

Therefore, this research addresses the gaps in previous studies by developing the Logit-RS-VARX model, making it highly valuable for formulating long-term policies and national development plans for Thailand. The researcher has outlined the following research methodology:

1. Choosing indicators in alignment with the national development planning framework.
2. Analyzing the relationship determination capability within the model using the co-integration test.
3. Analyzing the causal influence pathways among key factors.

4. Prioritizing analysis using sensitivity analysis.
5. Projecting long-term greenhouse gas emissions for the period 2025-2065.
6. Discussion of findings and policy recommendations for guiding national management toward sustainable development goals, as illustrated in Figure 2.

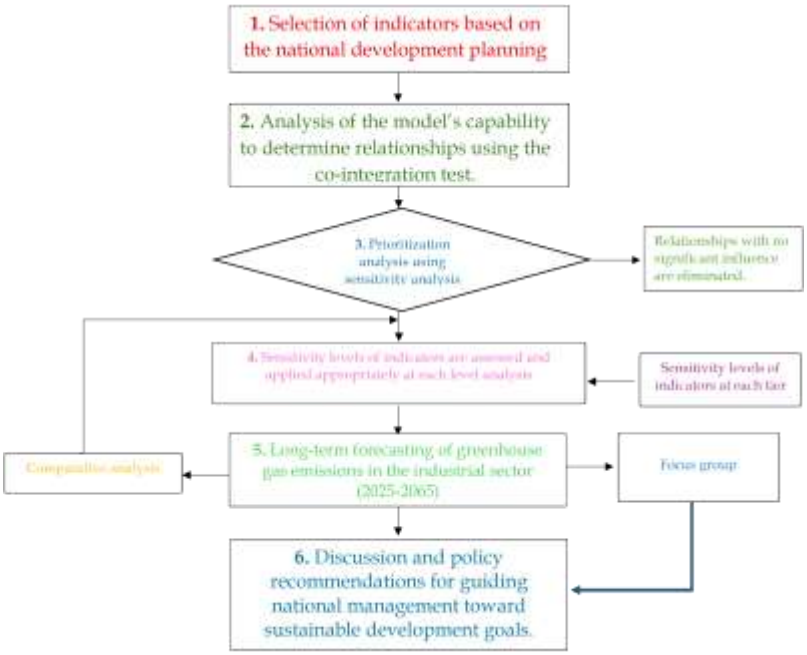

Figure 2: Research Implementation Steps.

Figure 2 outlines the steps followed in this research to examine the causal effects of key factors on national management strategies and their performance within the sustainability framework. Each step was carried out carefully, combining both quantitative and qualitative methods, to establish a solid foundation for guiding Thailand toward achieving net-zero emissions by 2065. Data for the study were sourced from relevant government agencies, including the Ministry of Natural Resources and Environment, the Ministry of Energy, and the Office of the National Economic and Social Development Council (NESDC). The analysis was conducted using the LISREL 8.5.4 software package (Joreskog and Sorbom, 2012).

4. EMPIRICAL ANALYSIS

In this study, the researcher designed the Logit-RS-VARX model to examine how key factors causally influence national management strategies, with the goal of achieving outcomes that align with sustainability objectives. The study combines quantitative and qualitative analyses to offer a thorough understanding of the relationships between these factors and their effects on policy results. The details are as follows (Sutthichaimethee et al., 2025):

4.1. Selection Of Indicators for Constructing the Logit-RS-VARX Model

In this study, the Logit-RS-VARX model was employed to analyze the causal influence of key factors on national management strategies, aiming to achieve performance aligned with sustainability goals. The model includes latent variables representing three main sectors: Green-Economic Sector, Social Culture Sector, and Pro-Environmental Sector. Each latent variable is composed of observed variables, which are indices continuously used by the Thai government for national administration. For this research, the observed variables were carefully selected to construct the Logit-RS-VARX model. Selection followed the model's methodological requirements, including passing the stationarity test to ensure suitability for time-series and panel data analysis. As a result, variables meeting the criteria were identified, including urbanization rate (H_1), industrial structure rate (H_2), foreign investment rate (H_3), Ecotourism rate (H_4) net-import rate(H_5), Average household income (H_6) family size (H_7), education rate (H_8), income distribution rate (H_9), protection rate (H_{10}), Biomass energy rate (H_{11}), renewable energy rate (H_{12}), green material rate (H_{13}), waste biomass rate (H_{14}), Biofuel oil

consumption rate (H_{15}), Biofertilizers rate(H_{16}), electric vehicle rate (H_{17}), solar cell rate (H_{18}), energy intensity rate (H_{19}), Carbon dioxide emissions (H_{20}), Methane emission (H_{21}), Nitrous oxide emission (H_{22}).

For all 22 indicators, a logarithmic transformation was applied to stabilize variance and normalize the data. These transformed indicators were then tested for stationarity using the Augmented Dickey-Fuller (ADF) test, with the results summarized as follows:

Table 1: Test Results of Indicator Properties for the Logit-RS-VARX Model.

