The Impact of Tourism Development on CO2 Emissions: Evidence from ASEAN Economies

A Thesis

Submitted to the Master's Study Program of Economics at the Faculty of Economics and Business in partial fulfillment of the requirements for the degree of

Master of Arts (M.A.)

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ABSTRACT

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For several decades, the tourism sector has played a pivotal role in driving economic growth across ASEAN economies. However, the sector now faces significant challenges due to its vulnerability to climate change. This study investigates the correlation between the growth of the tourism industry and CO2 emissions in ASEAN countries from 2010 to 2019. Utilizing a random effects model, we analyse the impact of tourism on CO2 emissions, a key contributor to climate change. The results indicate that sustainable tourism practices, such as ecotourism, sustainable tourism and cultural tourism, can significantly reduce CO2 emissions by promoting biodiversity and preserving natural beauty. Furthermore, the study finds a positive correlation between real GDP per capita, energy intensity, and carbon emissions. The regression results confirm that international tourists prefer less-polluting destinations with efficient infrastructure, indicating a strong attraction to environmentally friendly travel options in ASEAN economies. This preference has significant implications for sustainable tourism development in ASEAN economies. Policy recommendations include pursuing sustainable, eco-friendly tourism through comprehensive and integrated sustainable tourism policies. These policies should focus on maintaining environmental quality, promoting green infrastructure, adopting clean technologies, and preserving forests to attract foreign tourists while minimizing environmental impact. Ultimately, integrated sustainable tourism policies will position ASEAN as a leading sustainable and eco-friendly destination, fostering both economic growth and environmental stewardship. By implementing these recommendations, ASEAN countries can balance economic development with environmental sustainability, contributing to the global effort against climate change.

Keywords: climate change; tourism; carbon emissions; ecotourism, economic development, environmental sustainability

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Climate change directly impacts social advancement, political stability, economic development, traditional way of life, and geopolitical dynamics (Bilgili et al., 2016; Koçak et al., 2020). ASEAN economies, heavily reliant on agriculture, tourism, and coastal resources, are particularly vulnerable to these effects. By the end of the century, climate change is predicted by the Asian Development Bank (ADB) to harm human health, labour productivity, tourism, fisheries, and agriculture, which might result in an 11% reduction in ASEAN's GDP (Raitzer et al., 2015). According to the Global Climate Risk Index (Figure 1.1) compiled by Germanwatch.org, Myanmar, the Philippines, Thailand, Vietnam, and Cambodia are among the top 15 countries globally most impacted by climate change from 2000 to 2019.

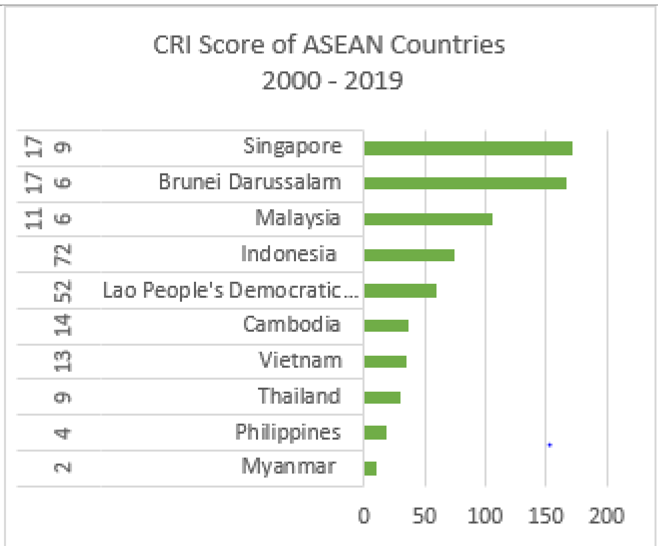

Figure 1.1 Global Climate Risk Index 2021
Source: Germanwatch.org

Southeast Asia presents a unique challenge in climate stabilization. The area contains roughly 15% of the global tropical forests and has at least four 25 biodiversity hotspots worldwide (Estoque et al., 2019). However, it faces significant deforestation pressures, particularly in tropical lowland and humid forests (Estoque et al., 2019). Significant human activities in the region, such as logging, clear-cutting for food production and cash crops, and agricultural expansion, are responsible for forest clearance and loss of canopy (Sodhi et al., 2004;Wilcove et al., 2013; Estoque et al., 2019). The increase in oil palm cultivation is a significant factor in deforestation, which leads to the loss of biodiversity and the release of greenhouse gases (Koh et al., 2011).

Research has established significant dynamic relationship between CO2 emissions and various macroeconomic variables, including economic growth, foreign direct investment, governance, trade openness, population, urbanization, energy use, financial development, renewable energy, natural resource rent and ICT development (Li and Lin, 2015; Nasrollahi et al., 2018; Park et al., 2018; Cetin et al., 2018; Dong et al., 2018; Behera & Dash, 2017; Bekun et al., 2019; Haini, H.,2021). While there is a direct correlation between tourism activities and carbon emissions, the relationship between tourism development has yet to be sufficiently examined in applied economics research.

Economically, the tourism sector is a trillion-dollar industry, with its share of global exports accounting for around 7% and significantly contributing to the worldwide GDP. The industry has demonstrated robust growth, with international arrivals and tourism receipts increasing by 3–5% annually, outpacing the development of global trade. In 2016 alone, tourism exceeded 1 billion arrivals and generated US$1.2 trillion in receipts. The rise in international tourism has increased household spending, positively impacting long-term economic growth (Chou, 2013).

Tourism has driven economic expansion for decades in many parts of the world. multiple studies have also emphasized its economic influence, including Archer (1984) for Barbados, Durbarry (2002) for Mauritius, Gunduz and Hatemi-J (2005) for Turkey, Lee and Chang (2008) for 55 OECD and non-OECD countries, Narayan et al. (2010) for four Pacific Island countries, Lee & Brahmasrene, (2013) for European Union, Paramati et al., (2017) for 18 developing countries and 26 developed countries, (Akadiri et al., 2020) for 16 small islands, and Daniel Balsalobre-Lorente et al. (2021, pp. 1–14) for the top 10 tourism destinations. Further studies by (Nonthapot et al., 2014) (Anggraeni, 2017) and (Indriani, Devi, 2022) focus on ASEAN countries and assert that the tourist sector makes substantial contributions to economic development, including (i) foreign exchange earnings, (ii) employment generation, (iii) investment stimulation, (iv) business expansion, (v) economic diversification, and (vi) technology transfer (Dwyer et al., 2020).

In many economies, inbound tourism is a vital export service for countries with strong tourism industries (Gunduz & Hatemi, 2005). In ASEAN, tourism significantly impacts employment even if its contribution of tourism to GDP may not be as substantial as the primary sector (Indriani, Devi, 2022). 2019 Tourism made up significant percentages of the GDP in 2019, with Cambodia at 25.8%, the Philippines at 22.5%, and Thailand at 20.3%. That same year, international tourism significantly contributed to exports, with Cambodia at 32.1%, Thailand at 19.8%, Myanmar at 16.9%, and Lao PDR at 13.6% (WTTC, 2022; OECD, 2023). While the tourism sector's contribution to GDP rebounded in 2021, its share of exports continued to wane in most of these countries. Nonetheless, the tourism industry's employment levels showed signs of recovery across the region (OECD, 2023).

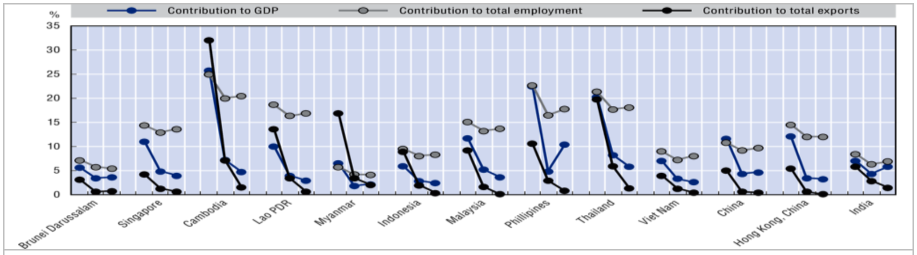

Figure 1.2. Travel and tourism contribution to the economy, 2019-21
Note: Contribution includes direct, indirect, and induced impacts.
Source: OECD (2023)

The tourism sector in ASEAN is highly susceptible to global disturbances, as demonstrated by the significant downturn triggered by the onset of the COVID-19 pandemic in 2020. Before the pandemic, Southeast Asia thrived on tourism. In 2019, the number of international visitors visiting Southeast Asia was 138.7 million. This influx of tourists accounted for 11.7% of the regional economy and supported 41.8 million jobs, representing 13.2% of total employment (WTTC, 2022 and OECD,2023). However, the pandemic triggered a dramatic decline in tourist arrivals, severely impacting millions of livelihoods across the region. While there are signs of recovery, the industry hasn’t necessarily reached pre-pandemic levels. In 2023, Malaysia emerged as the most visited country in Southeast Asia 2023, attracting nearly 29 million tourists, followed by Thailand with over 28 million visitors, Singapore with 13.6 million, Vietnam with 12.6 million tourists, Indonesia with 11.7 million, the Philippines and Cambodia with approximately 5.4 each (VN Express International, 2023).

Figure 1.3. Number of foreign tourists Arrival in Southeast Asia, 2023
Source: VN Express International (2023)

However, the economic benefits of tourism come at an environmental cost. Tourists consume energy directly from fossil fuels or indirectly from electricity, often fuelled by coal, natural gas, or oil (Paramati et al., 2017). Bach and Gössling (1996) were among the first to highlight the significant impact of the aviation sector on greenhouse gas emissions within a theoretical context. According to Lenzen et al. (2018), the tourism sector contributes to an estimated 11% of global emissions, with transportation—a major component of travel—being particularly energy and carbon-intensive. This share of emissions is expected to increase as global travel activities expand. These insights underscore the sector's substantial potential impact on climate change, emphasizing the urgent need for sustainable tourism practices (WEF,2021).

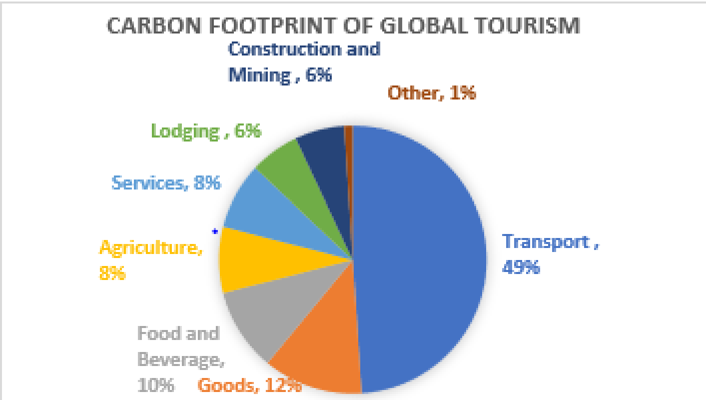

Figure 1.4 Activities that contribute to tourism's total carbon footprint.
Data Source: Lenzen et al. (2018)

Southeast Asia faces challenges in fulfilling its commitment to the 2015 Paris Agreement at COP21. The report released by the World Economic Forum's Travel & Tourism Development Index in 2021 revealed that most ASEAN countries ranked below the global average regarding environmental sustainability (Figure 1.7). The situation happened despite efforts from public and private institutions in Indonesia, Thailand, Malaysia, and Singapore since as early as 2010 to achieve global sustainable tourism standards. The report also noted that the region is experiencing biodiversity loss, water body pollution, deforestation, solid and industrial waste increase, and marine plastic pollution. The COVID-19 pandemic has intensified the region's focus on sustainability and responsible tourism, underscoring the need to manage ongoing risks associated with dwindling resources and climate change. At COP26 in 2021, over 140 countries pledged to reach net zero by mid-century, and 40 nations committed to phasing out coal (Trilemma Index, 2022).

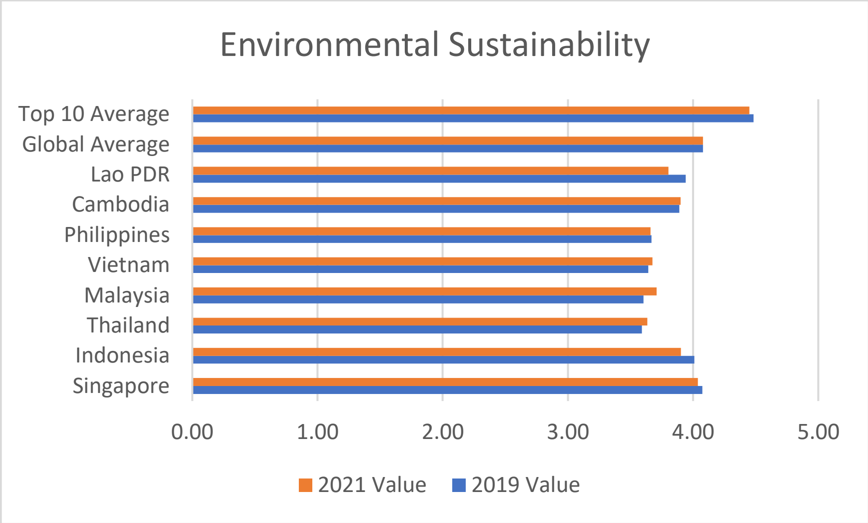

Figure 1.5 Environmental Sustainability Subindex
Source: WEF’s Travel and Tourism Development Index (2021)

Tourism is inherently linked to human consumption and spending, heavily reliant on natural and human-made resources and substantial investments in infrastructure (Kongbuamai et al., 2020). Sustainable tourism development requires a holistic approach, considering its multifaceted impacts on a destination's environment, socio-cultural aspect, and economy (Islam et al., 2023). Unsustainable practices in tourism, like deforestation, can directly degrade ecosystems (Baloch et al., 2023), highlighting the importance of fostering a sustainable tourism sector. If sustainability is the main objective, it is possible to understand how competitiveness and sustainability influence tourism (Daniel Balsalobre-Lorente et al., 2021).

The tourism sector is a strategic engine that contributes to multiple macroeconomic impacts and informs valuable policy recommendations (Daniel Balsalobre-Lorente et al., 2021; Brida et al., 2016). Environmental factors and broader economic trends can influence tourism's ecological footprint. For example, China's national energy intensity significantly affects its tourism carbon emissions, highlighting the influence of national policies (Luo et al., 2020). During the initial stages of economic development, energy sources were excessively utilized with minimal environmental restrictions (Zuo & Huang, 2018).

Technological progress and environmental regulation shape how the tourism sector reacts to ecological challenges and energy advancement, promoting more efficient energy processes (Li et al., 2018). A key driver of this shift is the growing adoption of clean energy solutions, such as solar panels in resorts and hotels or electric vehicles for transportation. Literature underscores the significant impact of clean energy on sustainable tourism. Clean energy development is both a catalyst and consequence of economic growth, driven by anticipated economic advantages (Guo et al., 2023; Chau et al., 2023). Utilizing clean energy is essential for establishing sustainable practices, as it effectively mitigates the environmental consequences of carbon dioxide emissions and the consumption of fossil fuels.

According to Tourism4SDGS.org, tourism is a robust sector with the potential to impact all of the Sustainable Development Goals (SDGs) outlined in the 2030 Agenda. This ambitious framework aims to eradicate extreme poverty, combat inequality and injustice, and tackle climate change. Given the interconnected nature of the 17 SDGs and their 169 targets, tourism is uniquely positioned to drive sustainable solutions that benefit people, the planet, prosperity, and peace. For instance, tourism can create jobs and promote economic growth (SDG 8), encourage responsible consumption patterns and reduce waste (SDG 12), and support the conservation of marine ecosystems (SDG 14). Notably, the tourism sector is explicitly integrated within the targets of these three SDGs, highlighting its potential for positive impact.

However, despite its potential for positive contributions to economic variables such as GDP and employment, tourism also impacts the environment, such as traffic congestion, road accidents, crime, litter, noise, crowds, property damage, environmental degradation, police and fire protection, vandalism, and other negative behaviours. In addition, tourist attractions, including special events like the Grand Prix, MotoGP, international concerts, and festivals, are linked to increased energy consumption, water use, and waste generation. These activities can place significant pressure on the limited resources of certain locations (Dwyer et al., 2020). Hence, tourism sector needs help achieving sustainability. One significant challenge is the industry's environmental impact, particularly its contribution to greenhouse gas emissions. This study investigates the intricate dynamics between tourism development and CO_2 emissions in ASEAN countries.

1.2 Problem Statement

Southeast Asian nations strive to meet ambitious carbon neutrality goals by 2050 but face significant challenges. The region's heavy reliance on fossil fuels, uncertain regulatory environments, and political instability complicate efforts towards sustainable development. Furthermore, Southeast Asia is positioned as the third-largest contributor to global carbon emissions, which are anticipated to increase persistently. Understanding how tourism contributes to carbon emissions is crucial, particularly given that tourism is one of the economic engines in ASEAN economies.

Several studies assessed the impact of tourism on the environment in developed and developing countries (Paramati et al., 2017). Existing research in ASEAN by

Azam et al. (2018) and Ahmad et al. (2019) investigated the environmental impact of tourism in several countries in ASEAN, while Kongbuamai et al. (2020) use the entire ASEAN population but do not exclusively explore the holistic environmental impact of tourism development across ASEAN economies. A recent study by Nonthapot et al. (2024) examined the role of economic factors and energy usage as mediators between tourism and carbon emissions in ASEAN countries. However, the gap remained due to the need for more exploration of the role of energy intensity in ASEAN economies. Previous studies Koçak et al. (2020) have investigated the environmental impacts of tourism development on carbon emissions using energy intensity. Still, their studies focused on the top 10 most visited countries from 1995 to 2014. León et al. (2014) investigated the impact of tourist arrivals, population, economic growth, and energy intensity on CO2 emissions. Their analysis utilized data from 1998-2006 in both developed and undeveloped countries. Their study did not exclusively address the unique situation in Southeast Asia.

Furthermore, a critical gap exists in understanding the impacts of tourism as an enabler to achieving Sustainable Development Goals (SDGs), particularly Goals 8 (Decent Work and Economic Growth), 12 (Responsible Consumption and Production), and 13 (Climate Action). This study addresses the critical research gaps surrounding tourism's connection with the Sustainable Development Goals (SDGs). This study utilizes a robust statistical framework to examine the lasting effects of tourism on the quality of the environment, namely carbon emissions in Southeast Asia. This understanding is crucial for informing evidence-based policy to achieve carbon neutrality and foster sustainable development.

In addition, this study used the STIRPAT model to assess the ecological consequences of tourism. Using the STIRPAT model allows for a comprehensive examination of the impact of shifts in human development dynamics on the environmental outcomes of tourist development in ASEAN.

1.3 Research Objectives

Based on the problem statement, this study has several objectives, one of which is to investigate the impact of tourism development on carbon emissions in ASEAN economies. As a support for the research, this study also utilizes a series of control variables identified as factors affecting a country's emission levels: real GDP per capita, population size and energy intensity following the STIRPAT model.

1.4 Research Questions

Regarding the nexus between tourism development and carbon emissions, it is essential to address the following questions:

1. What is the growth rate of tourism development and current landscape of sustainable tourism development in ASEAN economies?
2. How does tourism development affect CO2 emissions in ASEAN economies?
3. What is the role of control variables; real GDP per capita, energy intensity, and Population size in impacting carbon emissions in ASEAN economies?