Variables	Tau Test	Variables	Tau Test	MacKinnon Critical Value		
	Level I(0) Value		Level I(0) Value	1%	5%	10%
$ln(H_1)$	-2.99	$\Delta ln(H_1)$	-4.52***	-4.50	-3.75	-3.25
$ln(H_2)$	-3.10	$\Delta ln(H_2)$	-4.59***	-4.50	-3.75	-3.25
$ln(H_3)$	-3.01	$\Delta ln(H_3)$	-5.01***	-4.50	-3.75	-3.25
$ln(H_4)$	-3.56	$\Delta ln(H_4)$	-5.09***	-4.50	-3.75	-3.25
$ln(H_5)$	-3.20	$\Delta ln(H_5)$	-5.89***	-4.50	-3.75	-3.25
$ln(H_6)$	-3.75	$\Delta ln(H_6)$	-5.54***	-4.50	-3.75	-3.25
$ln(H_7)$	-2.79	$\Delta ln(H_7)$	-4.59***	-4.50	-3.75	-3.25
$ln(H_8)$	-3.56	$\Delta ln(H_8)$	-4.89***	-4.50	-3.75	-3.25
$ln(H_9)$	-3.68	$\Delta ln(H_9)$	-4.94***	-4.50	-3.75	-3.25
$ln(H_{10})$	-2.02	$\Delta ln(H_{10})$	-4.55***	-4.50	-3.75	-3.25
$ln(H_{11})$	-2.89	$\Delta ln(H_{11})$	-5.15***	-4.50	-3.75	-3.25
$ln(H_{12})$	-2.91	$\Delta ln(H_{12})$	-6.01***	-4.50	-3.75	-3.25
$ln(H_{13})$	-3.01	$\Delta ln(H_{13})$	-5.23***	-4.50	-3.75	-3.25
$ln(H_{14})$	-3.46	$\Delta ln(H_{14})$	-5.08***	-4.50	-3.75	-3.25
$ln(H_{15})$	-3.20	$\Delta ln(H_{15})$	-4.75***	-4.50	-3.75	-3.25
$ln(H_{16})$	-3.41	$\Delta ln(H_{16})$	-4.59***	-4.50	-3.75	-3.25
$ln(H_{17})$	-4.20	$\Delta ln(H_{17})$	-6.75***	-4.50	-3.75	-3.25
$ln(H_{18})$	-4.05	$\Delta ln(H_{18})$	-6.66***	-4.50	-3.75	-3.25
$ln(H_{19})$	-3.59	$\Delta ln(H_{19})$	-5.04***	-4.50	-3.75	-3.25
$ln(H_{20})$	-3.16	$\Delta ln(H_{20})$	-5.05***	-4.50	-3.75	-3.25
$ln(H_{21})$	-3.45	$\Delta ln(H_{21})$	-5.44***	-4.50	-3.75	-3.25
$ln(H_{22})$	-3.73	$\Delta ln(H_{22})$	-5.65***	-4.50	-3.75	-3.25

*** **Denotes Significance $\alpha = 0.01$**

Source: Author's Estimate (2025)

As presented in Table 1, all variables at level I(0) were found to be non-stationary, with Tau test values falling below the MacKinnon critical values. To address this, the researcher applied a first-difference transformation. The results showed that at the first-difference level I(1), the Tau test values exceeded the MacKinnon critical values, indicating statistical significance at $\alpha = 0.01$ (Sutthichaimethee et al., 2025). Hence, all selected indicators are suitable for constructing the Logit-RS-VARX model.

4.2. Short-Term And Long-Term Relationship Analysis of Indicators in Constructing the Logit-RS-VARX Model

In this study, the researcher analyzed the ability to determine relationships among indicators using the co-integration test. All indicators that were found to be stationary were included in the test to examine both short-term and long-term relationships.

Table 2: Test Results of Short-Term and Long-Term Relationship Determination Using Co-Integration Test.

Variables	Trace Statistic Test	Max-Eigen Statistic Test	Error correction mechanism (Ecm)	MacKinnon Critical Value
$\Delta ln(H_1)$	175.21***	150.79***	-0.42***	75.05
$\Delta ln(H_2)$				
$\Delta ln(H_3)$				
$\Delta ln(H_4)$				
$\Delta ln(H_5)$				
$\Delta ln(H_6)$			-0.61***	
$\Delta ln(H_7)$				
$\Delta ln(H_8)$				
$\Delta ln(H_9)$				
$\Delta ln(H_{10})$				
$\Delta ln(H_{11})$			-0.01***	
$\Delta ln(H_{12})$				
$\Delta ln(H_{13})$				

$\Delta ln(H_{14})$				
$\Delta ln(H_{15})$				
$\Delta ln(H_{16})$				
$\Delta ln(H_{17})$				
$\Delta ln(H_{18})$				
$\Delta ln(H_{19})$				
$\Delta ln(H_{20})$				
$\Delta ln(H_{21})$				
$\Delta ln(H_{22})$				

*** **Denotes Significance α = 0.01**

Source: Author's Estimate (2025)

Table 2 shows that the relationships among all indicators at first difference I(1) are statistically significant. The co-integration test results reveal that the Trace Statistic and Max-Eigen Statistic are 175.21 and 150.79, respectively, both surpassing the MacKinnon critical value of 75.05 at the α = 0.01 significance level. This confirms that all indicators are appropriate for building the Logit-RS-VARX model and can be used to examine the long-term causal effects of the factors. The results also demonstrate that long-term policy changes can remain effective over time, as the relationships among all indicators continue to exert influence, as shown in Table 1. Moreover, the analysis reveals an important insight when applying the Logit-RS-VARX model: short-term adaptability significantly influences the speed at which sectors respond to policy changes. Specifically, the study found that if the government implements a policy, the Social Culture Sector can adjust to equilibrium most rapidly, with an adaptability magnitude of 61%. This is followed by the Green Economy Sector at 42%, and the Environmental Sector at 1%. Therefore, for policies to achieve rapid effectiveness, it is crucial to prioritize the Social Culture Sector, enabling it to respond quickly to new policies. Subsequently, policies can also target the Green Economy Sector and the Environmental Sector. This indicates that focusing on social culture is the most effective strategy for accelerating policy impact and achieving sustainable outcomes across all sectors.

4.3. Analysis Of Causal Influence Pathways

The analysis identified the causal influence pathways among the three latent variables within the sustainability framework: the Green-Economic Sector, the Social Culture Sector, and the Pro-Environmental Sector. The findings reveal how these sectors interact and affect one another, offering valuable insights into the factors that are most crucial for effective policy implementation and achieving sustainable outcomes.

Table 3: Causal Influence Pathway Analysis Results from the Logit-RS-VARX Model.