1.5 Research Hypothesis

The study derives hypotheses concerning the influence of tourist development on carbon emissions in ASEAN countries based on the findings obtained from the literature review. This study proposes a hypothesis for this study:

Main Variable:

1. H0: Tourism does not significantly induce carbon emissions
   H1: Tourism significantly induced carbon emissions

Control variables:

2. H0: Real GDP per capita does not lead to significantly increased carbon emission
   H1: Real GDP per capita leads to a significant increase in carbon emissions
3. H0: Energy intensity does not lead to significantly increased carbon emissions
   H1: Energy intensity leads to substantially increased carbon emissions
4. H0: Population size does not lead to significantly increased carbon emissions
   H1: Population size leads to substantially increased carbon emissions

1.6 Significance of the Research

Rapid economic development in Southeast Asia is partly driven by tourism, which can also significantly impact energy consumption and climate change. This study investigates the combined effects of tourism, energy intensity, population size, and economic growth on carbon emissions in ASEAN countries. By addressing the knowledge gap regarding how these factors collectively influence carbon emissions, our research offers valuable insights for:

1. Sustainable Tourism Policies: Understanding these factors' influence on emissions can inform policymakers in designing strategies that minimize the environmental

impact of tourism and optimize its contribution to sustainable economic growth in ASEAN.

2. Policymaking in ASEAN: This research equips policymakers and stakeholders with knowledge of the strategic role of tourism in climate change mitigation and reducing environmental degradation in the rapidly developing ASEAN region. The findings can support policies that balance tourism development with ecological sustainability.
3. Researchers and Global Audiences: The findings contribute valuable knowledge to global audiences by highlighting how tourism could influence carbon emissions in developing regions like Southeast Asia. The study's insights can help build sustainable tourism models in other areas experiencing rapid economic development.

1.7 Organization of the Research

The writing of this paper is based on a systematic arrangement consisting of several chapters as follows:

CHAPTER I: INTRODUCTION

The introduction contains the research background, objective, questions, significance, and outline.

CHAPTER II: LITERATURE REVIEW

The literature review provides an overview of the research framework, which includes the theoretical framework that discusses each variable utilized in the study, in-depth reviews of relevant previous research, and research hypotheses.

CHAPTER III: RESEARCH METHODOLOGY

The methodology chapter explains the research design, operational definitions of each variable, techniques for collecting data to observe and address research questions, and methods utilized for data analysis.

CHAPTER IV: RESULT and DISCUSSION

The findings and their interpretation are presented in this chapter, and how the influence of the variables used will be explained while answering the research questions and evaluating the research hypotheses.

CHAPTER V: CLOSING

This chapter is a closing that contains conclusions from the research findings, policy recommendations that may be offered and research limitations

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides a comprehensive conceptual framework by thoroughly examining pertinent literature. The primary objective of this section is to investigate the correlation between tourism and carbon emissions. This study incorporates additional factors known as control variables. These control variables, which include real GDP per capita, energy intensity, and population, are used by the STIRPAT model.

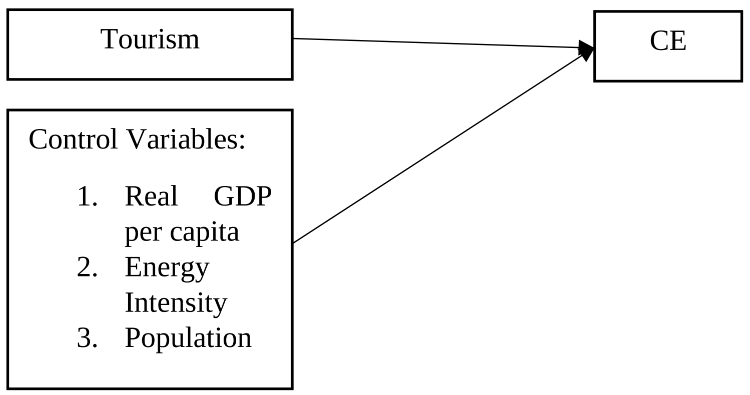

Figure 2.1 Conceptual Framework
Source: Author's compilation

2.2 Tourism and Carbon Emissions Nexus

A recent study demonstrated the impact of tourism on CO2 emissions through many pathways related to energy consumption (Koçak et al., 2020). Gössling et al. (2015) and Koçak et al. (2020) highlighted that international tourism trips constitute the most energy-intensive component of global tourism. According to Gössling and Peeters' (2015) and Koçak et al. (2020), the tourism industry relies mainly on fossil fuels, including oil, natural gas, and coal, to meet its energy needs. It was identified that fossil fuels are primarily utilized in transportation, lodging, and activities at tourist destinations within the tourism industry. Recently, the aviation industry's contribution to global CO2 emissions has increased faster than other modes of transportation, primarily due to the rapid expansion of air travel (Gössling et al., 2015; Koçak et al., 2020).

Furthermore, vacation destinations require substantial energy to import food and other commodities, transport water, and manage waste (Gössling et al., 2015; Koçak et al., 2020). Attraction centres, ski resorts, and theme parks consume substantial energy using machinery and mechanized activities (Dwyer et al., 2010). Tourism investments have a notable impact on changes in land use (Al-Mulali et al., 2015; Raza et al., 2017; Sharif et al., 2017; Zaman et al., 2017; Koçak et al., 2020). These land-use changes lead to deforestation and are the second largest contributor to emissions increases, following fossil fuel consumption (Bilgili et al., 2017; Koçak et al., 2020).

Conversely, the literature suggests that well-managed tourism can positively contribute to the preservation of the environment by promoting environmentally friendly technologies and transportation modes (Koçak et al., 2020). Improvements such as adding more lanes, improving road surfaces, creating larger and safer highways, and implementing rail transit can reduce CO2 emissions by decreasing fuel consumption (Paramati, Alam, and Lau, 2018; Koçak et al., 2020). Therefore, the tourism industry can improve environmental conditions, as it produces less pollution than other sectors that are more detrimental to the environment (G. Grossman & Krueger, 1991; G. M. Grossman & Krueger, 1995). From this perspective, the ongoing development process involves a transition from the industrial and agricultural sectors to the service sector. This shifting means that economic production moves from more polluting sectors (industry and agriculture) to cleaner ones (services). Thus, the tourism sector has the potential to reduce carbon emissions, as it generates less pollution compared to other more polluting industries. Implementing sustainable tourism policies can enhance public consciousness regarding the importance of environmental preservation and provide a source of funding for activities to address ecological degradation (Paramati et al., 2017).

Based on theoretical explanations, tourism's impact on CO2 emissions can be mitigated or exacerbated. Therefore, empirical evidence is vital in discussing the correlation between tourism and CO2 emissions.

2.2.1 Tourism and Carbon Emissions nexus – specific country

Research on the correlation between tourism and CO2 emissions in certain countries provides significant insights for developing future tourist policy. Katircioglu and Katircioglu (2022), using ARDL methods, revealed that tourism activities correlate with increased environmental pollution in Malta. Using a similar approach, S. T. Katircioglu, (2014) conducted a study investigating the correlation between tourist arrivals, energy consumption, and CO_2 emissions in Cyprus. Their research reveals a substantial and positive correlation, indicating that tourism and energy use contribute considerably to the increase in CO_2 emissions. Işik et al. (2017) conducted a study using the ARDL approach to investigate the correlation between Carbon dioxide emissions, real GDP per capita, financial development, trade, and tourism expenditure in Greece. The study found that Tourism Expenditure has a positive effect on increasing CO_2 emissions. The research conducted by Sghaier et al. (2019) investigated the influence of tourist arrivals on carbon dioxide (CO_2) emissions in Tunisia, Egypt, and Morocco by employing the autoregressive distributed lag (ARDL) approach. Their findings revealed a nuanced relationship across the three countries. While no statistically significant association was observed in Morocco, tourism arrivals exhibited an opposing influence in the other two countries. In Egypt, there was a nexus between tourist arrivals and a reduction in CO_2 emissions, but in Tunisia, there was an association between increasing tourist arrivals and a rise in emissions.

Several Asian studies have utilized the Spatial Dependence Model (SDM) and Structural Equation Modelling (SEM) methodologies. Bi & Zeng (2019) employed the SDM approach, while Tong et al. (2022) utilized SEM in their research conducted in China. Bi & Zeng (2019) suggested that tourism can reduce carbon emission intensity if appropriately managed. Increased tourism reduces carbon emission intensity through improved efficiency and sustainable practice (Tong et al., 2022).

Similarly, Bi & Zeng (2019) identified an inverse U-shaped relationship where tourism initially increases emissions but ultimately reduces them as tourism receipts grow. Both studies underscore the significance of spatial variability in the tourism-environment relationship, Tong et al. (2022) noted significant regional differences in how tourism affects carbon emissions, indicating the need for region-specific strategies. Bi & Zeng (2019) highlighted a spatial lag effect, where tourism development in one province influences emissions in neighbouring areas. This spatial interdependence necessitates coordinated policy efforts across regions to effectively manage tourism's environmental impact.

The relationship between tourism and the environment within the ASEAN framework is intricate and subtle. The studies by Azam et al. (2018) and Ahmad et al. (2019), both using Fully Modified Ordinary Least Square (FMOLS), highlighted the heterogeneous impacts of tourism on environmental quality across different ASEAN countries. Tourism in certain nations, such as Thailand, Singapore, and

Vietnam, improves the environment by decreasing CO_2 emissions and pollution. Conversely, tourism contributes to environmental degradation in Malaysia, Indonesia, and the Philippines due to increased energy consumption and higher pollution levels. Both studies underscore the importance of several factors like sustainable practices and regulations, energy consumption patterns, and economic development levels.

2.2.2 Tourism and CO_2 emissions nexus – group country studies

The purpose of multi-country research on the correlation between tourism and CO_2 emissions is crucial for formulating a unified or standardized tourism policy. Shaheen et al. (2019) investigated the interrelationships among energy, economic growth, tourism, and the environment in ten economies heavily influenced by tourism, consisting of China, France, Italy, the UK, Mexico, Germany, Turkey, Spain, the USA, and Russia. The empirical evidence confirmed a cause-and-effect connection between tourism and environmental pollution. The study conducted by Koçak et al. (2020) analysed the ten most visited countries in 2017 (France, Spain, USA, China, Italy, Mexico, UK, Turkey, Germany, and Thailand) using the Continuously Updated Fully Modified (CUP-FM) and Continuously Updated Bias-Corrected (CUP-BC) techniques. The findings revealed that the arrival of tourists leads to an increase in carbon emissions, while the reduction of carbon emissions is associated with tourism revenue.

Chishti et al. (2020), focusing on South Asian countries using NARDL techniques, found that the overall impact of tourism leads to increased pollution emissions. Akadiri et al. (2020) studied 16 small island economies using the panel Granger causality approach and concluded that tourism significantly impacts environmental damage. Erdoğan et al. (2022) examined the economies attracting the most tourists globally. Using panel quantile regression models, researchers discovered a direct and positive relationship between tourism and carbon emissions. Ghosh et al. (2022) investigated G7 countries and concluded, using FMOLS and DOLS, that tourism exacerbates environmental degradation. A study conducted by Cevik (2022) employing Panel Fixed Effect and System GMM methodologies unveiled a direct association between tourism and carbon emissions in the Caribbean nations.

However, evidence from other regions provides a contrasting perspective. The study by Lee and Brahmasrene (2013) revealed that the European Union tourism industry responded proactively to carbon dioxide (CO_2) emissions by implementing substantial policy and operational adjustments to lower emissions. This research was achieved through panel fixed effects and cointegration methodologies (Lee & Brahmasrene, 2013). Ben Jebli et al. (2019) examined the relationship between renewable energy, tourism, CO2 emissions, economic growth, foreign direct investment, and trade in 22 countries in Central and South America. The study emphasized the significant contribution of tourism in reducing CO2 emissions.

Moreover, as stated by S. Katircioglu et al. (2018) study, which examines the top 10 most-visited countries (France, USA, Spain, China, Italy, UK, Germany, Mexico, Thailand, and Austria) covering the 1995-2014 periods and employs random effects, it demonstrates that tourism expansion has yet to have an ecological imprint in these countries. This significant finding underscores the successful management of tourism and urban development practices in maintaining environmental quality. Similarly, Ozcan et al. (2021) found the tourism sector reduces both CO2 emissions and ecological footprints in the Top 20 Tourist Destinations (France, Spain, the United States, China, Italy, Turkey, Mexico, Germany, Thailand, the United Kingdom, Japan, Austria, Greece, Hong Kong, Malaysia, Russia, Portugal, Canada, Poland, and the Netherlands) for 1995 -2018. In ASEAN, research from Kongbuamai et al. (2020) provide a comprehensive view of the ASEAN region, confirming that tourism generally promotes environmental quality across ASEAN. This overarching positive contribution suggests that, despite the negative impacts observed in specific countries, the region benefits from tourism in terms of environmental quality.

Several studies have investigated the relationship between tourism and CO2 emissions utilizing the STIRPAT model. León et al. (2014) conducted a study investigating the influence of population, tourist arrivals, economic growth, and energy efficiency on CO2 emissions in industrialized and developing nations from 1998 to 2006. According to their research, population growth, economic expansion, and tourist arrivals are increasingly contributing to the release of CO2 emissions. Moreover, it is important to highlight that the effect of tourism on CO2 emissions is more substantial in developed nations than in developing countries. The study by Paramati et al. (2017) investigated the relationship between tourism revenue, economic growth, and CO2 emissions in developed and developing nations from 1995 to 2012. According to their findings, tourism receipts greatly influence CO2 emissions.

In a recent study, Balsalobre-Lorente et al. (2023) investigated the impact of tourism, urbanisation, and natural resources rent on carbon emissions in OECD nations using STIRPAT model, with an emphasis on the moderating role of ICT. They utilised the AMG and two-step GMM technique. Based on their research, tourist arrivals contribute to an increase in CO_2 emissions. One potential factor is that the goods and services purchased in advance are not environmentally friendly. In addition, he observed that hotels and restaurants in all tourist destinations experience a substantial annual rise in their carbon emissions as a result of the large quantity of waste they generate and the environmentally irresponsible behaviour of their customers. Moreover, extensive digitalization has led to a reduction in carbon emissions from tourism. Tourists now primarily travel for entertainment purposes, as information and communication technologies have considerably diminished the need for activities like dining out and shopping (Balsalobre-Lorente et al., 2023).

2.3 GDP per Capita and Carbon emissions nexus

In recent decades, developing economies, especially in Southeast Asia, have experienced rapid economic growth, heavily supported by the energy sector. Lee and Brahmasrene (2013) discovered a direct relationship between economic growth and CO_2 emissions, indicating that as the economy grows, so do CO_2 emissions. This impact is likely due to the correlation between economic expansion and increased energy use. The concept that energy consumption is linked to economic growth deviates from traditional economic growth ideas, such as those proposed by Solow (1956), which do not consider energy as a factor of production (Haini, 2021).

This growth has also resulted in significant increases in energy consumption, predominantly from non-renewable sources (Haini, 2021). Significantly, prominent tourism destinations in the region, like Malaysia, Thailand, Singapore, Vietnam, and Indonesia, have experienced substantial economic growth by extensively depending on fossil fuels, leading to increased carbon dioxide emissions. Several Studies in ASEAN regions (Azam et al., 2018; Ahmad et al., 2019; Kongbuamai et al., 2020; Haini, 2021) confirmed that income per capita growth leads to environmental degradation. The present research will examine how GDP per Capita correlates with carbon emissions.

2.4 Energy Intensity and Carbon Emissions Nexus

Research repeatedly demonstrates a strong correlation between energy use and carbon emissions, with energy intensity as a vital determining factor. Research conducted by Shaheen et al. (2019) and Lenzen et al. (2018) demonstrates that the tourism industry's overall energy demand and specific energy requirements substantially generate carbon emissions. The energy intensity of tourism-related activities and services largely shapes the carbon footprint in tourism.

Further investigation into energy intensity reveals its profound impact on national carbon outputs. Luo et al. (2020) document how reductions in China's energy intensity were pivotal in lowering national carbon emissions. This underscores the role of energy efficiency improvements across various sectors, including tourism, driven by policy interventions and sector-specific practices. A study conducted by S. T. Katircioglu in 2014 revealed that for small islands like Cyprus, there is a strong correlation between the number of foreign tourists visiting and the amount of energy consumed and CO2 emissions released.

The intersection of tourism and national energy policies is crucial for understanding sector-specific emission trends. Reports by global organizations like UNWTO, UNEP, and WMO (2008) indicate that strategic adjustments in energy intensity within the tourism sector—through improved energy practices and changes in tourist behaviour—significantly influence carbon emissions. Additionally, enhancing energy efficiency and reducing energy intensity is crucial to address the contradiction between economic expansion and environmental preservation (Huang et al., 2023). This relationship highlights the potential for targeted energy management strategies to reduce the environmental impact of tourism. Given these insights, this study will specifically highlight how variations in energy intensity impact carbon emissions across ASEAN countries, considering their diverse energy policies and practices

2.5 Population and Carbon Emissions Nexus

The population and carbon emissions relationship are complex and diverse across ASEAN countries. In a study conducted by Jones (1991), the relationship between urbanization, population increase, and energy consumption was investigated in 59 developing nations. The data used for analysis came from 1980. The results of his research showed that there is a connection between population growth and higher energy consumption per person (Jones, 1991 & Ozpolat et al., 2021). More specifically, he estimated that for every 10% increase in population, there is a 4.5-4.8% increase in per capita energy consumption (Jones, 1991 & Ozpolat et al., 2021). The escalating global population, coupled with the burgeoning production and consumption of goods and services, has profoundly contributed to climate change and global warming. In recent decades, administrators and policymakers have implemented regulations and energy policy initiatives to tackle and mitigate environmental degradation (Ozpolat et al., 2021).

2.6 Theoretical Foundation

2.6.1 Tourism

According to Hunt & Layne (1991) and Gohar (2017), a tourist is defined as an individual who travels a minimum distance of 50 miles (one way) from their residence for purposes such as business, leisure, personal matters, or any other reason, excluding commuting to work. This definition applies regardless of whether the individual stays overnight or returns on the same day.

The most common definition is one given by the United Nations World Tourism Organization (UNWTO). Tourism comprises the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business, and other purposes not related to the exercise of an activity remunerated from within the place visited (Matsoso, 2019).

The UNWTO has established a set of categories based on the destination and purpose of the trip. These categories can be stated as follows:

1. Rural Tourism
2. Ecotourism
3. Adventure tourism
4. Cultural Tourism
5. Business Tourism
6. Gastronomic Tourism
7. Coastal, Maritime, and Inland Water Tourism
8. Urban Tourism
9. Health tourism
10. Mountain Tourism
11. Educational Tourism
12. Sports Tourism

2.6.2 Sustainable Development Theory

Sustainable development, as a concept, originated from the Rio Declaration texts. Notably, the Brundtland Report, published by the World Commission on Environment and Development in 1987, is among the most significant documents related to the Rio

Declaration. Likewise, Agenda 21, adopted at the United Nations Conference on Environment and Development in 1992, holds great importance in this process. Despite controversies surrounding these contributions, they all concur on a threefold purpose that any sustainability policy must accomplish. This consensus highlights three key objectives essential for any sustainability policy:

1. To stimulate additional economic growth while
2. To maintain environmental sustainability, avoiding surpassing the earth's carrying capacities is important.
3. To advance social equality by establishing a more equitable allocation of natural resources and sinks and guaranteeing fair access to the wealth generated.

Sustainable development encompasses the interconnectedness of economic and ecological factors, integrating global-scale environmental and social considerations (Huber, 2000). Rio's Agenda 21 (UNCED, 1992) addresses the global preservation of critical transnational ecosystems and related issues, such as fostering global prosperity and facilitating the transfer of capital, science, and technology (Huber, 2000). Sustainable development can also be applied to tourism, with approaches like sustainable tourism and responsible tourism aiming to balance environmental, social, and economic well-being within the industry.

2.6.3 Externalities and Public Goods

Interactions between consumers and producers, as well as between producers and consumers, can give rise to externalities. Externalities refer to actions taken by either a producer or a consumer that impact other producers or consumers but are not taken into account in the calculated market price (Pindyck & Rubinfeld, 2018). The magnitude of these effects can be either positive or negative, contingent upon whether the actions of one party benefit another party or incur costs for the other party.

According to Dwyer et al. (2020), environmental degradation caused by human activities is a clear example of a substantial market failure, mainly because of the existence of external costs and the characteristics of public goods.

1. As a shared resource, the climate offers non-excludable and non-rivalrous benefits; individuals who do not contribute to its conservation can nevertheless profit from it, and the use of the climate by one person does not reduce its

availability for others. However, markets for vital industries such as energy, land use, and aviation do not fully incorporate the costs and benefits linked to consumption and investment choices that affect the environment.

2. Tourism, together with other economic activities that produce greenhouse gas (GHG) emissions, worsens the effects of global warming and climate change, meaning significant financial burdens on present and future generations.
3. Human-caused climate change is a globally externality that, without government action, cannot be adequately mitigated by market systems. Carbon-emitting entities frequently do not instantly assume the whole financial burden of their emissions, resulting in market distortions. Lack of a carbon emissions tax and omission of these costs from national income statements exacerbate these distortions, therefore eroding market efficiency even further.

2.6.4 Environmental Stewardship

Local environmental stewardship encompasses the actions undertaken by individuals, groups, or networks of individuals with varying motivations and capabilities to protect, nurture, or responsibly utilize the environment to achieve environmental and social objectives in diverse social-ecological context. (Bennett et al., 2018).

Figure 2.2 Environmental Stewardship: A Conceptual Framework
Source: (Bennett et al., 2018)

Stewards engage in stewardship activities, which can be performed by individuals, groups, or networks of individuals (Connolly et al., 2014; Bodin, 2017; Bennett et al., 2018). The responsibilities of the individuals participating in various stewardship activities are mostly determined by the size and intricacy of the problem, as explained in the following discussion (Bennett et al., 2018). Several types of capital provide capacity to enable local environmental stewardship, according to (Bennett et al., 2018):

1. Social capital
2. Cultural capital
3. Financial capital
4. Physical capital
5. Human capital
6. Institutional capital

2.6.5 Ecological Modernization Theory (EMT)

The "ecological modernization" has dominated environmental policy discussions for over two decades. It emphasizes technological advancements and innovation for ecological solutions. Recently, concepts like "eco-efficient innovation" have emerged, focusing on environmentally friendly technologies improving resource efficiency (Jänicke, 2008).

In capitalist economies, constant improvement and innovation are essential for businesses to stay competitive. This focus on modernization has led to rapid technological advancements. Proponents of ecological modernization argue that these advancements can lead to "win-win" environmental and economic benefits, mainly through cost reduction and innovation (Jänicke, 2008). Ecological modernization can involve incremental improvements (e.g., cleaner technologies) or radical innovations (e.g., entirely new clean technologies). These advancements can target various aspects like material use, energy efficiency, logistics, and space utilization. Notably, the environmental effectiveness of these innovations depends not only on their novelty but also on how widely they are adopted. (Jänicke, 2008).

The "efficiency revolution" concept reflects the industry's current understanding of sustainable development. Businesses seek strategies that allow for continued economic growth alongside environmental improvements. This approach emphasizes implementing environmental management systems to improve resource efficiency (materials, energy) and productivity (Huber, 2000).

The Brundtland report established guidelines for resource utilization to determine the ecological sustainability of economic development. The 'management norms' mentioned here have been widely acknowledged as a foundation for subsequent research and development (WCED, 1987, pp. 44 – 60). Huber (2000) identifies the following five rules as highly significant.

1. Population growth must align with the ecosystem's ability to support and sustain it, as well as the available resources and productivity.
2. The levels of contaminants in the environment and organisms should not surpass their ability to absorb and regenerate.
3. Renewable resources such as water, biomass, and soil should not be utilized at a rate that exceeds their natural replenishment rate.
4. The consumption of exhaustible resources, such as land, oil, coal, and natural gas (excluding common materials like sand and stones), should be decreased by
    a. Replacing finite resources with renewable ones;
    b. Enhancing the utilization of resources, optimizing energy consumption, and
    c. Recycling to an amount that is environmentally rational and financially viable.
5. There will be an increased focus on advancing and implementing environmentally friendly, sustainable resources, technology, and innovative goods.

2.7 Foundational Concept

2.7.1 Sustainability and Sustainable Development

According to the neoliberal Perspective, 'sustainable development' refers to a type of development that achieves harmony between the environment, society, and economy. It is a sustainable development that fulfils the current generation's requirements without jeopardizing future generations' well-being. The UNWTO has provided a comprehensive definition of sustainable tourism, which involves a detailed assessment of its present and future economic, social, and environmental effects. It also emphasizes the importance of meeting the demands of tourists and considering the industry's interests, the environment, and the local communities hosting the tourism activities. Sustainable tourism should, therefore, maximize the utilization of environmental resources, demonstrate respect towards host communities, and guarantee economically sustainable operations in the long run while ensuring equitable distribution of benefits among all stakeholders (UNEP;

UNWTO, 2005;(Dwyer et al., 2020). Three characteristics of sustainability can be identified for the global tourism business, as shown in Figure 2.2) as follows:

1. Economic sustainability guarantees the continued viability of economic activities over the long term. It ensures that socioeconomic benefits are spread equally among all stakeholders and helps alleviate poverty by providing steady jobs and income-earning possibilities for everyone involved.
2. Social sustainability entails the acknowledgement and safeguarding basic human rights and promoting fair opportunities for all individuals in society.
3. Environmental sustainability encompasses preserving and managing resources, especially non-renewable or essential for sustaining life. Conserving crucial ecological processes, mitigating air, land, and water pollution, and protecting biological variety and natural heritage

For sustainable tourism to be successful in the long run, it is necessary to carefully manage and address environmental, social, and economic considerations (Dwyer et al., 2020).

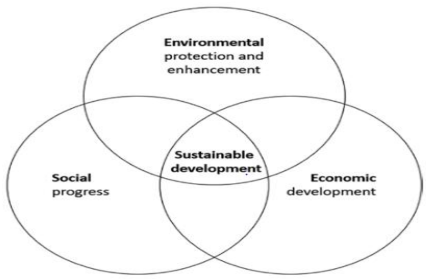

Figure 2.3 The three pillars of sustainability
Source: Dwyer et al. (2020)

Another perspective from ecological economics challenges neoliberal economic models by prioritizing human well-being and environmental health. Ecological economics provides a more comprehensive viewpoint than neoliberal models. It considers the economy as a component of a larger social and ecological system with limited resources. Unlike conventional economics, it emphasizes environmental and social well-being and the interconnectedness of economic, social, and natural capital. Ecological economics views the economy as part of a larger ecological and social system, emphasizing resource limits and sustainability. Ecological economics provides a crucial framework for sustainable tourism development. The relationship between society and its economy is integral, with the economy being integrated inside society and society positioned within the ecological framework. A systems approach underscores the interconnectedness of all aspects, challenging the notion of externalities as separate from decision-making and behaviour (Dwyer et al., 2020).

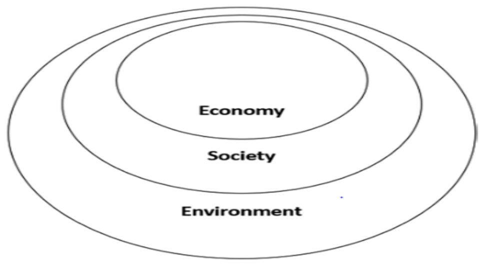

Figure 2.4: The Perspective of Ecological Economics
Source: Dwyer et al. (2020)

2.7.2 Tourism and Sustainable Development Goals (SDGs)

The United Nations' 2030 Agenda for Sustainable Development, with 17 Sustainable Development Goals (SDGs), is an all-encompassing framework for global progress. As the United Nations World Tourism Organisation (UNWTO) emphasizes, the tourism sector substantially impacts this agenda. Three Sustainable Development Goals (SDGs) - 8.9, 12. b, and 14.7 - explicitly refer to tourism; however, its impact extends to several other goals (Dwyer et al., 2020).

Tourism, which requires much energy, can help accelerate the global transition to renewable energy. This aligns with the objective of Sustainable Development Goal 7, which aims to provide everyone with affordable, dependable, sustainable, and contemporary energy. SDG 8 emphasizes the importance of tourism as a significant contributor to international exports and employment. It is one of the top four sectors that generate export income and supports one of every ten jobs globally. The sector is crucial in providing considerable employment prospects and promoting inclusivity, especially for young individuals and women (Dwyer et al., 2020).

The tourism sector must implement sustainable practices to promote a transition towards sustainability, which aligns with SDG 12's objective of ensuring sustainable consumption and production patterns. SDG 13 recognizes the necessity of prompt actions to tackle climate change and its impacts. It believes that tourism is both a contributor to and a recipient of climate change. Stakeholders in the tourism industry have a vital role in implementing steps to reduce carbon emissions from the transport and hotel sectors (Dwyer et al., 2020).

2.7.3 Sustainable Tourism

Sustainable tourism is a concept that highlights the significance of maintaining a balance between economic and environmental factors (Mihalic, 2016). In this regard, the imperative for sustainability and recognizing adverse impacts have given rise to Sustainable Tourism (Z. Liu, 2003; UNEP, 2005). The widespread acceptance concept of Sustainable Tourism, according to UNEP (2005, p. 11), "t, takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities"). According to Fridgen (1991) and Gohar (2017), sustainable tourism is a subset of sustainable development (see Figure 2.4).

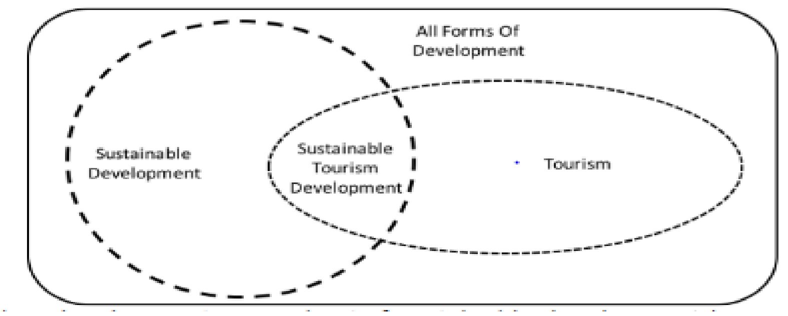

Figure 2.5: Sustainable Tourism is a subset of sustainable development
Source: Fridgen (1991)

2.7.4 Responsible Tourism

Responsible tourism was officially defined and established during the International Conference on Responsible Tourism in Destinations (ICRTD) in Cape Town in 2002, concurrently with the World Summit on Sustainable Development. Responsible tourism offers excellent travel experiences while maximizing positive impacts on local communities, minimizing negative social or environmental effects, and preserving delicate cultures, habitats, or species (Nair et al., 2020). Responsible tourism operations aim to safeguard the local environment and culture, ensuring long-term sustainability and providing benefits. Responsible tourism is using tourism to enhance people's and visitors' well-being, with priority given to the local community's well-being (Goodwin,2007). This approach is apparent in numerous successful and responsible rural tourism destinations throughout Asia (Kumar & Shekhar, 2020).

2.7.5 Responsible tourism versus sustainable tourism

Sustainable tourism and responsible tourism differ in their focus. While sustainable tourism encompasses a broader scope, Responsible tourism focuses on the efforts made by individuals, corporations, and governments to maximize tourism's beneficial impacts on the economy, society, and environment. The objective is to identify the crucial local concerns, address them effectively, and provide transparent updates on the progress in utilizing tourism for sustainable development. Responsible tourism supports the advancement of a broader sustainable tourism agenda. Therefore, stakeholders, the local community, operators, governments, and non-governmental organizations (NGOs) must be responsible for accomplishing this agenda. However, despite their distinct characteristics, sustainability and responsibility are used interchangeably (Kumar & Shekhar, 2020).

2.8 Tourism and Climate Change

The tourism industry plays an essential part in exacerbating climate change. Its carbon footprint stems from direct emissions generated during tourism activities and indirect emissions associated with the supply chain and transportation. This footprint can be measured for the entire industry, individual destinations, tourist origins, travel modes, and specific tourism segments (Dwyer et al., 2020).

Furthermore, according to Dwyer et al.(2020), there are two main categories of policy aimed at addressing human-caused climate change: mitigation and adaptation. Mitigation encompasses any proactive actions to decrease the overall atmospheric concentration of greenhouse gases (GHGs). This strategy includes a variety of economic and complementary methods aimed at mitigating the extent or timing of climate change. The UNWTO (2008) identifies four primary mitigation measures for tackling the tourism sector's greenhouse gas (GHG) emissions:

a. Energy consumption reduction (i.e., energy conservation). One strategy to accomplish this is to change transportation habits, such as increasing public transportation, opting for rail and coach travel instead of cars and aeroplanes, and selecting locations closer. Changing management techniques, such as videoconferencing for business tourism, can also contribute to this goal.

b. Energy efficiency Improvement. This approach employs advanced and innovative technologies to reduce energy consumption by performing the same task with less input.
c. Renewable or carbon-neutral energy utilization. This approach entails substituting conventional fossil fuel sources with cleaner energy alternatives that generate reduced emissions, such as biomass, hydro, wind, and solar power.
d. Carbon dioxide (CO2) can be absorbed by storing it in natural carbon sinks, such as soils and forests. This alternative has the potential to substantially affect the tourism industry, especially in poor nations and small island locations that rely on air travel as a key driver of their economies. These locations are known for their abundant biodiversity and play a crucial role in storing biomass CO2. Eco-tourism can have a vital impact on the preservation of these natural regions.

Implementing mitigation techniques in the travel and tourism industry will incur additional expenses, potentially leading to higher prices for local tourism items. This price increase may dissuade travellers from engaging in local tourism due to the higher costs. This condition will negatively impact a country's competitive position in the global tourism business. However, in the long run, most adjustments will be made to the consumers/tourists over an extended period. Several instruments available to make consumers and producers take account of the full cost of their emissions decisions. The market-based instrument is the most potential to reduce GHG emissions at least cost

Adaptation involves implementing strategies to strengthen the ability of people, ecosystems, and infrastructure to withstand and recover from climate change's negative impacts. Adaptation policies aim to modify and accommodate climate and environmental changes to prevent or lessen potential harm, exploit favourable circumstances, and manage the effects. Adaptation is crucial for the tourism industry to tackle the challenge of climate change adequately. Adaptation aims to reduce susceptibility to climate change and uncertainty, limiting its negative impacts. Adaptation strategies should also strive to enhance a destination's ability to capitalize on the benefits of climate change. Considering the current levels of greenhouse gases (GHGs), adaptation is the only viable way to deal with their effects in the coming decades (Dwyer et al., 2020).

Adaptation can operate at two primary levels: augmenting the ability to adapt and carrying out measures to adapt (Dwyer et al., 2020).

a. Developing adaptive capacity involves creating essential information and conditions, including regulatory, institutional, and administrative frameworks, to support adaptation. This helps reduce the destination's vulnerability to the impacts of climate change.
b. Implementing Adaptation Actions: This entails reducing susceptibility to climate risks or taking advantage of new possibilities.

Climate change adaptation is crucial, but its costs are difficult to estimate due to the uncertain nature of climate impacts. Each tourist attraction needs to assess the financial viability of adaptation measures through cost-benefit analysis. This analysis considers the damage avoided by adaptation (benefit) versus the cost of implementing those measures. Ignoring climate change entirely is far more expensive than adapting, as the combined price of unaddressed damage and future adaptation efforts will be significantly higher (Dwyer et al., 2020).

The approaches of adaptation and mitigation are interconnected. In the absence of timely and robust mitigation measures, the expenses associated with adaptation will increase, limiting the capacity of destinations and individuals to adapt effectively.

2.9 ASEAN Tourism

Tourism has been a significant focus of ASEAN cooperation since the Association's establishment. In 1977, ASEAN leaders established a Committee on Trade and Tourism under the ASEAN Economic Ministers, marking one of the five permanent committees. In 1981, four years after officially establishing tourism cooperation in 1976, ASEAN established the ASEAN Tourism Forum (ATF). The forum's purpose is to facilitate collaboration between ASEAN governments, corporate enterprises, and civil society organizations and promote ASEAN as a unified tourism destination. As the organization's structure and tourism cooperation evolved, ASEAN leaders decided in 1997 to establish a standalone sectoral body for managing tourism under the ASEAN Tourism Ministers' meetings.

Understanding the importance of tourism to the growth of a region's economy, the ASEAN Leaders enacted the Manila Declaration in 1987 to promote intra-ASEAN travel and the development of a competitive tourism sector, recognizing its significance in driving economic growth in the region. The ASEAN Tourism Ministers signed a Ministerial Understanding on ASEAN Cooperation in Tourism in January 1998 during their visit to Cebu City, Philippines. This document described the development and promotion of ASEAN as a single travel destination with high-quality standards, facilities and attractions. The ASEAN Tourism Agreement was signed during the Eighth ASEAN Summit in Phnom Penh, Cambodia, on November 4, 2002. The Agreement exemplified ASEAN's commitment to collaborating with the private sector in order to enhance the efficiency and competitiveness of the tourism industry. By endorsing this Agreement, the member nations of ASEAN committed to facilitating travel within and beyond the region, enhancing market entry under the ASEAN Framework Agreement on Services, promoting high-quality tourism, ensuring the safety and security of travellers, collaborating on marketing and promotion efforts, and enhancing the development of human resources in the travel and tourism industry.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter focuses on the research methodology used to answer the research objectives, which investigate the impact of tourism, GDP per capita energy intensity, population size, and carbon emissions. This chapter discussed the type of research, research approach, data and data source, object and subject of study, data collection methods and data analysis discussed in sequential order.

3.2 Research Design

This research then described the empirical model by referring to previous research. The research approach was quantitative, using panel data covering 2010 through 2019.

3.3 Subject of research

This study explores tourism's influence on environmental degradation, particularly emphasizing carbon emissions in Southeast Asia from 2010 to 2019. The primary focus lies in elucidating how tourism development interacts with other pertinent factors, such as real GDP per capita, energy intensity, and population size, contributing to carbon emissions within ASEAN member states.

1. Environmental degradation: the decline of the environment caused by the depletion of resources, including air, water, and soil, as well as the destruction of ecosystems, habitat loss, species extinction, and pollution. It establishes the context for further inquiry by emphasizing the broad area of interest.
2. Geographical Focus (Southeast Asia): The specification of Southeast Asia as the focus area provides a regional context crucial for understanding the subject of the present study. This region is characterized by diverse natural environments, economic structures, and stages of development, all of which can influence environmental degradation in unique ways.
3. Tourism and Environmental Impact: This study delves into the role of tourism development as a contributor to environmental degradation, with a particular emphasis on carbon emissions. By examining tourism with other relevant factors,

the research aims to understand its ecological impact comprehensively.