Dependent Variables	Type of effect	Independent Variables		
		Green-Economic sector	Social culture sector	Pro-Environmental sector
Green-Economic sector	DE	-	-	-
	IE	-	-	-
Social culture sector	DE	0.25***	-	0.33***
	IE	0.01***	-	-
Pro-Environmental sector	DE	0.29***	0.42***	-
	IE	0.05***	0.10***	-

Note: * Denotes Significance $\alpha = 0.01$, DE Represents Direct Effect, And IE Represents Indirect Effect.**

Table 3 presents the estimated causal influence pathways among the latent variables based on the Logit-RS-VARX model. After completing the estimation, the model's performance and validity were assessed using a range of statistical criteria, as detailed below (Sutthichaimethee et al., 2025; MacKinnon, 1991; Dickey and Fuller, 1981):

1. Validity checks: $HTMT_{ij} = 0.78$, $AVE_q = 0.95$, Cronbach's alpha $\alpha_q = 0.90$, and Composite Reliability (CR) $pq = 0.08$
2. Chi-square statistics: $\chi^2/df = 2.55$
3. Root Mean Squared Residual (RMR): 0.04
4. Root Mean Square Error of Approximation (RMSEA): 0.05
5. Standardized Root Mean Square Residual (SRMR): 0.02
6. Normal Fit Index (NFI): 0.90
7. Comparative Fit Index (CFI): 0.97
8. Goodness of Fit Index (GFI): 0.90
9. Adjusted Goodness of Fit Index (AGFI): 0.91f

The validity assessment results show that the model satisfies all validity criteria and successfully passes each test. Following this, the researcher

examined the model for potential spurious effects and found no issues: there was no heteroscedasticity ($LM - test > LM - value$), no multicollinearity (VIF = 2.5), and no autocorrelation (Durbin-Watson D.W. = 2.18). Therefore, the Logit-RS-VARX model is deemed suitable for analyzing prioritization in selecting new scenario policies, with sensitivity values as follows.

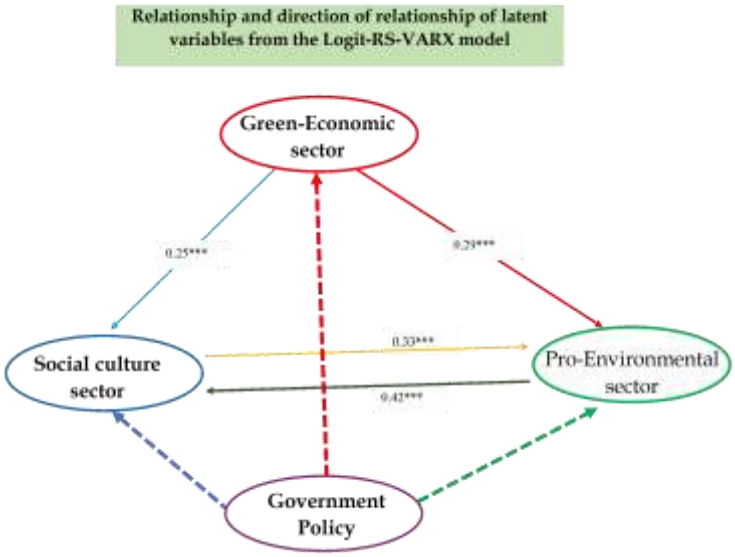

Figure 3: Results Of Prioritization Analysis for Selecting New Scenario Policies Using the Logit-RS-VARX Model.

As illustrated in Figure 3, the relationships among the latent variables include both direct and indirect effects. The Social Culture Sector has the strongest direct impact on the Pro-Environmental Sector, with an influence magnitude of 42% in the same direction. This indicates that when the government implements policies targeting the Social Culture Sector, the Pro-Environmental Sector is expected to respond with a 42% change in the same direction. Conversely, if policies are implemented in the Pro-Environmental Sector, the Social Culture Sector changes by only 33% in the same direction. These two factors exhibit a causal relationship, suggesting that the government can target policies in either sector, or both, based on the strength of influence and each sector's ability to adapt to equilibrium, which are critical considerations for decision-making. Additionally, the Green-Economic Sector directly affects the Pro-Environmental Sector with a 29% influence in the same direction, and the Social Culture Sector with a 25% direct influence in the same direction (Sutthichaimethee et al., 2025).

The study's findings highlight a causal link between the Social Culture Sector and the Pro-Environmental Sector, allowing the researcher to use sensitivity analysis to develop new scenario policies and prioritize key indicators. The analysis shows that only two indicators have a priority level above 80%: the electric vehicle rate and the solar cell rate. Among these, the electric vehicle rate exhibits the highest sensitivity at 91%, indicating that incorporating this indicator into national policies and planning will produce the fastest impact on sectoral changes. The solar cell rate follows with a sensitivity of 82%. Furthermore, when considering the magnitude of influence on causal factor changes, both in terms of causal variables and outcome variables, the Social Culture Sector demonstrates the highest influence on changes in other sectors and can adapt to equilibrium most rapidly. Therefore, this study sets the new scenario policy based on the electric vehicle rate and solar cell rate. Using the Logit-RS-VARX model, the researcher can analyze how changes in Social Culture affect energy consumption and, in turn, greenhouse gas emissions, providing a basis for long-term greenhouse gas emission forecasting, as detailed in the following sections.

4.4. Long-Term Projection of Greenhouse Gas Emissions (2025–2065)

Prior to using the Logit-RS-VARX model for forecasting, its performance was assessed against several existing models, including the OLS multiple regression model, ARIMA and ARIMAX models, Artificial Neural Network (ANN) model, Neural Network (NN) model, Grey Model GM (1,1), and the Anisotropy Factor (ANIF) model. The model's

accuracy was evaluated using MAPE and RMSE statistics. The analysis results are summarized as follows:

Table 4: Comparison of Logit-RS-VARX Model Performance with Existing Models.