4. Interdisciplinary Approach: The subject matter necessitates a multidisciplinary approach, drawing upon insights from environmental science, economics, and social sciences. This multifaceted perspective is crucial for effectively comprehending and addressing the complexities of economic development and ecological degradation in tourism development.

3.4 Object of research

This study examines the impact of tourism development on carbon emissions in Southeast Asian countries between 2010 and 2019. It considers the influence of real GDP per capita, energy intensity, and population size. It aims to elucidate the processes and mechanisms through which tourism development and several control variables contribute to the region's carbon emissions. This research employs a country-level analysis utilizing data from ASEAN member states from 2010-2019. The data will be sourced from the World Bank's Open Data platform, ensuring cross-country comparability.

3.5 Research Model

This work employs the STIRPAT model to assess the impact of tourism development on CO2 emissions, drawing on the research conducted by León et al. (2014), Paramati et al., (2017), and Koçak et al., (2020). The study will evaluate the impact of population, energy intensity, GDP per capita, and tourism development on Carbon emissions using the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model.

The STIRPAT model extends the IPAT (Impact = Population x Affluence x Technology) model by (Ehrlich & Holdren 1971). The IPAT model considers the proportionate effects of technology, affluence, and population on environmental impact. York et al., (2003) extended this model to allow for the assessment of non-proportional impact by rephrasing the IPAT model into STIRPAT. The authors expand the model to calculate the non-proportional influence of population, prosperity, and technology on the environment, specifically CO2 emissions. This research presents a formal exposition of the STIRPAT model, which is utilized in the following manner: This provides a formal presentation of the STIRPAT model used as follow:

$$Ia = aPb_{it}\ Ac_{it}\ Td_{it}\ U_{it} \quad \text{(Eq.1)}$$

The logarithmic structure of the IPAT model, as presented by Lin, Wang, Marinova, Zhao, and Hong (2017), is expressed in equation 2:

$$\ln I_{it} = a + b\ln P_{it} + c\ln A_{it} + d\ln T_{it} + u_{it} \qquad \text{(Eq.2)}$$

Where b, c, and d represent the parameters of Population (P), Affluence (A), and Technology (T). The constants α and ϵ denote the intercept and error term, respectively, while i and t refer to country and time dimensions. The natural logarithm on equation 2 is used to reduce heteroscedasticity and the difference in the volume of the variables.

According to the STIRPAT model, represented in equation (3), incorporating tourism and energy intensity are proxies for affluence and technology, respectively (Koçak et al., 2020). Thus, we have identified four potential variables that have been taken into account for this study: tourism, real GDP per capita, energy intensity, and population size. The link between carbon emissions and these potential explanatory variables is described in Equation 3 as follows:

$$\ln CEit = a + b(\ln POPit) + c1(\ln GDPCit) + c2(\ln ITAit) + d(\ln EIit) + uit \qquad \text{(Eq.3)}$$

lnCE, lnPOP, lnGDPC, lnITA, and lnEI in eq. (3) stand for carbon emissions, population size, real GDP per capita, tourism, and energy intensity, respectively.

Based on preliminary analysis, our model has a symptom of spurious regression. The characteristic of spurious regression as follow:

1. The t statistic is high to reject the hypothesis of B=0 and high R2, although in fact the trend of the two variables is not related at all.
2. Durbin Watson value is low while R2 is high.
3. Mean is constant, but variance is not constant.

The problem of spurious regression can be mitigated by differencing the data (Ruxanda & Botezatu, 2008). In panel data with a fixed number of entities (N) and a large number of time periods (T), the risk of spurious regression can become more pronounced in the Fixed Effects (FE) model (Wooldridge, 2010). This is because, as T increases, the likelihood of encountering non-stationary time series also increases, which can exacerbate the issue of spurious regression in FE models. Both the time-demeaned equation in FE models and the First Differences (FD) equation can apply the Generalized Least Squares (GLS) procedure under the assumption of strict exogeneity (Wooldridge, 2010). GLS is particularly crucial for the Random Effects Model (REM), as it efficiently handles the variance-covariance structure of the random effects and idiosyncratic errors, ensuring robust estimation. In short, the study utilizes the differenced variables when estimating the regression models to mitigate the symptom of spurious regression in the dataset. A number of earlier studies (Anser et al., 2020; Haini, 2021; Katircioglu et al., 2018; Kongbuamai et al., 2020; Lee & Brahmasrene, 2013) also applied differencing on their Fixed Effect Model and Random Effect Model (REM) when testing the impact of tourism development and several macroeconomic variables.

3.6 Data and Data Source

The present study used secondary data. The dependent variable is carbon emissions; the independent variables are tourism development, real GDP per capita, energy intensity, and population size.

1. Variables Operationalization

Operationalization is the process of identifying actual measurement scales to assess research variables. There are four measurement scales: nominal, ordinal, interval, and ratio, according to Zikmund et al. (2010:297). The operational variables and the data source are as follows:

Variable	Definition and Indicator	Scale	Source
Dependent Variables			
Carbon Emissions	Carbon dioxide emissions result from the combustion of fossil fuels and the production of cement. These emissions consist of carbon dioxide generated when solid, liquid, and gaseous fuels are consumed, as well as emissions from gas flaring. Indicator: CO_2 emissions (metric tons per capita) Reference: Lee & Brahmasrene (2013)	Ratio	WDI
Independent variables			
International Tourism Arrivals	International inbound tourists, also known as overnight visitors, refer to individuals who travel to a country different from their usual residence for up to 12 months. These tourists visit for reasons other than engaging in paid activities within the visited country. If statistics regarding the number of tourists are unavailable, the number of visitors, encompassing tourists, same-day visits, cruise passengers, and crew members, is displayed instead. Indicator: International tourism, number of arrivals.	Nomi-nal	WDI

	Reference: Balsalobre-Lorente et al. (2023)		
Real GDP per Capita	GDP per capita is calculated by dividing the gross domestic product by the population at the year's midpoint. Gross Domestic Product (GDP) is the total worth of goods and services produced by all producers within a country, including any taxes on items and excluding any subsidies that are not accounted for in the value of the products. The calculation does not consider the reduced value of manufactured assets or the decreased quantity or quality of natural resources. The real GDP per capita in this study is calculated by adjusting GDP per capita to a constant of 2015 U.S. dollars with the Consumer Price Index (CPI) and adjusted to reflect changes in the price level of 2010. Indicator: Real GDP per capita (Constant 2010, US$ dollar) Reference: Ozcan et al. (2021)	Ratio	WDI
Energy Intensity	The energy intensity level of primary energy refers to the ratio of energy supply to gross domestic product, which is assessed using purchasing power parity. Indicator: Energy intensity level of primary ene (MJ/$2017 PPP GDP) Reference: Koçak et al. (2020)	Ratio	WDI
Population (POP)	Indicator: Total Population Reference: (Paramati et al., 2017)	Nomi-nal	WDI

Table 3.1 Operational variables and the data source
Source: World Bank Databank

The current study will use international tourist arrivals out of four ways measurements introduced by (S. Katircioglu et al., 2018) consisting of International Tourist Arrivals, International Tourist Expenditure, International Tourist Receipt and Tourism Index to measure the tourism sector due to its ability to capture the direct relationship between inbound tourism activities and carbon emissions (Daniel Balsalobre-Lorente et al., 2021). This proxy is safer than tourist receipts to minimize the possibility of a multicollinearity issue. This indicator is also the most widely used by previous studies (Azam et al., 2018); (Balsalobre-Lorente et al., 2023) and (Akadiri et al., 2020).

2. Research Population and Sampling

a. Research Population

The study's research population encompasses all member states of the Association of Southeast Asian Nations (ASEAN), comprising ten nations. This delineation provides a defined geographic and political framework for examining the relationship between tourism development and environmental impacts.

b. Sampling Method and Sample Selection

Myanmar and Brunei Darussalam are excluded from the analysis. The exclusion of Myanmar is due to the country's political instability, which significantly impacts its tourism sector and environmental policy framework, making it an outlier in the context of this study. Similarly, Brunei Darussalam is not a tourist-dependent economy. The country is heavily dependence on oil exports for its economic development. Exclusion aims to maintain the comparative impact of sustainable tourism initiatives. These exclusions are based on purposive sampling criteria, aiming to ensure the homogeneity of the sample concerning the research objectives.

Consequently, the analysis focuses on the ASEAN countries: Cambodia, Indonesia, Lao PDR (People's Democratic Republic), Malaysia, Philippines, Singapore, Thailand, and Vietnam. This selection allows for a comprehensive examination of economies with varying reliance on the tourism sector, providing a representative overview of regional practices and impacts.

c. Data and Observations

The study utilizes available annual panel data spanning from 2010 to 2019. This period was chosen to capture the dynamics of economic development, including tourism development and environmental policies, following significant regional and global shifts toward Sustainable Development Global (SDGs) and carbon neutrality in the mid of 2010s.

As defined by Gujarati (2004), panel data refers to data collected from individuals, businesses, nations, countries, and other entities during a specific time period. Panel data offers the advantage of generating more useful, diversified, and efficient data by combining time series with cross-sectional observations, leading to increased degrees of freedom and reduced correlation. Panel data is superior in identifying and measuring effects that cannot be observed just through cross-sectional or time series data. The study employed a balanced panel dataset, in which each cross-sectoral unit consists of an equal number of time series observations (Brooks, 2019).

The study analyses data from the World Bank Database, ensuring reliability and comparability across the selected variables and countries. The dataset comprises

80 data points across the specified years, indicating the breadth of information available for analysis. This figure reflects the aggregate of annual observations for each included country across all examined variables, providing a robust foundation for the study's econometric modelling.

d. Potential Limitations

While methodologically justified, excluding Myanmar and Brunei Darussalam introduces a sampling limitation that may affect the study's generalizability to the ASEAN region. This aspect is acknowledged in the research design, with a commitment to transparency in reporting and interpreting the findings within the defined scope of the sampled nations.

3.7 Data collection methods

Data collection was obtained in the following way:

a. Field Research

The research’s primary, secondary data source was the World Bank's Databank. This platform was utilized to access and download datasets relevant to the study's objectives, including information on carbon emissions, tourism, energy Intensity, economic growth and population size for ASEAN countries.

b. Library Research

Extensive library research was undertaken to supplement the quantitative data obtained through field research. This involved reviewing academic books, peer-reviewed journals, and magazines to gather theoretical insights and empirical findings relevant to the study. The goal was to build a solid theoretical foundation and contextualize the data within the existing body of knowledge on tourism development and its economic and environmental impact in Southeast Asia.

c. Internet Research

Recognizing the limitations of traditional library resources, especially in capturing the most current studies and data, internet research was conducted. This involved searching for additional scholarly articles, reports, and datasets from reputable sources online. The aim was to ensure a comprehensive literature review and to gather the latest data and insights that could inform the study, enhancing the robustness of the analysis.

These methods combined ensured a thorough collection of secondary data and literature, providing a robust foundation for analyzing the nexus between tourism and carbon emissions within ASEAN countries.

3.8 Data analysis

The variables discussed in the current study are as follows:

The Impact of Tourism Development on Carbon Emissions

According to theory, tourism activities impact not only environmental but also social, cultural, and economic subsystems. While it can drive economic growth, it may also pose social and environmental risks. (Saenz-de-Miera & Rosselló, 2014) Emphasize that tourists cause demand for transportation and accommodation for their travelling activity. They also consume natural and human-made resources such as foods and beverages, which frequently lead to carbon emissions.

Energy efficiency is considered one of the fundamental components of a sustainable policy.

Dwyer et al. (2020) describe energy efficiency as one of the twin pillars of a sustainable energy policy. Energy intensity, which measures the energy used per unit of economic output, is a critical indicator of energy efficiency. Lower energy intensity suggests higher efficiency and is generally associated with reduced environmental impact. Luo et al. (2020) demonstrate that reducing energy intensity can significantly decrease carbon emissions.

Economics Development, Population Size and Environmental Impact

Economic Development often comes at a cost to the environment, as highlighted by the Grossman and Krueger model (1995). Economics expansion due to increased production and consumption can cause pollution, resource depletion, and social costs (Dwyer et al., 2020). The growth of population is associated with increased per capita energy consumption, which contributed much to climate change and global warming (Daniel Balsalobre-Lorente et al., 2021).

3.9 Model Estimation

a. Cross-sectional dependence.

Since tourism is closely related to globalization, detecting cross-sectional dependence (CD) in the panel data is essential (Balsalobre-Lorente et al., 2023). Therefore, following the works of (Paramati et al., 2017) and (Akadiri et al., 2020), the current study employs Pesaran's cross-sectional dependence (Pesaran CD) proposed by (Pesaran, 2004). Under the assumption of cross-sectional dependency, when the number of observations (N) and the period (T) approach infinity, the null hypothesis of no cross-sectional dependence is tested using the CD test statistic, which asymptotically follows a conventional normal distribution (Akadiri et al., 2020).

b. Classical Assumption Test

1. Normality test

The normality test aims to test whether the confounding or residual variables have a normal distribution in the regression model (Ghozali, 2009). There are two methods to determine if the residuals follow a normal distribution: graphic analysis and statistical tests. A good regression model is normally distributed or close to normal. If this assumption is violated, the statistical test will be invalid or biased, especially for small samples. One way to test this is the Shapiro-Wilk W test. This test is carried out before the data is processed. So, the Shapiro-Wilk W test detects the normality of data, whether normally distributed or not. The residuals are declared normally distributed if the Shapiro-Wilk W significance value exceeds 0.05. So, null hypothesis (H0): The data follows a normal distribution and alternative Hypothesis (H1): The data does not follow a normal distribution.

2. Multicollinearity Test

The multicollinearity test was carried out to test whether there was a correlation between the independent variables. The determination of whether there are symptoms of multicollinearity is based on the correlation matrix and the Variance Inflation Factor (VIF) value. If the VIF value is less than 10, then the regression equation is free of symptoms of multicollinearity. On the other hand, if the VIF value is more than 10, then the regression equation has symptoms of multicollinearity. The interpretation of the correlation matrix is as follows:

Coefficient Interval	Correlation
0,00 - 0,199	Very Low
0,20 - 0,399	Low
0,40 - 0,599	Moderate
0,60 - 0,799	Strong
0,80 - 1,000	Very Strong

Table 3.2: Coefficient Interval
Source: Sugiono (2011)

3. Heteroscedasticity Test

This heteroscedasticity test assesses whether there is a disparity in the variance of residuals between different observations in a regression model. Homoscedasticity refers to a situation where the variance of the residual remains constant, while heteroscedasticity occurs when the variance of the residual differs. The absence of heteroscedasticity characterizes an ideal regression model. This study used the Breusch-Pagan/ Cook Weisberg Test. So, the null hypothesis (H0) is homoscedasticity (constant variance), and the alternative Hypothesis (H1) is heteroscedasticity (constant variance).

4. Autocorrelation Test

This test aims to determine whether there is a correlation between confounding errors in period t and confounding errors in period t-1 in a linear regression model (Ghozali, 2009). This study used Wooldridge statistics to detect autocorrelation (Wooldridge, 2010). The presence of autocorrelation can lead to potentially misleading conclusions from the analysis.

c. Panel Regression

This study employs pooled OLS, random effects, and fixed effects techniques for static panel data (Gujarati, 2003; Gujarati & Porter, 2009). Static panel data analysis has several benefits, including managing individual heterogeneity, foreseeing forecasting issues with data multicollinearity, and generating precise micro-relationship estimates. The model will utilize panel data from multiple countries over a specific period. The choice of this method is based on previous studies (Cevik., 2022); (Lee & Brahmasrene, 2013) and (Anser et al., 2020).

The subsequent phase involves using static panel data regression, specifically pooled Common Effect Model (CEM), Fixed Effects Model (FEM), and Random Effects Model (REM), to analyze the nexus between tourism, energy intensity, population size, real GDP per capita and carbon emissions. Panel regression equations address the influence of country-specific and time-invariant shocks, thus reducing the impact of unobserved heterogeneity.

1) Fixed Effect Model (FEM)

The Fixed Effect Model is a statistical method employed in panel data analysis to address individual-specific disparities, such as variations in intercepts among various units, and to manage unobserved variability. It enables controlling unique attributes consistent over time but may differ among multiple units or entities. The model uses fixed effects to analyse changes within each unit over time and ascertain the association between independent and dependent variables while accounting for unit-specific characteristics that remain consistent over time. This model includes cross-section identifiers and periods in both the dependent and independent variables. Two estimators are used in the fixed effect (FE) regression model: the dummy variable and the FE estimator. Both techniques consistently predict shocks across a cross-section, particularly in each country.

2) Random Effect Model (REM)

The random effect model is a statistical technique that includes error factors to address errors that may arise in the interaction between time and individuals. The random effect model assumes that there is heterogeneity in intercepts among individuals. There are two distinct residual components: the general and individual residuals. The total residual includes both time-series and cross-sectional data, whereas the individual residual refers to the residual of each cross-sectional unit.

3) Common Effect Model (CEM)

This model employs the pooled least squares estimation method to combine cross-sectional and time series data into a single dataset. The parameters of the model are determined using the least squares approach, also known as ordinary least squares (OLS). Among panel data regression model estimation methods, the common effect model is the most basic. It disregards differences in individual and temporal dimensions, assuming that the behavior of each individual remains consistent over time. Parameter estimation in this model involves integrating cross-sectional and time-series data into a unified entity, without accounting for variations in time and individual characteristics (Widarjono, 2007).

d. Model Assessment

The selection of the appropriate model—whether it be the Common Effect Model (CEM), Fixed Effect Model (FEM), or Random Effects Model (REM)—is contingent upon both considerations regarding the data-generating process and the outcomes of statistical tests. When dealing with an open sample, where the N cross-section units are randomly drawn from a large population, employing random effects becomes a natural choice. Conversely, a fixed effect is deemed suitable when the sample encompasses all units of interest and is not a subset of a larger population. This study used Chow's, Hausman's, and Breusch-Pagan's LM tests to aid model selection. The obtained p-values of these tests play a crucial role as they inform our decision-making process.

1. Chow Test

The Chow test is a statistical method used to evaluate whether the coefficients in two separate regression models are equal. This test is particularly useful in econometrics for identifying significant changes in the data structure, especially in time series or panel data analysis. The Chow test compares the sum of squared residuals from a regression using combined data to those from regressions using subsets of the data. The resulting test statistic is then compared to a critical value from the F-distribution. The Chow Test is used to determine the reliability of concluding either the common effect model or the fixed effect model when picking the best model using static panel data. This test will determine whether the estimates for the fixed effects (FE) are suitable, based on the p-values produced, which should be lower than the 5% significance level.

H0: Common Effects Model (CEM) is appropriate.

H1: Fixed-Effects Model (FEM) is appropriate

2. Hausman test

Hausman's test determines the reliability of results from either the fixed or random-effects models when choosing the best model for static panel data. The specification test in the Hausman test follows a chi-square distribution according to the Wald criterion. The two estimated models make different assumptions about the relationship between the independent variables and the individual-specific unobserved effects. Suppose all the p-values obtained in this situation are below the 5% threshold. In that case, we can conclude that there are significant differences between the coefficients of FE and RE and reject the null hypothesis of no systemic changes.

H0: Random-Effects Model (REM) is appropriate

H1: Fixed-Effects Model (FEM) is appropriate

This observation will suggest whether the estimation for the Fixed-Effect Model (FEM) or Random Effect Model (REM) is appropriate.

3. Lagrange Multiplier Test

The Lagrangian multiplier test is a statistical method used to assess the validity of a regression model. It determines whether a set of restrictions on the model's variables is consistent with the data. This test evaluates the compatibility between the model and the imposed restrictions by independently estimating the parameters. The Lagrangian multiplier test determines the reliability of concluding either the common effect model or the random effects model when choosing the best model for static panel data. If all the p-values obtained are below the 5% threshold, we will reject the null hypothesis and conclude that the Random Effect Model (REM) is suitable. Conversely, if the p-value exceeds 0.05, we will accept the null hypothesis and determine that the Common Effect Model (CEM) is the most appropriate.

H0: Common-Effects Model (CEM) is appropriate

H1: Random-Effects Model (REM) is appropriate

e. Driscoll-Kraay Standard of Error

Following (Kongbuamai et al., 2020), this study utilized the Driscoll-Kraay standard error technique introduced by Driscoll and Kraay (1998). This method is non-parametric for examining relationships between variables across panel series (Driscoll & Kraay, 1998). This approach garners significant attention due to its ability to address several critical challenges in panel econometrics. The technique's strengths lie in its reliability and consistency, mainly when dealing with cross-sectional dependence (Sarkodie & Strezov, 2019).

Furthermore, Baloch et al. (2019) and Sarkodie & Strezov (2019) emphasize several benefits of using the Driscoll-Kraay approach, as follows: (1) It is flexible and can handle an extensive time dimension. (2) It can handle missing values, allowing its application to balanced and unbalanced panel data sets; and (3) The method effectively tackles issues of cross-sectional dependence, heteroscedasticity, and spatial effects (Kongbuamai et al., 2020). These characteristics collectively position the Driscoll-Kraay standard error technique as a valuable tool for researchers analyzing panel data, particularly when encountering the aforementioned econometric concerns.

Therefore, this study employs the Driscoll-Kraay standard error method to examine the relationship among tourism, economic growth, energy intensity, population size, and carbon emissions using data from ASEAN economies spanning 2010 to 2019. Initially, the study calculates average values from the outputs of independent variables and residuals. These averages are then utilized in the weighted heteroskedasticity and autocorrelation consistent (HAC) estimator to compute standard errors, ensuring robustness against issues such as cross-sectional dependence (Heberle & Sattarhoff, 2017).

3.10 Hypothesis test

This research employs panel data analysis to achieve the research objectives. Hypotheses testing is conducted as follows:

a. The Wald test and t statistical tests are used to conduct significance tests between the independent and dependent variables, both concurrently and partially.

b. The Wald statistical test

The Wald chi-squared is determined using a significance threshold of 5% and degrees of freedom df = (nk) and (k-1), where n represents the number of observations and k represents the number of variables, including the intercept. The test criterion employed is as follows:

Ho: b1, b2, b3, b4…. bx = 0;

Ha: b1, b2, b3, b4…. bx ≠ 0

This means that there is no influence (alternatively, there is an influence) that is simultaneously significant from all the independent variables on the dependent variable.

The calculated Wald chi-squared can be found using the following formula.

$$\text{Wald chi}(2) = \frac{R^2/(k-1)}{(1-R^2)/(n-k)}$$

To determine the Wald chi2 value, the significance level used is 5% with degrees of freedom df = (nk) and (k-1) where n is the number of observations, k is the number of variables, including the intercept with the test criteria used is:

If the probability value of Wald chi2 > 5% (significance level), then Ho is accepted

If the probability value of Wald chi2 < 5% (significance level), then Ho is rejected

The simultaneous hypothesis is as follows:

H_{01}: b1, b2, b3, b4 = 0; Tourism, real GDP per capita, energy intensity, and population size simultaneously do not significantly affect the ASEAN countries' carbon emissions during 2010-2019.

H_{0a}: b1, b2, b3, b4 ≠ 0; Tourism, real GDP per capita, energy intensity, and population size significantly affect the carbon emissions of ASEAN countries during the 2010-2019 period.

c. The t-statistical test

The significance of the coefficient (bi) was determined by doing a t-test using the student t-statistic. The t-test is employed to assess the importance of the partial regression coefficient of the independent variable. The hypothesis employed is

Ho: $bi \leq 0$

Ha: $bi > 0$

and

Ho: $bi \geq 0$

Ha: $bi < 0$

This test indicates that the independent variable does not substantially impact the dependent variable.

The statistical t value can be found using a formula

$$\text{t} - \text{count} = \frac{\text{regression coefficient}}{\text{standard of deviation bi}}$$

To assess the t-statistical value of the table, a significance level of 5% is determined with degrees of freedom df = (nk-1) where n is the number of observations and k is the number of variables including the intercept with the test criteria being:

If the probability value of t value > 5% (significance level), then Ho is accepted

If the probability value t value < 5% (significance level), then Ha is rejected

To assess the collective explanatory power of the independent variables on the dependent variable, one can examine the multiple coefficients of determination (R2), which range between 0 and 1. A higher R2 value approaching 1 indicates a stronger ability of the independent variables to explain variations in the dependent variable.

The partial hypothesis for the present study is as follows:

H_o: $\beta_1 \leq 0$ Tourism did not significantly increase carbon emissions in ASEAN countries during 2010–2019.

H_a: $\beta_1 > 0$ Tourism significantly induced carbon emissions in ASEAN countries during 2010-2019.

H_o: $\beta_2 \leq 0$ Real GDP per capita does not lead to significantly increased carbon emissions in ASEAN countries during 2010-2019.

H_a: $\beta_2 > 0$ Real GDP per capita led to a significant increase in carbon emissions in ASEAN countries during the 2010-2019 period.

H_o: $\beta_3 \leq 0$ Energy intensity does not lead to significantly increased carbon emissions in ASEAN countries from 2010 to 2019.

H_a: $\beta_3 > 0$ Energy intensity increases carbon emissions in ASEAN countries during 2010-2019.

H_o: $\beta_4 \leq 0$ Population size does not lead to significantly increased carbon emissions in ASEAN countries during 2010-2019.

H_o: $\beta_4 > 0$ Population size increases carbon emissions in ASEAN countries during 2010-2019.

3.11 Determination of Significance Levels

The level of significance used in this determination is 1%, 5% and 10%, meaning that the probability of the conclusion being drawn correctly has a probability of 95% or an error tolerance of 5%. This significance level was chosen because it was considered strict enough to be representative and widely used in social science research.

3.12 Drawing Conclusions

This study will determine the research outcome based on the analysis and hypothesis. We utilized Microsoft Excel, Eviews 10.0 software, and Stata 14.2 to complete all the analysis stages discussed in the previous section.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Introductions

Since, sustainability and responsible tourism are inevitable to address climate change, this study examines the effect of tourism development on CO2 emissions in ASEAN countries from 2010 to 2019. The following is a list of sample countries studied with their most popular tourism destinations as follow:

Table 4.1 List of Sample Countries

No.	Country	Destinations*	Type of Tourism
1	Cambodia	Phnom Penh, Siem Reap	Ecotourism and Cultural Tourism
2	Indonesia	Bandung, Bali, Lombok	Ecotourism and Cultural Tourism
3	Lao PDR	Luang Prabang	Ecotourism
4	Malaysia	Kuala Lumpur	Urban Tourism and Cultural Tourism
5	Philippines	Palawan Island	Ecotourism
6	Singapore	Singapore	Sustainable Tourism and Cultural Tourism
7	Thailand	Pattaya, Bangkok, Phuket, Chiang Mai, Khao Lak	Ecotourism, Cultural Tourism
8	Viet Nam	Halong Bay, Sapa, Hanoi, Hoi An, Hue	Ecotourism, Cultural Tourism,

*Compiled based on Top 25 Best of the Best Destinations from Travelers' Choice Awards on tripadvisor.com

Source: Data compiled from Tripadvisor.com

4.2 The tourism growth rate and current landscape of sustainable tourism development

The tourism sector in ASEAN experienced a positive trend from 2010 to 2019. international tourism arrivals and international tourism receipts saw an average annual rise of 7.5% and 7% respectively. Thailand surpassed Malaysia in terms of international tourist arrivals in 2015 and maintained its position as the leading destination until 2019. In 2019, Thailand welcomed nearly 40 million international tourists and received US$64.371 billion in tourism receipts. From 2010 to 2019, in ASEAN countries, the percentage of international tourism receipt is around 11.25% of total exports.

Figure 4.1 International Tourists Receipt
Source: (WDI, 2024)

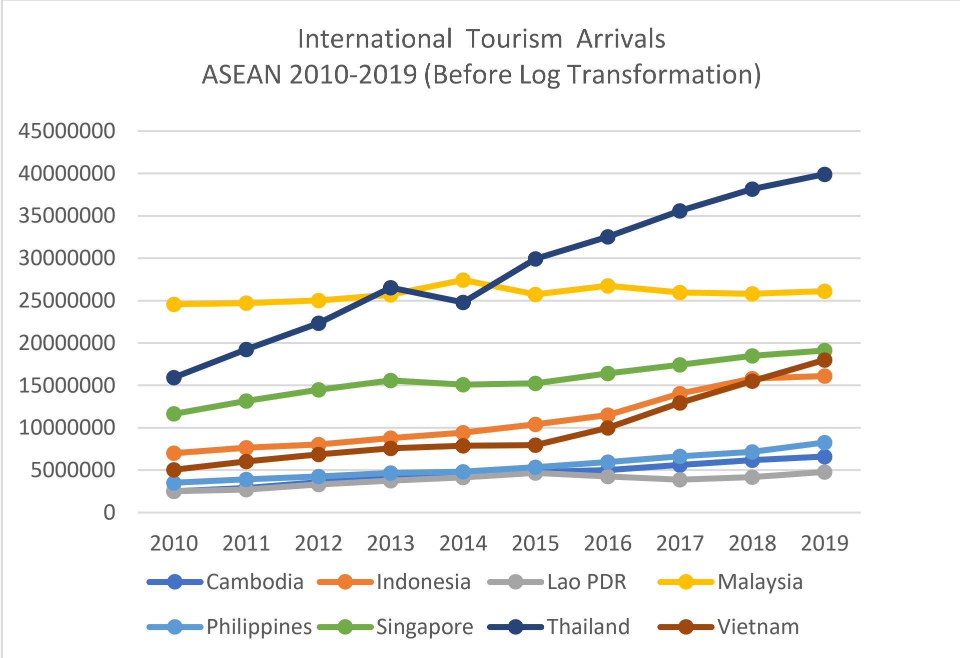

Figure 4.2 International Tourists Arrivals
Source: (WDI, 2024)

Thailand has become the most attractive tourism destination, with a growth in international tourist arrivals and international tourist receipts of around 11.1% and 12.2%, respectively. Thailand is a major global player due to its natural attractions, historical sites, cultural activities, friendly citizens, delicious Thai cuisine, and recreational amenities (Wirudchawong, 2017). In 2003, the Ministry of Tourism and Sports established the Designated Areas for Sustainable Tourism Administration (DASTA) with the aim of promoting Community-based tourism (CBT). This platform serves as a means for local communities to enhance their standard of living, create job opportunities, encourage the return of young people to their hometowns, boost economic income, and foster a sense of empowerment and pride in their cultural heritage. The success of Thailand in the tourism business can be credited to the effective efforts of the Tourism Authority of Thailand (TAT) in promoting, propagating, and ensuring convenience and safety for travelers (Wirudchawong, 2017).

Thailand has long incorporated elements of sustainable tourism in its policy agenda. Despite its efforts, Thailand’s popularity has led to overtourism and negative impact on natural and heritage tourist attractions, with the case of Maya Bay in the Phi Phi Islands being the most well-known. In 2018, Thailand embarked on a critical environmental restoration project, closing the bay to rejuvenate the coral reefs and ecosystem. The marine park was reopened in January 2022, but with new measures in place, including a carrying capacity, the prohibition to swim and a new docking area for boats on the opposite side of the island (Sustainable Tourism Development in ASEAN, 2024).

Even though the growth in international tourist arrivals and international tourist receipts is modest, around 0.7% and 1.8%, respectively, which is below the regional growth, Malaysia remains highly sought-after as a tourism destination in Asia due to various factors. Based on the rankings by ECA International, Kuala Lumpur holds the second position as the most liveable city in Southeast Asia. Kuala Lumpur has recently achieved the second-highest ranking among Southeast Asian cities in the Oxford Economics Global Cities Index 2024. Malaysia is renowned for its hospitality, pleasant climate, cultural abundance, delicious cuisine, proficiency in English, affordable options. contemporary architecture, and highly developed infrastructure, as stated by Lillagreen.com. To enhance its attractiveness and accelerate tourism growth, Malaysia should focus on promoting innovation, diversifying tourism offerings, and improving the quality of its destinations, with an emphasis on sustainable travel experiences.

Sustainable development has been an integral part of Malaysia's tourism goal since the formulation of its first Tourism Policy in 1992. Subsequently, more extensive plans have been formulated, placing increased emphasis on conserving and improving natural attractions, historical sites, buildings, and artefacts. The 2020-2030 National Tourism Policy (NTP) establishes sustainable tourism as a strategic advantage and catalyst for equitable economic expansion. Transformation initiatives encompass enhancing governance, establishing specialized investment zones, embracing smart tourism, and advocating for sustainability. Emphasis is placed on prioritizing products such as ecotourism, adventure tourism, and cultural experiences. Malaysia places significant emphasis on the involvement of the business sector and local government, actively promotes travel within the ASEAN region, and firmly advocates for the development of community-based tourism (Sustainable Tourism Development in ASEAN, 2024).

Singapore has become the third most attractive tourism destination in ASEAN, with a growth in international tourist arrivals and international tourist receipts of around 5.8% and 5.2%, respectively. Singapore is popular for tourism because it has been the most liveable city in Asia (ECA international). Singapore is a vibrant centre for tourism, renowned for its exceptional cuisine, shopping, and cultural events. The development of the tourism industry is closely linked to transportation, with transportation infrastructure being the most critical component for the industry's growth. Singapore continuously innovates and expands its tourism offerings to attract global visitors. The city-state boasts a well-developed transportation infrastructure, facilitating easy access to various attractions and destinations. The efficient transportation system, comprising an extensive network of trains, buses, and taxis, has significantly supported the tourism industry's growth. The accessibility and convenience provided by this infrastructure have made it easier for tourists to explore Singapore's attractions, thereby contributing to the overall success of its tourism sector (Abdullah et al. 2023). Moving forward to achieve sustainable development, the government of Singapore emphasizes sustainable tourism in the Singapore Green Plan 2030. The tourism sustainability program was launched in April 2022 to support businesses in capability development, innovation, education, and awareness. (Sustainable Tourism Development in ASEAN, 2024).

Indonesia has immense potential to be one of the most competitive tourism destinations in the future, with a significant growth rate in terms of international tourist arrivals and international tourist receipts of around 9.8% and 10.5%, respectively. Indonesia started to revitalize and institutionalize its tourism sector in 2016. Before 2016, Indonesia's sustainable tourism policy was not as well articulated or integrated. In 2016, the government introduced 10 new priority tourism destinations, called the "10 New Balis," which include Toba Lake, Belitung, Tanjung Lesung, Seribu Islands, Borobudur Temple, Bromo Mountain, Mandalika Lombok, Komodo National Park, Wakatobi National Park, and Morotai. The government's ongoing development projects demonstrate its commitment to utilizing the tourism sector as a primary catalyst for economic growth. The country's tourism strategic plan prioritizes regional commitment, collaboration, and the establishment of sustainable tourism destinations. Key performance indicators are employed to monitor various sites beyond commercial enterprises, reflecting the acknowledgement of stakeholders. Challenges include financial limitations and geographical obstacles, necessitating technological advancements and crisis management for the achievement of sustainable tourism. One of Indonesia's endeavours in promoting sustainable tourism and environmental protection is the implementation of a visitor management strategy in 2019 at Komodo National Park. This approach restricts the number of daily visitors and has led to an increase in entrance fees, with a portion of the revenue directly allocated to conservation and community development initiatives (Sustainable Tourism Development in ASEAN, 2024).

Similarly, Vietnam also has huge potential to be a competitive tourism destination in the future. During the 2010–2019 period, the growth rate of international tourist arrivals was 15.5%, which is the highest in the region, while the international tourist receipt was around 11.8%, fourth place after the Philippines, Cambodia, and Thailand. The country boasts many attractive destinations. Although the term sustainable tourism is relatively new in Vietnam, the country has initiated community-based tourism (CBT) initiatives since 2000 that align with the Millennium Development Goals (MDGs) and, later, the Sustainable Development Goals (Phi & Pham, 2022 & Doan, 2018). Practically, the tourism industry demonstrates sustainable tourism by assuming responsibility for resource and environmental management. However, it is crucial to prioritise the rigorous implementation of regulations for environmental protection, ensuring the long-term viability of tourism development, and actively engaging in international agreements regarding sustainability matters such as water resources, waste management, and biodiversity preservation (Sustainable Tourism Development in ASEAN, 2024).

Likewise, the Philippines has significant potential to become a competitive tourism destination in the future. The growth rate of international tourist arrivals is 10%, while the growth rate of international tourist receipts is around 14.7%, the highest in the region. The huge margin between the growth rate of arrivals and international tourism receipts indicates that the country aims for high tourism spending. The country emphasizes sustainability in tourism through its National Tourism Development Plans (NTDP) and National Ecotourism Strategies (NES). The NTDPs, covering periods from 2011-2016 and 2016-2022, aim to integrate competitiveness and inclusive growth, in line with the ASEAN Tourism Strategic Plan. The NES, spanning 2013-2022, focuses on developing globally competitive ecotourism, diversification, empowering rural communities, offering conservation incentives, promoting recreation, and fostering community involvement. The Transforming Communities towards Resilient, Inclusive, and Sustainable Tourism (TouRIST) program, launched in 2019, targets seven pilot sites and emphasizes inclusive local economic development and environmental sustainability. The Philippines also encourages sustainable practices among tourism businesses by adopting certification, ASEAN standards, and roadmaps for low-carbon tourism. However, the country lacks a nationwide system for monitoring sustainable tourism, necessitating a harmonized approach for integrated destination management (Sustainable Tourism Development in ASEAN, 2024).

Cambodia remains an emerging competitor in the regional tourism sector. During the 2010–2019 period, the growth rate of international tourist arrivals was 11.5%, which is the second highest in the region after Vietnam, while the international tourist receipt was around 14.1%, second only to the Philippines. The country heavily relies on Siem Reap, its most visited destination, which has grown rapidly due to the popularity and significance of Angkor Wat. However, this has led to challenges in visitor management and heritage conservation. In response, the Tourism Development Master Plan of Siem Reap (2021-2035) aims to transform the area into a high-quality destination, focusing on attracting affluent tourists and mitigating the impact on the heritage site. The plan emphasizes sustainable heritage management and inclusive development across seven key areas: site development, new product offerings, promotion, quality enhancement, environmental management, infrastructure development, and participatory governance. Even prior to the Master Plan, the government was committed to ecotourism for green economic development, having established 22 ecotourism communities to stimulate local economies (Sustainable Tourism Development in ASEAN, 2024).

Lao PDR is another emerging competitor in the ASEAN tourism sector. The growth rate of international tourist arrivals is 7.9%, which is slightly higher than the regional growth rate in ASEAN, while the international tourist receipt is around 11.5%, ranking fifth after the Philippines, Cambodia, Thailand, and Vietnam. While tourism is crucial for the country's socioeconomic development, it faces challenges in increasing international openness, connectivity, and competitiveness. As the tourism industry grows, Lao PDR aims to position itself as a sustainable tourism destination by emphasizing its cultural and natural assets and attracting high-end, longer-stay tourists for green recovery. Nam Et-Phou Louey National Park exemplifies sustainable tourism development in a protected natural area. The park's ecotourism initiative provides an additional income source for communities around the protected zone. Tours are strategically designed to link conservation efforts with tourism, ensuring that visitor contributions support local residents' motivation to safeguard biodiversity (Sustainable Tourism Development in ASEAN, 2024).