Forecasting Model	MAPE (%)	RMSE (%)
OLS model	10.76	11.29
ANN model	7.85	9.73
ANIF model	6.02	8.11
GM (1,1)	5.77	6.44
NN model	5.29	5.75
ARIMA model	5.25	5.71
ARIMAX model	3.79	4.02
Logit-RS-VARX model	1.25	1.50

Source: Author's Estimate (2025)

Table 4 shows that, based on MAPE and RMSE performance metrics, the Logit-RS-VARX model outperformed all previous models. It achieved the lowest MAPE and RMSE values at 1.25% and 1.50%, respectively. The next best model was ARIMAX, with MAPE and RMSE of 3.79% and 4.02%, followed by ARIMA (5.25% and 5.71%), the NN model (5.29% and 5.75%), GM (1,1) (5.77% and 6.44%), ANIF (6.02% and 8.11%), ANN (7.85% and 9.73%), and OLS (10.76% and 11.29%). These results indicate that the Logit-RS-VARX model is highly suitable for long-term forecasting of greenhouse gas emissions from 2025 to 2065. The results can be summarized as follows:

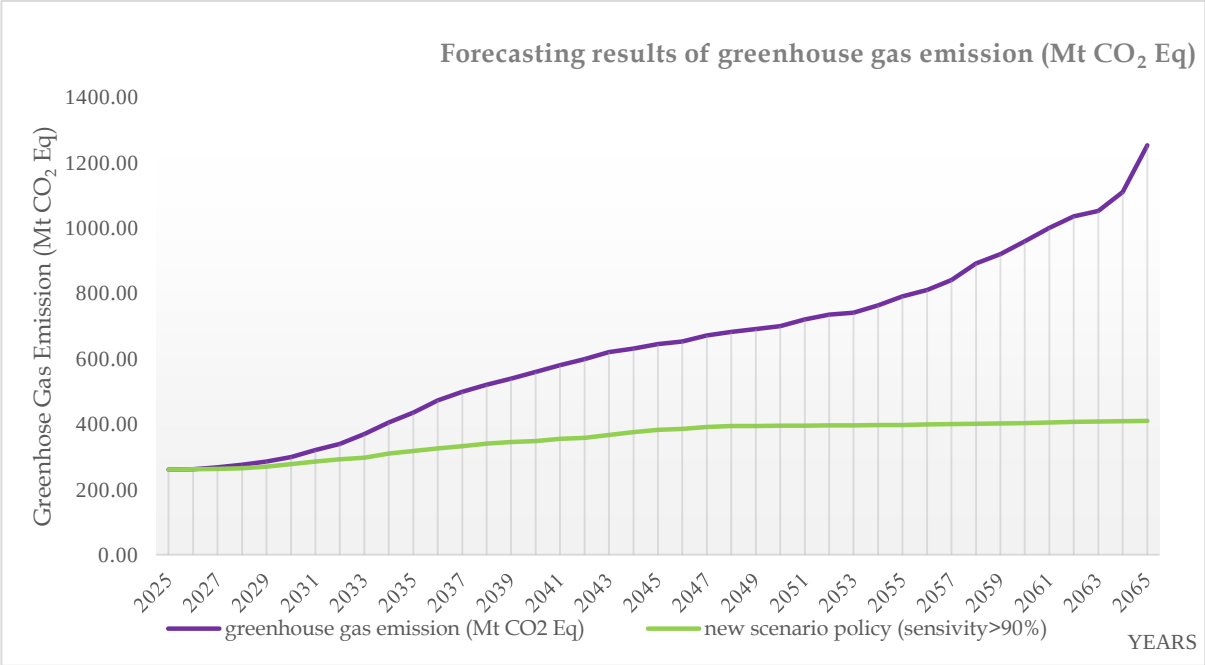

Figure 4: Projected Greenhouse Gas Emissions Under the New Policy Scenario.

Figure 4 shows that, without intervention, the forecasted growth of greenhouse gas emissions from 2025 to 2065 would reach 380.44%, resulting in total emissions of 1,950.1 Mt CO_2 Eq., far exceeding the defined carrying capacity of 650.55 Mt CO_2 Eq. However, by applying the study's key indicators, specifically the adoption rates of electric vehicles and solar cells, within the Logit-RS-VARX model, it was possible to account for how shifts in social culture could influence energy consumption and, consequently, greenhouse gas emissions. Under this new scenario policy, the growth rate of emissions would slow to 57.01%, with total emissions reaching 512.25 Mt CO_2 Eq., remaining below the carrying capacity. These findings suggest that implementing the proposed scenario policy can effectively reduce greenhouse gas emissions by 2065, keeping them within the government's target. However, the effectiveness of this policy depends on changes in, or acceptance by, the social culture sector. Furthermore,

analyzing the relationship between the social culture sector and the electric vehicle and solar cell rates, the researcher found that changes in acceptance or actions by the social culture sector would maximize the effectiveness of using the electric vehicle rate and solar cell rate in national energy planning. This type of analysis has not been conducted previously, which has often led to misdirection in policy planning. In addition, this study confirms the analytical results and uses them as a tool for guiding Thailand's policy-making. Through focus groups involving relevant stakeholders, the analysis results can be summarized as follows:

4.5. Focus Group Findings on Social Culture Affecting the Effectiveness of Long-Term Greenhouse Gas Emission Management

The relationship between culture and sustainable development is continuous and long-standing, similar to the environmental, social, and economic dimensions of sustainable development. Therefore, culture should be considered one of the dimensions supporting sustainability. Sustainable development is closely linked to culture, as culture determines how society values natural resources. Consequently, culture plays a crucial role in a society's economic progress. Sustainable societies place importance on three aspects: economic sustainability, environmental responsibility, and social justice and equity. While these aspects are critical, they are not sufficient on their own to support humanity's future well-being. In other words, no matter how well-designed national policies may be, if the social culture does not accept or cannot adapt to them, these policies cannot be effectively implemented and may eventually be abandoned. The interaction between environmental, economic, and social dimensions of sustainable development requires culture as a mediating foundation. Cultural heritage plays several important roles, including energy resources, cultural diversity, employment, and social capital. These elements aim to find sustainable solutions to economic, environmental, and social challenges. Cultural heritage can be continuously preserved and utilized as a tool or channel for economic development. Sustainable development is the outcome of such development, and when stakeholders or society accept and maintain it, projects can achieve their objectives effectively and efficiently. National policies on electric vehicle rates and solar cell adoption must be initiatives that are preserved and disseminated across all communities. This is because successful implementation relies heavily on societal acceptance and cooperation in changing behaviors. Extreme behavioural changes are often slow to be adopted and can incur significant costs. If such policies can effectively influence social culture, they will greatly contribute to sustainable development in the long term. At the initial stage of societal dissemination, government support in all dimensions, such as budgeting, provision of useful knowledge, and effective consultation, is essential for long-term sustainability. Therefore, the primary responsibility of the government is to engage with all stakeholders to foster the growth of social culture, which in turn significantly supports environmental growth and drives sustainable development across all dimensions in the long term.

5. DISCUSSION AND CONCLUSION

In this study, the researcher designed the Logit-RS-VARX model to examine how causal factors influence national management strategies with the goal of achieving sustainable performance. The study combined a quantitative approach with qualitative methods to ensure a comprehensive analysis. The Logit-RS-VARX model incorporates three latent variables, the Green-Economic Sector, the Social Culture Sector, and the Pro-Environmental Sector, along with 22 observed variables, which were tested for stationarity using the Augmented Dickey-Fuller test. At the level $I(0)$, all variables were found to be non-stationary. Therefore, the researcher applied first differencing to the data. At the first difference level $I(1)$, all variables were statistically significant at $\alpha = 0.01$, allowing them to be used as indicators for constructing the Logit-RS-VARX model. Next, the researcher examined the relationships among all indicators. At the first difference level $L(1)$, the co-integration test results for all variables were significant at $\alpha = 0.01$. Thus, all indicators were deemed suitable for inclusion in the Logit-RS-VARX model to analyze the long-term influence of causal factor relationships. The results demonstrate the potential effectiveness of implementing long-term policy changes.

However, the analysis in this study also revealed that the Logit-RS-VARX model can adapt toward equilibrium. Specifically, if the government implements any measures or policies, the Social Culture sector is able to adjust and adopt these policies most rapidly. This is followed by the Green-Economic sector and the Pro-Environmental sector, respectively. Therefore, it is essential for the government to design policies targeting the Social

Culture sector, as this sector can respond most quickly to policy implementation. Subsequently, the Green-Economic sector and the Pro-Environmental sector can adapt accordingly. This indicates that prioritizing policies in the Social Culture sector is the most effective approach, as it possesses the highest adaptive capacity and exerts the strongest relational influence. This influence can then be transmitted to the Pro-Environmental sector, thereby contributing to reductions in greenhouse gas emissions. Next, the researcher analyzed the relationships among the latent variables, taking into account both direct and indirect effects. The results showed that the Social Culture Sector exerts the strongest direct influence on the Pro-Environmental Sector in the same direction, followed by the Green-Economic Sector, which also has a direct positive effect on the Pro-Environmental Sector.

The study found that a key causal relationship exists between the Social Culture Sector and the Pro-Environmental Sector. This suggests that implementing strategies targeting these two sectors can guide change and form the foundation for a new scenario policy. In particular, the policy developed in this study focuses on leveraging the adoption rates of electric vehicles and solar cells to drive changes in social culture. Long-term forecasts using the Logit-RS-VARX model indicate that, from 2025 to 2065, greenhouse gas emissions would grow at a slower rate and remain below the defined carrying capacity. These findings demonstrate that implementing the new scenario policy can effectively reduce emissions by 2065, keeping them within the government's target. However, the effectiveness of this policy depends on societal change and acceptance, particularly from the Social Culture sector. Without such acceptance, the policy cannot achieve its intended impact. To date, such an analysis has not been conducted, which has previously led to misdirected policy planning. The results of this study reveal a gap compared to past research. Nevertheless, the findings are consistent with previous studies (Çetiner and Yenilmez, (2021); Elkhial (2025); Sutthichaimethee et al. (2025); Sutthichaimethee et al. (2025); Sutthichaimethee et al. (2025); Winyuchakrit et al. (2021); Setiawan et al. (2025); Sutthichaimethee et al. (2025); and Xiao (2025)), and this consistency serves as important evidence when evaluating performance. This evidence provides a robust basis for using the results as a key tool in formulating Thailand's long-term policies and plans, effectively and efficiently aligning with national management objectives.

However, the findings of this study clearly demonstrate that culture is a key driver of attitude changes necessary for sustainable development. It plays an essential role in shaping lively, inclusive communities and cities where people can thrive. Culture also supports both social and economic well-being. Building a sustainable society, therefore, requires cultivating a sustainable culture, one in which individuals appreciate and preserve their cultural heritage. Cultural sustainability entails protecting both tangible and intangible cultural assets. This foundation is vital for realizing social, economic, and environmental sustainability. In the modern world, sustainability perspectives are shifting to focus more on environmental balance, social engagement, and economic progress. As global societies confront pressing environmental, social, and economic issues, values such as diversity, creativity, and knowledge have become indispensable for achieving peace. These elements are directly connected to human development and progress. Historically, Thailand has lacked caution in consumption practices, which has severely impacted the nation, leading to environmental degradation. Past policy and planning efforts have consistently failed because they lacked a holistic perspective, focusing only on individual sectors rather than the system as a whole. If policies consider the overall picture and promote a conservation-oriented consumption process by fostering a new social culture that changes collective mindsets and values, it will enable true sustainable growth. Such an approach allows ecosystems to develop in harmony with the country's economic and social systems over the long term, achieving the most complete and integrated form of sustainable development.

As for the recommendations, this study provides several recommendations for long-term policy and planning in Thailand as follows:

1. The government should prioritize cultural sustainability. Culture shapes human needs and interests related to sustainable development. To achieve a more sustainable society, cultural transformation is necessary in every community. Culture not only influences individual attitudes but also establishes the goals and behaviors that form the foundation of societal conduct. Often, culture is placed at the center of sustainable development processes. Cultural sustainability is applied differently across various contexts. However, there has been little effort to systematically and

analytically integrate culture with sustainability. Even today, culture is frequently viewed as a subset of social sustainability rather than being recognized as an independent pillar within the broader sustainability framework. If governments prioritize embedding culture into sustainability discussions, acknowledging that human actions, behaviors, and stories, all deeply influenced by cultural contexts, are central to achieving sustainability objectives, policy implementation could become more effective. Furthermore, culture is not only a fundamental aspect of sustainable development but also one of its outcomes. Emphasizing cultural sustainability allows for diverse interpretations of human development and offers valuable models for future generations. To ensure that future generations remain self-sufficient and capable of fulfilling their own needs, it is essential to prevent the overexploitation of natural resources. Ultimately, cultural values elevate the way of life in any society, serving both as a foundation and as a moral compass guiding sustainable development.