4.3 Descriptive Statistics

This study aims to investigate the impact of tourism development on environmental degradation, specifically measured by per carbon emissions in ASEAN countries, a region identified as highly reliance on the tourism sector as well as the most vulnerable to climate change based on the Global Climate Risk Index 2021. This analysis took into account the level of economic development, population dynamics, and technological advancements within each group of countries. The summary of statistical data used in this study is as follows:

Table 4.2. Summary Statistics on a Panel Data Set*

Variable	Mean	Std. Dev.	Minimum	Maximum	Observations
Carbon Emission	0.799	0.955	-1.027	2.155	80
Tourism	16. 104	0.771	14.735	17.502	80
Real GDP per capita	3.666	1.191	2.057	6.376	80
Energy Intensity	1.304	0.235	0.722	1.666	80
Population	17.403	1.302	15.440	19.412	80

Note: Std. Dev = standard deviation;*Datal in Natural Logarithm

Source: Data Compiled from Stata 14.2

Table 4.2 presents the statistical summary of the research model, encompassing all observations from ASEAN countries. It shows the average natural logarithm of Carbon emissions, tourism, real GDP per Capita (GDPC) energy intensity, and population size of ASEAN economies are 0.799, 16.104, 3.666, 1.304, and 17.403. Meanwhile, the standard deviation of Carbon emissions, tourism, energy intensity, GDP per Capita, and population size of ASEAN economies are 0.955, 0.771, 1.191, 0.235, and 1.302 from 2010 to 2019. The negative sign on the minimum carbon emission dataset belongs to Cambodia because of the logarithm transformation of carbon emissions less than 1 metric ton per capita. The logarithmic trends for each variable are outlined as follows:

1. Carbon Emissions

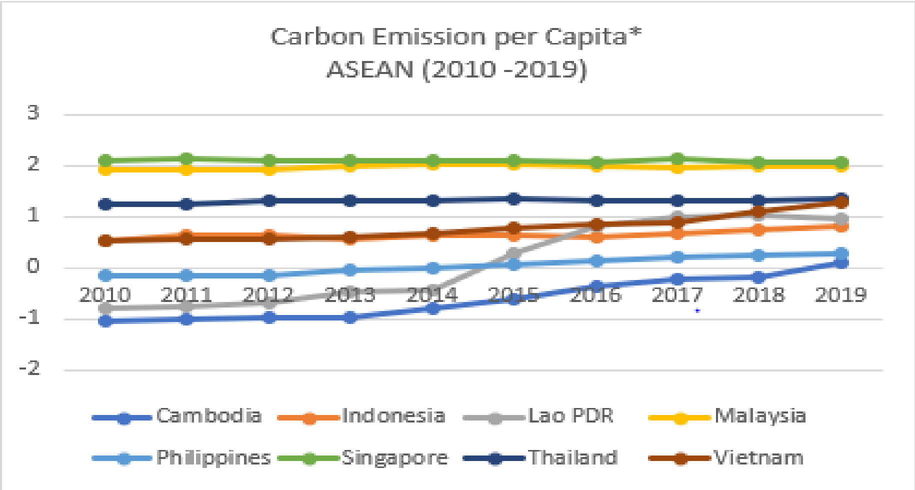

Figure 4.3: Carbon Emissions
Source: Data Processing Results of Microsoft Excel

Figure 4.3 (above) shows that the average carbon emissions in ASEAN countries increased from 2010 to 2019. Singapore, Malaysia and Thailand are the leading countries in carbon emissions per capita. However, these countries can keep its emission to stay almost flat for one decade. The countries with significant increases in carbon emissions are Vietnam, Lao PDR and Cambodia. Cambodia has been one of the fastest improvers in terms of energy equity since 2000 (World Energy Trilemma Index, 2019). Meanwhile, Laos PDR experienced a significant increase since 2014 with the start of production of the lignite (brown coal) power plants in 2014 (enerdata. net,2024).

2. Tourism

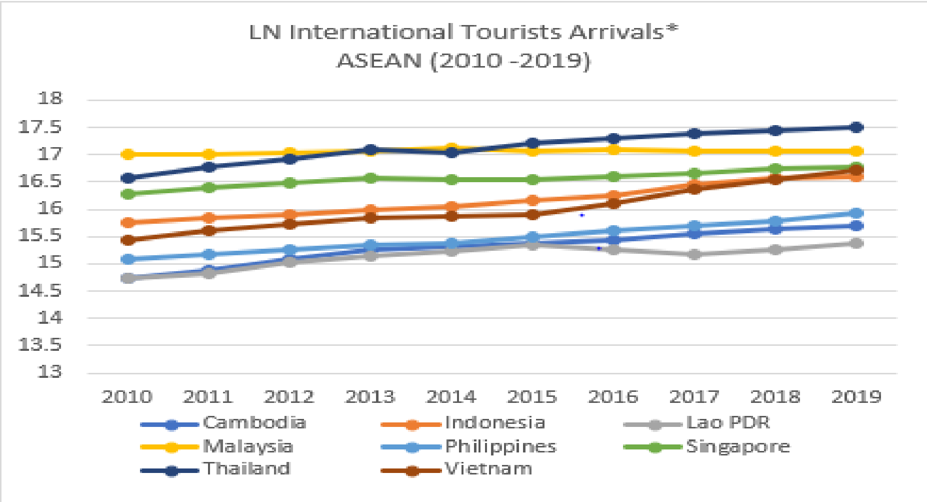

Figure 4.4: International Tourism Arrivals (Natural Log Transformation)
Source: Data Processing Results from Microsoft Excel

Figure 4.4 (above) shows that the number of international tourist arrivals in ASEAN territory constantly increased until 2019. The statistics showed that international tourism arrivals in ASEAN (excluding Myanmar and Brunei Darussalam) experienced an average increase of 7.5% from 2010 to 2019. Thailand was the most visited country in the region from the 2015-2019 period, followed by Malaysia and Singapore. The top 3 most visited countries in ASEAN are classified as the most developed countries in ASEAN during 2010-2019, according to the World Bank. So, it confirmed that the tourism sector is closely associated with the level of economic development of the host country. Most international tourists are attracted to countries with top-notch infrastructures. Developed countries invest significantly in tourism infrastructure such as airports, hotels, and resorts to cater for the tertiary needs of both domestic and international tourists.

3. Real GDP per Capita

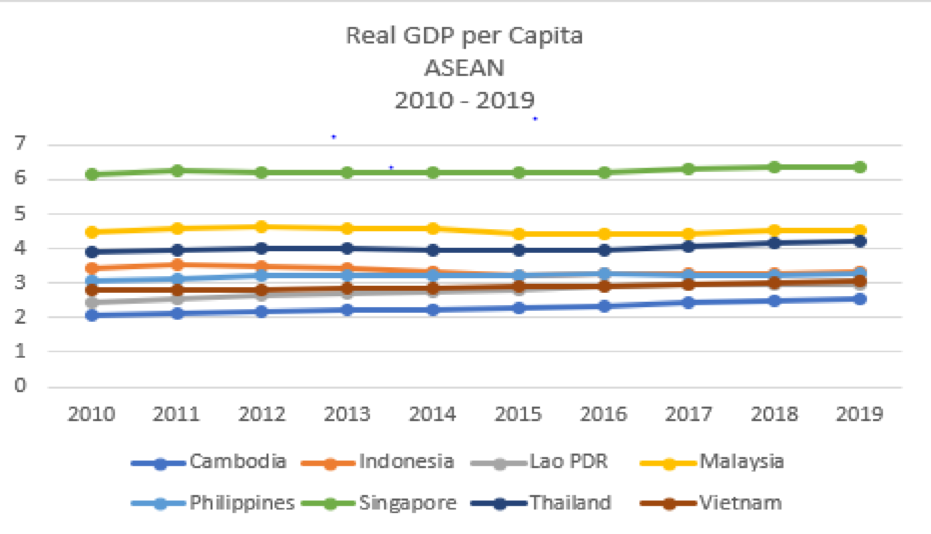

Figure 4.5 Real GDP Per Capita
Source: Data Processing Results from Microsoft Excel

Figure 4.5 (above) shows that the GDP per Capita of ASEAN countries experienced an insignificant increase in one decade from 2010 to 2019, led by Singapore, Malaysia, and Thailand. Indonesia reached upper middle-income status in 2019. According to World Bank (2021), Malaysia is expected to attain high-income status between 2024 and 2028. However, to maintain its competitive edge, it must enhance the quality, inclusiveness, and sustainability of its economic growth. Cambodia, Lao PDR, Philippines and Vietnam are classified as lower-middle income countries. Between 1995 and 2019, Cambodia's economy expanded at an average annual rate of 7.6 percent, primarily fuelled by tourism, manufacturing exports, real estate, and construction. This impressive growth positioned Cambodia as one of the world's fastest-growing economies (World Bank, 2021).

4. Energy Intensity

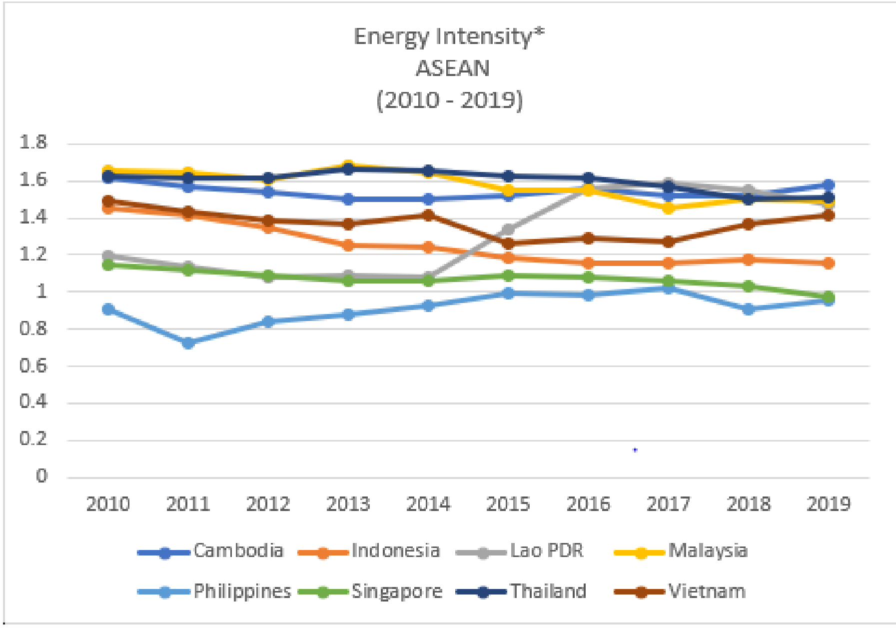

Figure 4.6: Energy Intensity
Source: Data Processing Results from Microsoft Excel

Figure 4.6 (above) shows that ASEAN countries' energy intensity ratio experienced a decrease until 2019 due to technological advancement in the region, except for Laos PDR, which experienced a significant increase since 2014 with the start of production of the lignite (brown coal) power plants in 2014 (enerdata.net,2024). The most significant country that experienced a decrease in energy intensity from 2010 to 2019 was Indonesia. Overall, Fossil fuels will continue to be a major source of energy for all consumption sectors until 2030 in ASEAN (Lau, 2022). Vietnam's goal to achieve high-income status by 2045 is at odds with its energy transition plans (Fallin et al., 2023).

5. Population Size

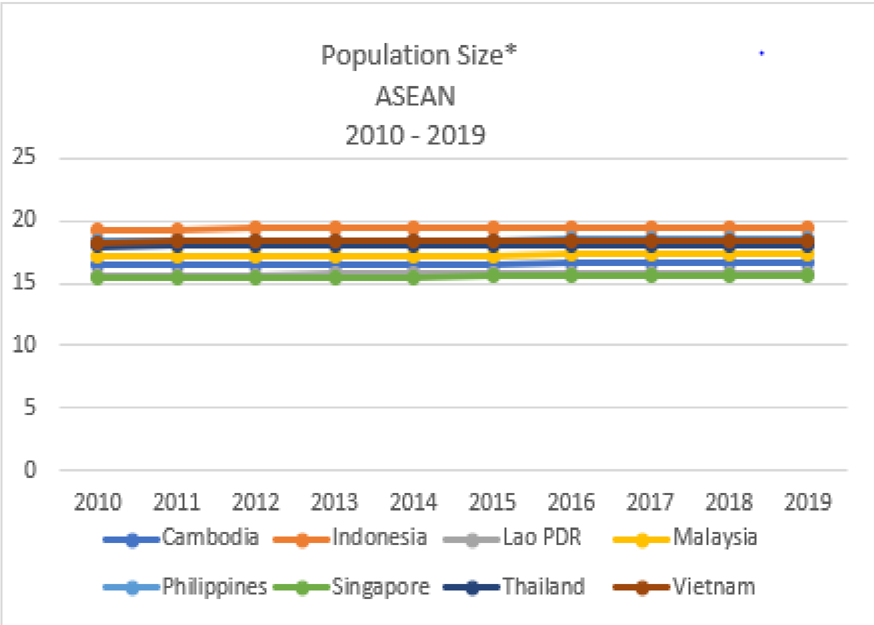

Figure 4.7 Population Size
Source: Data Processing Results from Microsoft Excel

Figure 4.7 shows that the population of ASEAN countries experienced an insignificant increase from 2010 to 2019. The most populous countries in ASEAN from 2010 to 2019 are Indonesia, Philippines and Vietnam.

4.4 Cross-sectional dependence

The result of the CD test is as follows:

Table 4.3 Cross-sectional Dependence

Average correlation coefficients & Pesaran (2004) CD test

Variable	CD test Statistic	P-Value
CO2	5.97	0.000
ITA	14.08	0.000
GDPC	4.49	0.000
EI	0.91	0.361
POP	16.60	0.000

Source: Data Processing Results from Stata 14.3

The findings of the CD test conducted by Pesaran (2004) in Table 4.3 indicate that the null hypothesis of no cross-sectional dependency can be rejected. The conclusion is supported by a probability value of less than 0.01 in most variables, with the exception of energy intensity. Hence, the findings offer evidence of the presence of cross-sectional interdependence for CO_2, ITA, GDPC, and POP. These findings indicate that a disturbance in one of the ASEAN countries can have an impact on the interconnected variables of other countries in the region. Hence, it is imperative to take into account the interdependence among nations.

4.5 Classic Assumption Test Results

Prior to the regression analysis, the classical assumptions that underlie the regression model must be evaluated. These assumptions include tests for normality, multicollinearity, heteroscedasticity, and autocorrelation. Here are the results obtained from testing these four assumptions.

Table 4.4 Classical Assumption Test Results

Normality Test	Multicollinearity Test	Heteroscedasticity Test	Autocorrelation Test
Shapiro-Wilk W test	VIF value	Breusch-Pagan test	Wooldridge test
Z value	Average value	Chi2 value	F value
(Prob > z)		(Prob > chi2)	Prob > F
-1.587 0.94375	1.05 -	40.38 0.0000	26.674 0.0013

1. Normality test

   The normality test determines whether each variable follows a normal distribution. If the regression model deviates from normality, the validity of conclusions drawn from the F-test and t-test results becomes questionable, as these statistical tests in regression analysis assume a normal distribution. In this study, the one-sample Shapiro-Wilk W test was employed to assess the normality of residual values. Based the residual Shapiro-Wilk W test results (Table 4.4) indicate that the residual values are normally distributed. The regression model has a probability value of around 0.94375, which is greater than 5% (0.05), indicating that the residuals are normally distributed for this model.

2. Multicollinearity Test.

The multicollinearity test looks for a strong relationship between some or all of the independent variables in the regression model. If multicollinearity exists, the regression coefficient becomes uncertain, and the error term becomes very large. This research uses the collinearity value to indicate whether there is multicollinearity between the independent variables.

Table 4.5 Multicollinearity Test Results

	LnITA	LnGDPC	LnPOP	LnEI	VIF
LnITA	1.000				1.07
LnGDPC	0.659	1.000			1.07
LnPOP	0.179	-0.316	1.000		1.02
LnEI	0.196	-0.270	-0.014	1.000	1.04
Mean VIF					1.05

Source: Stata 14.2 Processing Results

Based on Table 4.5 above, the correlation value of the four independent variables is less than 0.799, and the average of VIF value is less than 5. This result indicates no very strong correlation between the independent variables (Sugiono,2011), so no significant multicollinearity issues exist in the equation.

3. Heteroscedasticity Test

The heteroscedasticity test is employed to ascertain the presence of deviations from the fundamental assumption of heteroscedasticity, which refers to the unequal variances of the residuals across all data in the regression model. The Breusch-Pagan Chi-square test is employed to examine the homogeneity of the residuals' variance by assessing the correlation between the four independent variables and the absolute value of the residuals (error). If there is a significant independent variable correlation coefficient at an error level of 5%, it indicates heteroscedasticity. Based on the results of the heteroscedasticity test (Table 4.4), it can be seen that the test statistics of the Chi-square (1) value for the model is 40.38. The model has a probability value below an appropriate threshold (Probability of Chi2 is 0.0000 < 0.05), so it can be concluded that there is a symptom of heteroscedasticity in the regression model.

4. Autocorrelation Test

The autocorrelation test is employed to ascertain the presence of departures from the conventional autocorrelation assumption, namely the correlation between the residuals in a single observation and other data in the regression model. It utilizes the Wooldridge test proposed by (Wooldridge, 2010). Based on the results of the heteroscedasticity test (Table 4.4), the value of Woodridge test for autocorrelation is 26.674 and its probability value is 0.0013 which is less than 0.05. So, there is autocorrelation issue in the regression models.

4.7 Panel Regression Analysis

This study employed several linear regression models to evaluate the impact of tourism, real GDP per capita, energy intensity, and population size on carbon emissions. The regression analysis utilizes annual data collected over ten years for observation. The study will be conducted on 80 data points collected from 8 ASEAN countries from 2010 to 2019. The study utilized static panel data approaches, including pooled OLS, random effects, and fixed effects models. The selection of the appropriate model—whether it be the Pool OLS, Fixed Effect (FE), or Random Effects (RE)—is contingent upon both considerations regarding the data-generating process and the outcomes of statistical tests the Chow's test and Hausman's test. The Equation of the regression equations to be tested is formulated as follows:

$$\Delta Y\text{it} = \alpha + \beta 1\, \Delta X1\text{it} + \beta 2\, \Delta X2\text{it} + \Delta\beta 3\, X3\text{it} + \beta 4\, \Delta X4\text{it} + \varepsilon\text{it} \quad (Eq. 4)$$

Where: Y = Carbon Emissions

X 1 = Tourism

X 2 = Real GDP per Capita

X 3 = Energy Intensity

X 4 = Population Size

Δ = First Difference

α = constant

βi = regression coefficient

i = The individual i-th

4.8 Model Assessment

Table 4.6 Model Assessment Test Results			
Chow Test	Hausman Test	Lagrangian Multiplier Test	The Best Model
(Prob > F)	(Prob > chi2)	(Prob > chibar2)	
4.15 0.0009	3.52 0.4755	127.23 0.0000	Random Effect Model

1. Chow Test

The calculated findings (Table 4.6) indicate that the test statistic value is 4.15, and the related p-value is 0.0009. Therefore, the null hypothesis, which suggests no significant difference between the pooled OLS and the fixed effects model (FEM), is rejected. So, the Chow test indicates a preference for fixed effects over pooled OLS, as the probability value is less than a 5% significance level (0.0009 < 0.05).