2. The government should establish a clear direction and formulate a national strategy focused on cultural sustainability. The application of cultural sustainability varies across different contexts, yet it is still often regarded as a subset of social sustainability rather than as an independent pillar within the broader sustainability framework. This underscores the need to integrate culture more explicitly into sustainability discussions, recognizing that human actions, behaviors, and narratives, deeply rooted in cultural contexts, are essential to achieving sustainability goals. Culture is not only a vital component of sustainable development but also one of its outcomes, offering valuable models for future generations. To ensure that these generations are self-reliant and capable of meeting their own needs, resource exploitation must be minimized. The quality of life within any society is strengthened through its cultural values, which should promote acceptance of pro-environmental practices and support the transition toward a green economy. Fostering such a social culture encourages communities to take ownership of their natural and cultural resources, protecting them from external threats. For sustainability to be truly holistic, members of society must understand and appreciate their cultural heritage. Cultural sustainability involves safeguarding both tangible and intangible cultural assets, as this is the foundation upon which social, economic, and environmental sustainability can be achieved.

3. The government must take an active role in nurturing values and cultural foundations within future societies. Cultural values are not static; they evolve continuously over time. To move forward, it is essential first to redefine the concept of social sustainability, as this redefinition will reshape how sustainability is understood globally, highlighting the fundamental role of culture in shaping human identity. Culture offers insights and solutions to many of the challenges confronting the world today. Therefore, it must be positioned at the core of global sustainability efforts. Rather than being treated as an additional or secondary element, culture should be fully integrated into the economic, environmental, and social dimensions of sustainability. Only through this holistic integration can genuine and lasting sustainable development be achieved.

4. The government should enhance organizational effectiveness, particularly in leadership. The attitudes and behaviors of individual organizational leaders are critical for achieving a sustainable organization. Without efforts to influence or align organizational culture, meaningful outcomes cannot be realized. It is essential to develop a society in which people's culture reflects sustainable behaviors. Environment and culture operate as a unified system, making it impossible to fully understand one without considering the other. Culture is a driving force toward sustainability and a key determinant of whether sustainability can be achieved. When processes are deeply embedded in culture, they can play a significant role in attaining sustainable development. When considering cultural issues in sustainability, these matters can be categorized under social sustainability, highlighting the importance of aligning cultural and social dimensions to support long-term sustainable outcomes.

5. The government should establish a sustainability model that interconnects four key dimensions: social equity, cultural vitality, economic well-being, and environmental sustainability. This integrated four-dimensional framework provides a holistic approach to assessing the impacts of social, economic, and environmental policies. A true understanding of the environment also requires recognition of people's identities and cultural contexts, as all dimensions; economic, environmental, and social, are inherently interdependent and mutually reinforcing. Such integration can be realized through practices like resource reuse, recycling, and the promotion of clean technology and sustainable consumption.

In terms of limitations, Thailand's energy consumption patterns from the past to the present have been shaped by a cultural legacy that perpetuates outdated practices and entrenches misconceptions, passed down from generation to generation. Historically, Thailand has consumed resources without consideration for future generations or for environmental conservation, failing to ensure that natural resources remain sustainable for the country and the planet. Therefore, transitioning from one consumption pattern to a more sustainable one is crucial for achieving sustainable development. Indigenous and local knowledge systems, along with traditional environmental practices, offer valuable perspectives on addressing ecological challenges. Cultural factors play a crucial role in reducing the impacts of climate change, protecting against land degradation, and conserving biodiversity. Moreover, culture can promote economic growth while ensuring that people enjoy improved living standards and enhanced adaptability to environmental changes. Thailand also lacks a governance approach that adequately integrates and prioritizes culture, including lifestyles, social capital, and methods for achieving sustainable values. When culture is incorporated into sustainability strategies, it can lead to inclusive and human-centered development. Because culture is multidimensional, it can influence all aspects of development. Furthermore, the government needs to understand and value culture more, as it links directly to the economy through employment, income generation, poverty reduction, civic engagement, and equal rights.

Author Contributions Statement: PS: conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing original draft preparation, writing review, and editing. DA: formal analysis and investigation. JL: software, validation, data curation, investigation. SU: software, resources, investigation. WS: formal analysis, investigation, writing review and editing, supervision, project administration. BW: methodology, validation, formal analysis, investigation, writing review and editing. SW: conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing original draft preparation, writing review and editing, supervision, project administration. All authors have read and agreed to the published version of the manuscript.

Funding Statement: This research project was financially supported by Mahasarakham University.

Acknowledgments: The authors wish to extend appreciation to the Faculty of Engineering, Mahasarakham University, and Electrical and Computer Engineering Research Unit, Mahasarakham University, for providing research support and facilities.

REFERENCES

Alakkas, A.A., Shabir, S., Alhumoudi, H., Boukhris, M., Baig, A., and Khan, I.A. (2023) The Impact of Sustainability Accounting on Environmental Performance and Productivity: A Panel Data Analysis. *International Journal of Sustainable Development and Planning*, Vol. 18, No. 8, 2431-2441.

Ali, S.M.O., Okba, E.M., and Sabri, N. (2023) The Role of Landscape in Achieving Environmental Sustainability for Residential Areas in Egypt "Slums Replacement Area Case Study". *International Journal of Sustainable Development and Planning*, Vol. 18, No. 5, 1425-1441.

Baltagi, B. H. (2021) *Econometric Analysis of Panel Data*. (6th ed.) Springer Nature. https://doi.org/10.1007/978 3-030-53953-5

Çetiner, B., Yenilmez, M.I. (2021) The Role of Culture in Environmental Sustainability. Present Environment and Sustainable Development, Vol. 15, NO. 2, 259-272.

Chen,X., Bao,K., Gao,C., Wen,Y., Zhang, T. (2025) towards Corporate Sustainability: Can the Cultural and Tourism Consumption Promotion Policy Enhance Corporate ESG Performance? *Sustainability,* Vol. 17, 8402.

Cheng, F.T. (2025) Taiwan's path to net-zero: fiscal and financial strategies for energy transition. *ACADEMIAGREENENERGY*, Vol.2 ,1- 12.

Dickey, D.A.; Fuller, W.A. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* **1981**, *49*, 1057–1072.

Elkhial, M.M. (2025) Integrating Preventive Conservation and Climate Change Adaptation: Strategies For Sustainable Protection of Cultural Heritage in Egyptian Museums. *SCIENTIFIC CULTURE*, Vol. 11, No. 1, 49-62.

Harvey, A.C. (1980) *Forecasting, Structural Time Series Models and the Kalman Filter*; Cambridge University Press: Cambridge, UK.

Hasanuddin, S.B., Demmalino, E.B., Tahara, T., Yassi, A., and Darhamsyah. (2025) Ecological Adaptation Patterns to Tropical Climate Change Phenomena in Climate Resilient Potato Crop Engineering. *Engineering, Technology & Applied Science Research*, Vol. 15, No. 4, 26038-26046

Haverkamp, P., Traverso, M., Ahmed, A.H., Liebscher, M., and Mechtcherine, V. (2025) Evaluating the Environmental Impacts and Social Risks of Limestone Calcined Clay Cement (LC3) Mortars. Sustainability, Vol. 17, 8364.

Joreskog, K.G., and Sorbom, D. (2012) *LISREL 9.1: LISREL syntax guide.* Chicago: Scientific Software International.

Kanwal, S., Mamun, A.A., Wu, M., Bhatti, S.M., and Ali, M.S. (2024) Corporate social responsibility: A Driver for green organizational climate and workplace pro-environmental behavior. *Heliyon,* Vol. 10, e38987.

Karimi, K., Amar, S., and Idris. (2024) A Simultaneous Equation Approach to Examining Linkages Between Income Inequality and Environmental Degradation in Lower Middle-Income Economies in ASEAN. *International Journal of Sustainable Development and Planning*, Vol. 19, No. 5, 1837-1844.

Kryshtanovych, M., Antonova, L., Larina, N., Larin, S., Inozemtseva, O. (2024) Application of a Methodology for Modeling the Influence of Environmental Factors on the Work of the Public Sector in the Context of Sustainable Development. *International Journal of Sustainable Development and Planning*, Vol. 19, No. 5, 1903-1910.

Laghari, A.N., Rajper, A., Walasai, G.D., Jatoi, A.R., Jalbani, N.B., and Soomro, H. (2018) Assessment of Climate Driven Changes in Flow Series of Alpine Basin: A Case Study of Danube River Basin. *Engineering, Technology & Applied Science Research,* Vol. 8, No. 6, 3505-3507.

Laghari, A.N., Rauch, W., and Soomro, M. A. (2018) A Hydrological Response Analysis Considering Climatic Variability Case Study of Hunza Catchment. *Engineering, Technology & Applied Science Research*, Vol. 8, No. 3, 2981-2984.

Liashenko, O., Demianiuk, O. (2025) Economic Dimensions of Responsible Consumer Behavior in Sustainable Development. *Economics of Systems Development*, Vol. 7, No. 1, 71-80.

MacKinnon, J. *Critical Values for Cointegration Test in Long-Run Economic Relationships*; Engle, R., Granger, C., Eds.; Oxford University Press: Oxford, UK, 1991.

Manti, P., and Henderson, J. (2025) Confronting Climate Crisis: A Call for Sustainable And Adaptive Heritage

Conservation. *SCIENTIFIC CULTURE,* Vol. 11, No. 1, i-vi.

Melnyk,S., Vasiutynska, K., Korduba,I., Trach, Y., Trach, R., Butenko, D., Chyli´nski, F., and Wrzesi´nski, G. (2025) Modeling and Forecasting of the Local Climate of Odesa Using CNN-LSTM and the Statistical Analysis of Time Series. *Sustainability*, Vol. 17, 8424.

Milinski, M., Sommerfeld, R.D., Krambeck, H.J., Reed, F.A., and Marotzke, J. (2008) The collective-risk social dilemma and the prevention of simulated dangerous climate change. *PNAS*, Vol. 105, No. 7, 2291-2294.

Mohanty, B., Aashima, Kaushik, M.B., Gehlot, V., Sharma, S. (2023) Investigating the Relationship Between Corporate Sustainability Reporting and Firm Performance: Evidence from Emerging Economy. *International Journal of Sustainable Development and Planning,* Vol. 18, No. 12, December, 2023, pp. 4031-4040.

National Statistical Office Ministry of Information and Communication Technology. Available online: http://web.nso.go.th/index.htm (accessed on 10 June 2025).

OECD. Historical Crude Oil Import Prices (Indicator), Organization for Economic Co-operation and Development. Available online: https://data.oecd.org/energy/crude-oil-import-prices.htm (accessed on 12 July 2025)

Office of Natural Resources and Environmental Policy and Planning. Long-term low greenhouse gas emission development strategy (revised version). Available online: https://www.onep.go.th/(accessed on 5 January 2025)

Office of the National Economic and Social Development Council (NESDC). Available online: https://www.nesdc.go.th/nesdb_en/main.php?filename=index (accessed on 10 June 2025).

ONEP. Thailand's Fourth Biennial Update Report, Office of Natural Resources and Environmental Policy and Planning. Available online: https://www.onep.go.th (accessed on 10 June 2025).

Pavlova, O., Liashenko, O., Mykhailovska, O., Pavlov, K., Posłuszny, K., and Korcyl, A. (2025) Roles, Risks and Responsibility: Foundations of Pro-Environmental Culture in Everyday Choices. *Sustainability*, Vol. 17, 9019.

Pereira, L.G., Ramos, N.P., Pighinelli, A.L.M.T., Novaes, R.M.L., Seabra, J.E.A., Debiasi, H., Hirakuri, M.H., and Folegatti, M.I.S. (2025) State-Level Inventories and Life Cycle GHG Emissions of Corn, Soybean, and Sugarcane Produced in Brazil. *Sustainability*, Vol. 17, 8482.