2. Hausman Test

Based on the statistical output (Table 4.6), the statistic value and the p-value of the Hausman test are 0.4755, respectively. The null hypothesis of the random effects model is appropriate, meaning that individual effects are not correlated with the regressors and cannot be rejected. The probability value is greater than 5% significance level (0.4755 > 0.05). In short, the Hausman test favours random effects over fixed effects.

3. The Breusch-Pagan LM test

The statistical analysis (Table 4.6) indicates that the Breusch-Pagan LM test supports the use of a random effects model instead of the pooled ordinary least squares (OLS) model. This conclusion is based on the calculated statistic value of 127.23 and a p-value of 0.000. The p-value denotes significance at a 5% significance level (0.000 < 0.05). Consequently, the random effect is the most appropriate for the model.

Table 4.7 The Random Effect Model and associated parameters	
Dependent Variable: Δ CO_2	
	Coefficient (Std. Err
Δ lnITA	-0.215 (0.139)
Δ lnGDPC	0.401** (0.194)
Δ lnEI	1.128*** (0.135)
Δ lnPOP	0.960 (2.876)
C	0.065 (0.042)
Observations	72
Wald chi2 (4)	82.10***
R-squared Within	0.560
R-squared Between	0.521
R-squared – Overall	0.527
Note: At the 1 per cent, 5 per cent, and 10 per cent levels, ***, **, and * denote significance	

All models in this study have undergone diagnostic testing including classical assumption tests as part of the ongoing analysis. The findings indicate that the model exhibits heteroscedasticity, autocorrelation, and cross-sectional dependence issues. Then, it is necessary to apply Driscoll-Kraay's standard errors to mitigate these issues. The final models are as follows:

Table 4.8 The Random Effect Model with Driscoll Kraay Std. Err.	
Dependent Variable: Δ CO_2	
Variables	Coefficient (Driscoll Kraay Std. Err)
Δ lnITA	-0.215** (0.074)
Δ lnGDPC	0.401*** (0.047)
Δ lnEI	1.128*** (0.258)
Δ lnPOP	0.960 (2.137)
C	0.065** (0.018)
Observations	72
Wald chi2 (4)	113.62***
R-squared – Overall	0.527
Note: At the 1 percent, 5 percent, and 10 percent levels, ***, **, and * de significance	

4.9 Model Interpretation

On the basis of estimation results, through the results of data processing using regression analysis, as shown in Table 4.9, a regression equation for the influence of tourism, real GDP per capita, energy intensity, and population size on carbon emissions can be formed as follows:

$$\Delta \mathbf{Y} = \Delta \mathbf{0.065} - \Delta\, \mathbf{0.215}\, X_1 + \Delta\, \mathbf{0.401}\, X_2 + \Delta \mathbf{1.128} X_3 + \Delta \mathbf{0.960}\, X_4 + \mathbf{e}$$

Based on the Equation above, the regression coefficient for each independent variable can be interpreted as follows:

a. The relationship between tourism and carbon emissions is negative. The coefficient indicates that a 1% increase in the change of tourism arrivals is associated with a 0.215% decrease in the change of carbon emissions, assuming that real GDP per capita, energy intensity, and population size remain constant.
b. The relationship between real GDP per capita and carbon emissions is positive. The coefficient indicates that a 1% increase in the change of real GDP per capita is associated with a 0.401% increase in the change of carbon emissions, assuming tourism, energy intensity, and population size remain constant.
c. The relationship between energy intensity and carbon emissions is positive. The coefficient indicates a 1% increase in the change of energy intensity is associated with a 1.128% increase in the change of carbon emissions, assuming tourism, real GDP per Capita, and population size remain constant.
d. The relationship between population size and carbon emissions is positive. The coefficient indicates a 1% increase in the change of population size is associated with a 0.960% increase in the change of carbon emissions, assuming tourism, real GDP per capita, and energy intensity remain constant.
e. The constant value of 0.065 means that, on average, the carbon emissions is expected to increase by 0.065 units even if there is no change in the independent variables.

The coefficient of determination (R-squared) indicates the proportion of variance in the dependent variable explained by the independent variables. The overall R-squared value is 0.527, showing that tourism, real GDP per capita, energy intensity, and population collectively account for 52.70% of the variance in carbon emissions. Factors outside the scope of this study influence the remaining 47.30% of the variance.

4.10 Hypothesis test

Next, hypothesis testing was carried out to prove whether tourism arrivals, real GDP per capita, energy intensity, and population significantly influenced the carbon emissions of ASEAN economies during the 2010-2019 period. Hypothesis testing starts with simultaneous testing and partial testing.

1. The simultaneous effect of tourism, real GDP per capita, energy intensity, and population on carbon emissions

   The Wald Chi2 statistic is used to determine whether the independent variables simultaneously significantly affect the dependent variable. The joint testing aims to prove whether tourism, real GDP per capita, energy intensity, and population size together considerably impact the carbon emissions of ASEAN countries during the 2010 - 2019 period with the following statistical hypothesis formulation

   H_{01}: b1, b2, b3, b4 : Tourism, real GDP per capita, energy intensity, and population size did not significantly affect the carbon emissions of ASEAN countries from 2010 to 2019.

   H_{0a}: b1, b2, b3, b4 ; Tourism, real GDP per capita, energy intensity, and population together significantly affected ASEAN countries' carbon emissions from 2010 to 2019.

   The Wald Chi2 statistic was obtained through the Stata equation output in Table 4.8 to test the hypothesis above. It can be seen that the Wald chi2 value is 113.62 with a significance value of 0.000., So, at a significance level of 5%, it was decided that H_0 should be rejected and Ha accepted. This means that at a confidence level of 95%, it can be inferred that tourism, real GDP per capita, energy intensity, and population have a simultaneous and significant impact on the carbon emissions of ASEAN countries from 2010 to 2019.

2. The partial effect of tourism, real GDP per capita, energy intensity, and population on carbon emissions

   The probability of the t-statistical test is used to test whether or not tourism, real GDP per capita, energy intensity, and population have a significant impact on carbon emissions. Therefore, the researcher sets a hypothesis with the following statistical hypothesis formulation:

a. The effect of tourism on carbon emissions

H_o: $\beta_2 \leq 0$ Tourism does not significantly induce carbon emissions in ASEAN countries during the 2010-2019 period.

H_a: $\beta_2 > 0$ Tourism significantly induces carbon emissions in ASEAN countries during the 2010-2019 period.

Table 4.8 displays the calculated coefficient and probability value for the tourism variable as -0.215 and 0.020, respectively. Given that the probability value is below the 5% significance level, we reject the null hypothesis. However, the negative coefficient indicates that, contrary to the hypothesis, the tourism sector has had a substantial impact in reducing carbon emissions in ASEAN countries from 2010 to 2019, rather than inducing them.

b. The effect of real GDP per capita on carbon emissions

H_o: $\beta_2 \leq 0$ Real GDP per capita did not lead to a significant increase in carbon emissions in ASEAN countries during the 2010-2019 period.

H_a: $\beta_2 > 0$ Real GDP per capita led to a significant increase in carbon emissions in ASEAN countries from 2010 to 2019.

Table 4.8 displays the data processing findings, revealing that the coefficient and probability value for the real GDP per capita variable are 0.401 and 0.000, respectively. Given that the probability value of the real GDP per capita variable is below 5% (significance level), the decision was made to reject the null hypothesis (Ho) and accept the alternative hypothesis (Ha). Therefore, real GDP per capita contributed to a significant increase in carbon emissions in ASEAN countries from 2010 to 2019.

c. The effect of energy intensity on carbon emissions

H_o: $\beta_3 \leq 0$ Energy intensity does not lead to significantly increased carbon emissions in ASEAN countries during the 2010-2019 period.

H_a: $\beta_3 > 0$ Energy intensity leads to significantly increased carbon emissions in ASEAN countries during the 2010-2019 period.

Table 4.8 displays the data processing findings, revealing that the energy intensity variable has a coefficient of 1.128 and a probability value of 0.002.

Given that the probability value of the energy intensity variable is less than 5% (significance level), the decision was made to reject the null hypothesis (Ho) and accept the alternative hypothesis (Ha). Therefore, there was a significant rise in carbon emissions in ASEAN countries throughout 2010-2019 due to energy intensity.

d. The effect of population size on carbon emissions

This hypothesis test is used to test whether population size positively correlates with carbon emissions. Therefore, the researcher sets a hypothesis with the following statistical hypothesis formulation:

$H_o: \beta_4 \leq 0$	Population size does not lead to significantly increased carbon emissions in ASEAN countries during the 2010-2019 period
$H_o: \beta_4 > 0$:	Population size leads to significantly increased carbon emissions in ASEAN countries during the 2010-2019 period

Table 4.9 displays the data processing results, revealing that the population size variable has a coefficient value and probability value of 0.960 and 0.665, respectively. Given that the probability value of the population size variable is higher than 5% (significance level), the decision was made to accept the null hypothesis (Ho) and reject the alternative hypothesis (Ha). Therefore, population size has a statistically insignificant positive effect on the carbon emissions of ASEAN countries during the period 2010-2019.

4.11 Discussion and Analysis

a. The effect of tourism on carbon emissions

The panel data analysis using a Random Effect Model (REM) for the research model reveals the influence of tourism on carbon emissions is -0.215 and significant at a 5% significance level (prob. 0.020 $<$ 5%), indicating that a 1% increase in the change of tourist arrivals is associated with a 0.215% reduction in the change of carbon emissions in ASEAN countries during the 2010-2019 period. This finding appears to contradict the established trend in tourism research, where tourism is often associated with increased carbon emissions from Chishti et al. (2020), Akadiri et al. (2020), Katircioglu (2014), Ghosh et al. (2022), Shi et al., (2020), Rasoolimanesh et al., (2023), Paramati et al., (2017), Katircioglu and Katircioglu (2022), Işik et al. (2017), Erdoğan et al. (2022), Cevik (2022), León et al. (2014), Balsalobre-Lorente et al. (2023), and Sharif et al., (2017). However, this negative relationship is consistent with prior research conducted by S. Katircioglu et al. (2018), Kongbuamai et al. (2020), Tong et al. (2022), Lee & Brahmasrene (2013), Ben Jebli et al. (2019), Ozcan et al (2021) and partially with Koçak et al. (2020) and Sghaier et al. (2019).

The role of Ecotourism and cultural tourism with a lower carbon footprint, which are dominant in the ASEAN region according to Table 4.1, plays a significant contribution to this relationship. Conceptually, ecotourism has a low footprint because its segmentation focuses on environmental sustainability, which aspires to protect the environment with more energy efficiency and renewable energy use (Ben Jebli et al., 2019). Ecotourism emphasizes sustainability, conservation, and minimal environmental impact, which can explain the reduction in carbon emissions despite increased tourist activity. Countries like Thailand and Malaysia have implemented effective ecotourism policies that promote environmental stewardship. In the rural tourism area, the government of Malaysia have constructed responsible rural tourism governance frameworks adopting ecological modernization principles such as installing Solar panels in the Belum-Temengor forest area and Sabah (Nair et al., 2020). The rise of ecotourism aligns with the global shift towards environmentally conscious travel (B. Ozcan et al., 2021).

Another perspective tourism sector, Tourism, considered a part of the service industry, is widely acknowledged to have a lower environmental impact compared to the industrial and agricultural sectors (Koçak et al., 2020; Bilgili et al., 2016; Simmons, 2013). This finding aligns with the underpinning theory that being a part of the service sector, the tourism industry in ASEAN is less polluting than the industrial sector. Hence, It plays a role in enhancing environmental quality (G. Grossman & Krueger, 1991).

Furthermore, according to Bilgili et al. (2017), land-use changes lead to deforestation and are the second largest contributor to emissions increases, following fossil fuel consumption. Forest Cover is one proxy for land-use change. In fact, in ASEAN, there was insignificant forest cover loss from 2010 to 2019. Several ASEAN countries, such as Vietnam and Indonesia, participate in REDD+ as a part of their Climate Change policy (Pham et al., 2021). In 2017, Cambodia also released its National REDD+ Strategy REDD+ Strategy as a part of its contribution to national and global climate change mitigation by improving the management of its natural resources and forest lands. Many tourists visit the ASEAN region due to its rich biodiversity, cleanliness, and wild beauty. Maintaining the environmental absorptive capacity of the natural environment to absorb carbon dioxide helps to mitigate the emissions from tourism activities, especially transportation. As destinations with substantial forest cover, the role of forest is vital to offset carbon emissions (Waheed et al., 2018), leading to a net reduction or stabilization of overall carbon emissions despite higher tourist numbers.

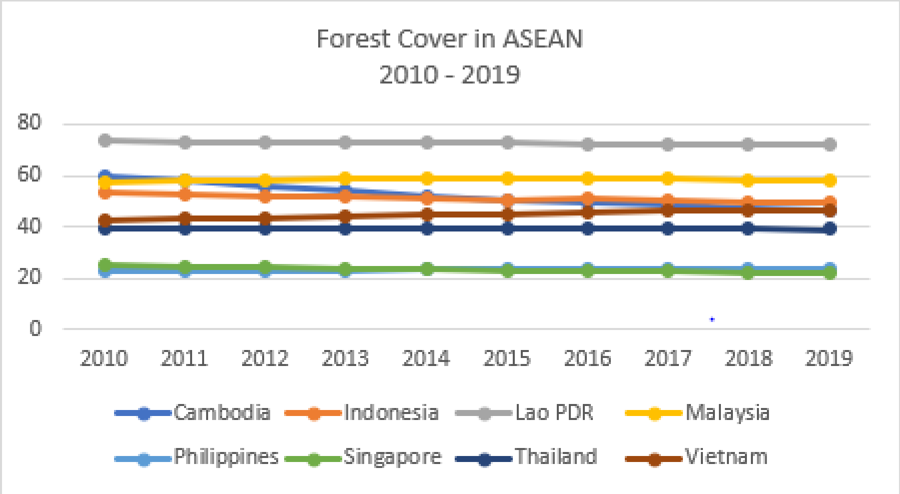

Figure: 4.8 Forest Cover in ASEAN 2010 – 2019
Source: WDI (2024)

According to Paramati et al. (2018), well-managed tourism can aid in environmental protection by encouraging the adoption of eco-friendly technologies and transportation methods. Improvements such as the addition of more lanes, the use of better road surfaces, the expansion of road width for safety, and the implementation of rail transit can effectively decrease CO2 emissions by reducing fuel use (Koçak et al., 2020). Efficient and comprehensive Infrastructure is essential for the effective operation of the economy. The development of Infrastructure is anticipated to enhance accessibility, boost regional competitiveness, and facilitate the timely integration of domestic and international markets with competitive costs (Husin et al., 2020). An effective transport infrastructure is essential for unlocking the productivity improvements that are the foundation of a destination's future prosperity.

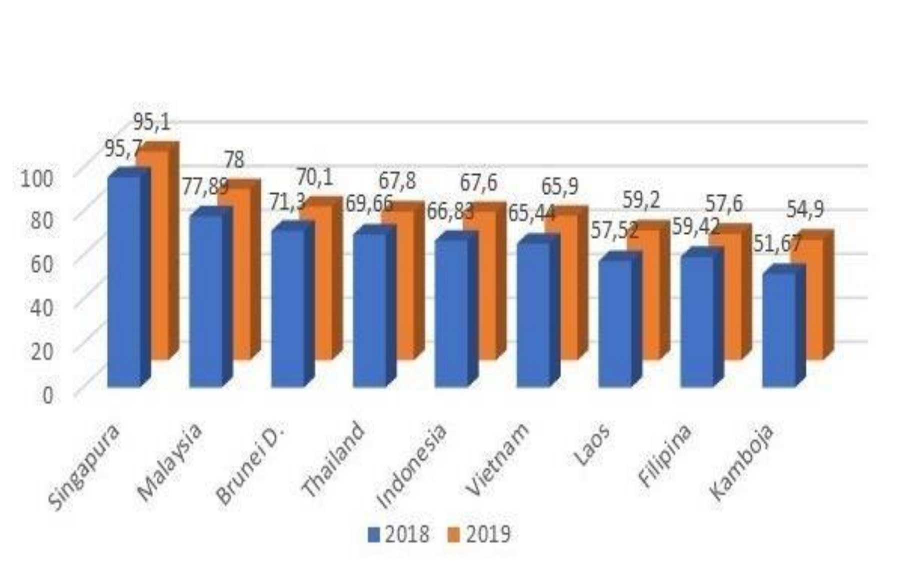

Figure 4.9: ASEAN Country Infrastructure Competitiveness Ranking Score 2019
Source: Husin et al. (2020)

According to Dwyer et al. (2020), tourism development and transportation are complementing each other. Countries like Singapore, Malaysia, and Thailand have the most competitive infrastructure, and they are among the top three most visited tourism destinations in ASEAN countries. New technologies in surface, maritime, and aviation transportation help carry people and goods more quickly, safely, and efficiently to and from destinations.

According to the Ecological argument, economic development and environmental protection can be complementary. Technological innovations and structural changes can lead to more efficient resource use and reduced environmental impact. As we can see in Figure 4.6, the statistics of energy intensity in ASEAN countries like Thailand, Malaysia, Singapore, and Indonesia show that there is a decrease in their energy intensity profile despite the significant increase in the number of international tourists. Technological advancements help reduce the depletion of natural resources, lower carbon footprints and enhance economic prosperity (M. Ahmad & Wu, 2022). Technical development has a crucial role in promoting sustainability in both industrialized and emerging economies (Ren et al., 2022; Sadik-Zada, 2021). Moreover, technical advancements facilitate the shift towards renewable energy sources, promoting low-carbon growth and fostering sustainable ecosystems (Jabeen et al., 2024).

Sustainable Development Theory posits that development should meet the needs of the present without compromising the ability of future generations to meet their own needs. In the context of tourism, this theory emphasizes the balance between economic growth, environmental protection, and social equity. Since 2015, the government of Indonesia has implemented sound policies by adopting global sustainable tourism certification, which has contributed to the observed negative correlation between tourism arrivals and carbon emissions. This certification also signals environmental stewardship by industry players and the government, attracting tourists while promoting environmental sustainability. Research by Bhattacharya et al. (2018) suggests that such policies can increase awareness about environmental protection.

A previous study from Azam et al. (2018) also observed the negative relationship between tourism and carbon emissions in Thailand is bolstered by strong community initiatives and high awareness about sustainable tourism. Green Leaf Foundation, Pacific Asia Tourism Association (PATA), Asian Ecotourism Network and Agoda are among the players in the Thailand tourism industry that have voluntarily adopted global sustainable tourism certification since 2010. Furthermore, ecotourism destinations like Phuket and Chiang Mai, which are known for their hospitality, are situated far from heavily polluted areas, enhancing their appeal to environmentally conscious tourists.

Singapore is another country that promotes sustainable tourism. Although Singapore does not implement a national-scale sustainable tourism policy like Indonesia, it has embraced ecological modernization in energy and waste management. According to Azam et al. (2018), there is anecdote fact in Singapore. The country implemented a massive initiative to decorate the country with gardening and planting more flora and fauna. Singapore is famous as a garden city after decades of planning and cultivation (Azam et al., 2018). Therefore, the earnings from the tourism industry are utilized to improve environmental quality in Singapore (Azam et al., 2018), a recent example coming from Grand Hyatt Singapore. Since 2010, they have been implementing various sustainable initiatives to protect the planet for future generations.