Prandelli, M., Rizzoli, V., and Tolusso, E. (2025) The sustainable challenge: Where does social psychology stand in achieving the sustainable development goals? *Br J Soc Psychol.*, Vol. 64, e12822.

Raj, B., and Ullah, A. (1981). *Econometrics (Routledge Revivals): A Varying Coefficient Approach* (1st ed.). Routledge: London, UK. https://doi.org/10.4324/9781315831961

Ren, L., Wang, X., Jiang, W., Ren, M., Yin, L., Zhang, X., and Zhang, B. (2025) Exploring Impact and Driving Forces of Land Use Transformation on Ecological Environment in Urban Agglomeration from the Perspective of Production-Living-Ecological Spatial Synergy. *Sustainability*, Vol. 17, 8235.

Sánchez-Rodríguez, A., Pérez-Campdesuñer, R., García-Vidal, G., Fernández-Ochoa, Y., Martínez Vivar, R., and Alvarez-Subía, F.I. (2025) Human Behavioral Drivers of Sustainable Supply Chains: The Role of Green Talent Management in Ecuadorian MSMEs. *Sustainability*, Vol. 17, 8810.

Setiawan, A., Alghoson, A., Abdul Hadi, A.R.B, Priadi, A.A., and Marciano, D. (2025) Renewable Energy and Equitable Environments – The Case of Asean Net Energy Exports. *SCIENTIFIC CULTURE*, Vol. 11, No 2, pp. 172-181.

Sobirov, Y., Artikov, B., Khodjaniyozov, E., Marty, P., and Saidmamatov, O. (2025) Economic Growth, FDI, Tourism, and Agricultural Productivity as Drivers of Environmental Degradation: Testing the EKC Hypothesis in ASEAN Countries. *Sustainability*, Vol. 17, 8394.

Sutthichaimethee, P., Sa-Ngiamvibool, W., Wattana, B., Luo, J., and Wattana, S. (2025) Enhancing Sustainable Strategic Governance for Energy Consumption Reduction Towards Carbon Neutrality in the Energy and Transportation Sectors. *Sustainability*, Vol. 17, 2659.

Sutthichaimethee, P., Saraphirom, P., and Junsiri, C. (2025) A Path Analysis—Generalized Method of Moments Based on a Nearest Neighbor with Observed Variable Model for Developing New Scenario Policies to Reduce Greenhouse Gas Emissions from Agricultural Waste Towards Sustainability. Appl. Sci., Vol. 15, 2160.

Sutthichaimethee, P., Saraphirom, P., and Junsiri, C. (2025) An Advanced Model for Greenhouse Gas Emission Reduction in the Agricultural Sector to Achieve Sustainability for Thailand's Future. *Appl. Sci.*, Vol. 15, 1485.

Sutthichaimethee, P., Saraphirom, P., and Junsiri, C. (2025) Efficiency of National Governance in Managing Long-Term Greenhouse Gas Emission Reduction in the Agricultural Sector Towards the Thailand 5.0 Goal. *Sustainability*, Vol. 17, 3959.

Sutthichaimethee, P., Saraphirom, P., and Junsiri, C. (2025) Long-Term Strategy for Determining the Potential of Climate-Smart Agriculture to Maximize Efficiency Under Sustainability in Thailand. *Sustainability*, Vol. 17, 3635.

Tabucanon, A.S., Sahavacharin, A., Rathviboon, S., Lhaetee, H., Pakdeesom, D., Xue, W., and Charmondusit, K. (2021) Investigating the Critical Issues for Enhancing Sustainability in Higher Education Institutes in Thailand. *International Journal of Sustainable Development and Planning*, Vol. 16, No. 3, June, 2021, pp. 503-514.

Tam, K.P., and Milfont, T.L. (2020) Towards cross-cultural environmental psychology: A state-of-the-art review and recommendation. *Journal of Environmental Psychology*, Vol. 71, 101474.

Thailand Greenhouse Gas Management Organization (Public Organization). Net-zero GHG Emissions. Available online: https://thaicarbonlabel.tgo.or.th/tools/files.php?mod=YjNKbllXNXBlbUYwYVc5dVgyUnZkMjVzYjJGaw&type=WDBaSlRFVlQ&files=TkRrPQ (accessed on 10 June 2025).

The World Bank: Energy Use (Kg of Oil Equivalent Per Capita) Home Page. Available online: https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE (accessed on 15 May 2025).

van der Werff, E., Steg, L., and Keizer, K. (2013) The value of environmental self-identity: The relationship between biospheric values, environmental self-identity and environmental preferences, intentions and behaviour. *Journal of Environmental Psychology*, Vol. 34, 55-63.

Villanueva, M.C. (2025) Developing Sustainable Environmental Guidelines for Collections in The Tropics: A Philippine Case Study. *SCIENTIFIC CULTURE*, Vol. 11, No. 1, 63-72.

Wang, Q. (2020) Public Attention, Government Subsidies and Corporate Environmental Disclosure: Empirical Evidence from Listed Chinese Enterprises in Heavy-Pollution Industries. *International Journal of Sustainable Development and Planning*, Vol. 15, No. 3, 301-308.

Winyuchakrit, P., Limmeechokchai, B., Matsuoka, Y., Gomi, K., Kainuma, M., Fujino, J., Suda, M. (2021) Thailand's low-carbon scenario 2030: Analyses of demand side CO_2 mitigation options. *Energy for Sustainable Development*, Vol.15, 460–466.

Xiao, Y., Yang, C.X., Yang, H., Wattana, S., Wattana, B. (2025). Policy-driven development of electric and hydrogen fuel cell vehicles for low-carbon transition in Hainan Province. *International Journal of Sustainable Development and Planning,* Vol. 20, No. 6, 2257-2268.

Yilmaz, V. (2025). Climate patterns in Europe: A focus on ten countries through remote sensing. *International Journal of Engineering and Geosciences*, Vol. 10, NO. 3, 398-418.

Zhu, Q., and Bao, Q. (2025) She Wants Safety, He Wants Speed: A Mixed-Methods Study on Gender Differences in Consumer Behavior. *Systems*, Vol. 13, 869.