Furthermore, Malaysia promotes urban and cultural tourism. Azam et al. (2018) found a positive relationship between tourism and carbon emissions in Malaysia using data from before the 2015 Paris Agreement (COP21). However, since 2015, Malaysia has observed a decline in energy intensity despite a notable rise in the number of international tourists. Li et al. (2018) confirmed that technological progress and environmental regulation shape how the tourism sector reacts to ecological challenges, promoting more efficient energy processes. These technological developments have contributed to the observed negative relationship between tourism arrivals and carbon emissions in Malaysia in recent years.

Vietnam is one of the most popular destinations for ecotourism and cultural tourism. According to F. Ahmad et al. (2018), the correlation between tourism and carbon emissions in Vietnam is negative. This negative correlation between tourism arrivals and carbon emissions in ASEAN countries can be attributed to the successful implementation of community-based tourism (CBT) policies, which focus on local community involvement in tourism development, prioritizing rural areas and nature-based activities. This approach not only improves livelihoods but also reduces the carbon footprint by limiting the use of private vehicles compared to mass tourism (Phi & Pham, 2022 & Doan, 2018).

Robust ecotourism initiatives, a modest number of tourists, extensive forest cover, and a substantial reliance on renewable energy underpin the negative correlation between tourism and carbon emissions in Laos. Laos actively promotes community-based tourism (CBT) within its tourism sector, exemplified by initiatives aimed at integrating local communities into tourism activities. The country attracts international tourists drawn to its offerings of cultural immersion, natural beauty, adventure opportunities, and a serene Southeast Asian experience. Luang Prabang stands out as one of Laos' premier tourism destinations. Despite these attractions, Laos registers as the least visited country in the region, potentially influenced by limited marketing efforts and investment in tourism infrastructure.

Strong ecotourism initiatives, low carbon emissions per capita, a low number of tourists, substantial forest cover, and a high proportion of renewable energy consumption bolster the negative relationship between tourism and carbon emissions in Cambodia. Cambodia actively promotes community-based tourism (CBT) through platforms like MlupBaitong, which exemplifies how ecotourism can foster environmental stewardship and support local livelihoods (Nair et al., 2020). The country appeals to international tourists seeking cultural immersion, natural beauty (including the iconic Angkor archaeological site), adventure, and a peaceful Southeast Asian escape. Despite these attractions, Cambodia faces challenges, such as relatively low visitor numbers compared to regional peers, possibly due to insufficient infrastructure and marketing efforts. However, Cambodia's economic activities, including tourism, benefit from significant forest cover and robust renewable energy use, which contribute to mitigating carbon emissions and promoting sustainable practices.

The Philippines is renowned for its ecotourism attractions. According to F. Ahmad et al. (2018), the correlation between tourism and carbon emissions in the Philippines is positive, based on data from 1995 to 2014. Despite this, the country remains attractive due to its beautiful beaches, hospitality, and rich cultural experiences. Palawan Island, the most visited spot, is situated far from heavily polluted areas such as Taguig City and Makati City in Metro Manila. Furthermore, the Philippines hosts a modest number of international tourists and maintains low carbon emissions per capita and low energy intensity.

b. The effect of real GDP per capita on carbon emissions

The panel data analysis using a Random Effect Model (REM) for this second model reveals the effect of economic growth is 0.401 and significant at a 5% significance level (Prob. 0.002 < 5%), indicating that a 1% increase in the change of real GDP per Capita is expected to induce the change in carbon emissions per capita by 0.401 % in ASEAN countries during the 2010-2019 period. This expected finding aligns with the established hypothesis that economic growth with a strong reliance on fossil fuel for energy generation leads to intensive production of carbon emissions especially from agriculture and industrial sectors as the key economic activities in the region (Haini, 2021). This result aligns mostly with previous research conducted by Shaheen et al. (2019), Kongbuamai et al. (2020), Koçak et al. (2020), Akadiri et al. (2020), Balsalobre-Lorente et al. (2023), and Lee & Brahmasrene (2013). In ASEAN, rapid economic development leading to increased industrial activity, transportation needs, and energy consumption primarily sourced from non-renewable energy contributes significantly to carbon emissions.

Extensive economic development, often propelled by tourism, can intensify energy consumption and escalate carbon emissions (WEF, 2012; 2019). In ASEAN, the path toward sustainability in the tourism sector needs to be followed by its supporting sector, particularly transportation, an energy-intensive industry. The transportation sector contributes significantly to human development and carbon emissions in ASEAN. According to Haini (2021), in ASEAN, the impact of GDP per capita on carbon emissions within the transportation sector is the highest compared to other industries such as manufacturing and residential. The transportation sector, the backbone of the tourism industry, was probably responsible for 29% of the world's carbon emissions in 2019 (EPA, 2019). Erdoğan et al. (2022) proposed that incorporating environmentally friendly technology into the transportation industry plays a vital role in decreasing carbon emissions.

For ASEAN countries, achieving carbon neutrality while maintaining economic growth is a critical challenge. Vietnam, for instance, will still prioritize economic development over decarbonization efforts (Fallin et al., 2023). However, there is a growing interest in the circular economy (CE) within the region; some countries, like Cambodia and Laos, have started embracing a circular economy and investing in renewable energy. This step is critical to anticipate the economic expansion and urbanization that have accelerated resource consumption and waste generation in many ASEAN countries (Herrador & Van, 2024). Likewise, their neighbour, Thailand, has introduced "Thailand 4.0, a part of its economic development strategy that emphasizes resource efficiency and waste reduction, aligning with CE principles. Adopting CE practices has become crucial to safeguarding natural resources and ecosystems while maintaining economic growth.

c. The effect of energy intensity on carbon emissions

The panel data analysis using the Random Effect Model (REM) for this model reveals the effect of energy intensity on carbon emissions is 1.128 and significant at the 5% significance level (prob.0.000 < 0.05) in ASEAN countries during the period 2010–2019. This finding indicates that a 1% increase in the change of energy intensity is expected to induce the change in carbon emissions, supporting the hypothesis that higher energy consumption relative to economic output leads to heightened carbon emissions. These results align with previous research conducted by Xu et al. (2022), Luo et al. (2020), Khan et al. (2024), Koçak et al. (2020), and Paramati et al. (2017). Energy intensity is a crucial indicator of technological efficiency (Koçak et al., 2020), with higher values suggesting lower efficiency and more significant carbon emissions per unit of economic activity.

Furthermore, Rudiany et al. (2023) suggested that integrating energy culture is critical to sustainable tourism. This would address the environmental, economic, and social aspects of tourism practices and mitigate the environmental impact of energy consumption. Rudiany et al. (2023) argued that ASEAN countries often face challenges of resource exploitation, particularly in countries with poor environmental performance. In order to achieve sustainability, the integration of energy culture is inevitable to achieve resource efficiency.

For climate change mitigation, F. Bilgili et al. (2021) suggested that the government should prioritize promoting emerging technologies that can significantly reduce carbon emissions by transitioning from fossil fuels to renewable energy sources in many sectors, such as transportation/aviation, accommodation, air conditioning, heating, lighting, laundry, and telecommunication.

Furthermore, Huang et al. (2023) emphasize that digitization has a substantial impact on reducing energy intensity and offering innovative approaches to energy management in the pursuit of carbon neutrality objectives. He determined that technical advancement, optimization of energy structure, and enhancement of energy efficiency should be regarded as primary outcomes of the process of digitalization. The equivalent suggestions can be drawn for the management of energy in emerging economies during the early phases of digital economy advancement.

d. The effect of population size on carbon emissions

The panel data analysis using the Random Effect Model (REM) for this second model reveals the effect of population size on carbon emissions is 0.960 and insignificant at the 5% significance level (prob.0.665 > 0.05) in ASEAN countries during the period 2010–2019. According to ecological modernization theory, population development must keep up with the ecosystem's carrying capacity and productive forces. Based on descriptive statistics of population size (figure 4.7), ASEAN countries are implementing measures to curb population growth in order to mitigate the impact of increased production and consumption of goods and services on climate change and global warming (Ozpolat et al., 2021). The positive correlation between population and carbon emissions aligns with previous study conducted by Paramati et al. (2017).

4.12 Robustness check

According to Lu & White (2014), robustness tests serve two important purposes: they enhance trust in the statistical analysis results and bolster the basis for making well-informed and impactful policy decisions in intricate economic situations. Firstly, this research conducted a robustness test using several statistical models consisting of the Fixed Effect Model (FEM) and Pool OLS (see Table 4.13). Overall, the robustness checks by comparison with the Fixed Effect Model (FEM) and Pool OLS confirmed the consistency of our primary findings using the Random Effect Model (REM).

Table 4.9 Robustness Check (Model Comparison)

Dependent Variable: CO2

	REM		FEM		POOL OLS	
	DK Coeff. (Std. Err)	Coeff. (Std. Err)	DK Coff. (Std. Err)	Coeff. (Std. Err)	DK Coeff. (Std. Err)	Coeff. (Std. Err)
Δ lnITA	-0.215** (0.074)	-0.215 (0.139)	-0.261** (0.089)	-0.261* (0.146)	-0.074 (0.062)	-0.074 (0.143)
Δ lnGDPC	0.401*** (0.047)	0.401** (0.194)	0.348*** (0.096)	0.348* (0.200)	0.545*** (0.087)	0.545 (0.206)
Δ lnEI	1.128*** (0.258)	1.128*** (0.135)	1.101*** (0.213)	1.101*** (0.137)	1.205*** (0.278)	1.205 (0.153)
Δ lnPOP	0.960 (2.136)	0.960 (2.876)	0.499 (1.201)	0.499 (3.427)	1.826 (2.132)	1.826 (2.312)
C	0.065** (0.019)	0.065 (0.042)	0.076*** (0.016)	0.076* (0.044)	0.039 (0.024)	0.039 (0.034)
Observations	72	72	72	72	72	72
Wald chi2 (4)	113.62	82.10				
Prob > chi2	0.000***	0.000***				
R-squared-Overall	0.527	0.527		0.516	0.54	0.54
F stat.			62.56	19.22	19.98	19.67
Prob > F			0.000***	0.000***	0.0003***	0.000***
Within R-squared		0.560	0.562	0.562		
Between R-squared		0.521		0.469		

Note: At the 1 percent, 5 per cent, and 10 per cent levels, ***, **, and * denote significance. DK: Driscoll Kraay

Source: Data Processing Results from STATA 14

Secondly, to see how reliable the study's results are, we looked again at how tourism development affected carbon emissions in each country, adding some variables to show how these variables influence the relationship: trade openness (trade), mobile penetration (mobile), voice and accountability (VA), and dummy variables to highlight the dynamic condition at the country level. The country's classification will be determined by income per capita (IC) and geographical location (GMA stands for countries located in the Greater Mekong Area) using the random effects model (REM).

Table 4.10 Robustness Check (With Dummy and Variable additions)		
Dependent Variable: CO2		
	REM	REM (With Variable Addition)
	DK Coeff. (Std. Err)	DK Coff. (Std. Err)
Δ lnITA	-0.215** (0.074)	-0.270** (0.106)
Δ lnGDPC	0.401*** (0.047)	0.420*** (0.089)
Δ lnEI	1.128*** (0.258)	0.914*** (0.147)
Δ lnPOP	0.960 (2.136)	2.653 (1.557)
Δ lnTrade		-0.365 (0.207)
Δ lnMobile		-0.197* (0.105)
Δ lnVA		0.054 (0.049)
GMA		0.072*** (0.019)
IC		-0.080*** (0.016)
C	0.065** (0.019)	0.049 (0.029)
Observations	72	69
Wald chi2 (4)	113.62	556.37
Prob > chi2	0.000***	0.000***
R-squared- Overall	0.527	0.727
Note: At the 1 percent, 5 per cent, and 10 per cent levels, ***, **, and * denote significance. DK: Driscoll Kraay Source: Data Processing Results from STATA 14		

Trade openness is a proxy for the inclination of economies towards globalization (Zafar et al., 2019); mobile penetration is a proxy for ICT readiness; and voice and accountability are a proxy for governance quality. All selected variables and dummies take into account the multicollinearity aspect. For income per capita classifications, the dummy (1) is assigned to upper-middle-income countries during 2010–2019, which consist of Malaysia, Thailand, and Singapore, while 0 is assigned to lower-middle-income countries, which consist of Cambodia, Indonesia, Laos, the Philippines, and Vietnam. For geographical area classification, the dummy (1) is assigned to Mainland Southeast Asian countries as well as the members of the Greater Mekong Subregion (GMS) during 2010–2019, which consists of Cambodia, Thailand, Laos, and Vietnam, while 0 is assigned to Maritime Southeast Asian countries, which consist of Indonesia, Malaysia, the Philippines, and Singapore. Overall, the result of robustness checks by adding more variables confirmed the consistency of our primary findings that the relationship between tourism development and carbon emissions was negative during 2010–2019. Trade openness tends to provide opportunities for environmental improvement, such as technology spillover (Zafar et al., 2019); ICT tends to reduce emissions because it optimizes environmental management and contributes to dematerialization in broad industrial sectors (Haini, 2021); and voice and accountability tends to increase energy consumption patterns due to better living standards, which ultimately increase carbon emissions. Based on income per capita classifications, the upper-middle-income groups are less polluting than the lower-middle-income group and this group is the most attractive destination for international tourists during 2010-2019. Lastly, according to geographical classifications, the mainland southeast Asian countries are more polluting than the maritime southeast Asian countries, probably due to its economic structure and lower energy efficiency.

CHAPTER V

CLOSING

5.1 Conclusion and Policy Recommendations

For several decades, the tourism sector has played a pivotal role in driving economic growth across ASEAN economies in the last decades. A significant number of international tourists would need a significant amount of energy and resources. The important forest cover assisted the region in absorbing emissions and wastes from economic activities, including tourism activities. This study employs an empiric investigation about the impact of tourism on CO2 emissions using panel data from Southeast Asia, covering the period from 2010 to 2019. To address the issue of cross-sectional dependence, we employed the Driscoll-Kraay standard of error on the chosen random effect model.

The result of the study affirms that inbound tourism contributes to carbon emissions reduction through sustainable practices such as ecotourism, sustainable tourism and cultural tourism initiatives. These nature-based tourism activities play a crucial role in safeguarding ASEAN's forests while promoting biodiversity and natural beauty. The present study also found real GDP per capita and energy intensity have a positive correlation to carbon emission. International tourists prefer destinations with less polluting destinations in ASEAN because they are looking for sustainable destinations with highly efficient and comprehensive infrastructure.

The study's empirical findings indicate some policy recommendations. First, ASEAN countries must uphold or enhance the sustainability of their tourism destinations to entice international tourists. Second, ASEAN countries should promote green infrastructure development and eco-friendly technology, which can not only attract more international tourists but also lower their carbon footprint. Third, ASEAN countries should maintain the sustainability of forests to maintain their absorptive capacity and attract foreign tourists.

Countries can further support the Glasgow Declaration on Climate Action in Tourism by implementing similar national policies, including measuring CO2 emissions, setting decarbonization targets, and collaborating through geographical or sectoral networks. These efforts will significantly contribute to developing the tourism sector while mitigating its negative environmental impacts.

Specific recommendations also consider the differences between the ASEAN countries. Among these, three are upper-middle-income countries (Singapore, Malaysia, Thailand), and five are lower-middle-income countries (Indonesia, Vietnam, Philippines, Cambodia, and Lao PDR). Developed countries can attract more tourists by using sustainable tourism as a competitive advantage. Developing countries that have more diverse and attractive tourism destinations could do the same as long as they can work on the improvement in environmental quality supported by green infrastructure, international openness, and technological advancement.

In conclusion, tailored, comprehensive and integrated sustainable tourism policies will make the ASEAN region the first option for international tourists seeking an eco-friendly tourism destination and bring more prosperity into the area.

5.2 Research Limitations

This study has several limitations:

1. Data Availability: The research relies on data from the World Development Indicators spanning 2010-2019. This timeframe might not capture recent trends in tourism, economic growth, or carbon emissions in ASEAN countries. Specifically, the exclusion of data from the COVID-19 era (2020-present) may underestimate the recent impact of travel restrictions on tourism-related carbon emissions. Additionally, more recent data could reveal shifts in tourist behaviour towards eco-friendly travel options, potentially influencing carbon emissions. Since 2019, some ASEAN countries may have implemented environmental sustainability policies that could affect the relationship between tourism and carbon emissions.
2. Variable Selection: The study could be enhanced by incorporating new variables and new methods that directly measure carbon emissions at tourism destinations and energy intensity at the industrial level. This would provide a more nuanced understanding of the tourism sector's environmental impact.
3. Proxy for environmental impact: Future study could incorporate other variables to measure environmental impact of tourism development such as GHG emissions (N_2O and CH_4) and Air pollutants (SO2, CO, NO_2, PM2.5). This would provide a more nuanced understanding of the tourism sector's environmental impact.
4. Environmental Sustainability: A future study could incorporate additional variables to measure the environmental sustainability performance of tourism development in ASEAN because WEF (World Economic Forum) uses several indicators, not only carbon emissions or GHG emissions, as a proxy for environmental sustainability. In

2021, it used indicators such as renewable energy share, forest cover loss, investment in green energy and infrastructure, number of environmental treaty ratifications, waste water treatment, and several more variables. This would provide a more nuanced understanding of why the tourism sector in ASEAN did not achieve environmental sustainability in the WEF’s Travel and Tourism Development Index (2021).

5. Methodological Considerations: Future research could employ more sophisticated econometric methods, such as the Two-Stage Least Squares (2SLS) model and the Generalized Method of Moments (GMM), to address potential endogeneity issues among variables. These methods could offer more robust insights into the causal relationships between tourism, economic growth, and carbon emissions.

By acknowledging these limitations, this study sets the stage for future research to build upon its findings and contribute to a more comprehensive understanding of the interactions between tourism development and environmental sustainability in ASEAN countries.

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APPENDIXES

	Output

Appendix 1 Correlation matrix

	ITA	GDPC	POP	EI
ITA	1.0000			
GDPC	0.6594	1.0000		
POP	0.1789	-0.3155	1.0000	
EI	0.1962	-0.2703	-0.0137	1.0000

Appendix 2 Cross Sectional Dependence Test

. xtcd CO2

Average correlation coefficients & Pesaran (2004) CD test

Variables series tested: CO2

Group variable: ID
Number of groups: 8
Average # of observations: 11.43
Panel is: unbalanced

TEST Tuesday June 18 19:23:37 2024 Page 4

Variable	CD-test	p-value	corr	abs(corr)
CO2	5.97	0.000	0.357	0.652

Notes: Under the null hypothesis of cross-section independence CD ~ N(0,1)

xtcd GDPC

Average correlation coefficients & Pesaran (2004) CD test

Variables series tested: GDPC

Group variable: ID
Number of groups: 8
Average # of observations: 11.43
Panel is: unbalanced

Variable	CD-test	p-value	corr	abs(corr)
GDPC	4.49	0.000	0.268	0.629

Notes: Under the null hypothesis of cross-section independence CD ~ N(0,1)

xtcd ITA

Average correlation coefficients & Pesaran (2004) CD test

Variables series tested: ITA

Group variable: ID
Number of groups: 8
Average # of observations: 11.43
Panel is: unbalanced

Variable	CD-test	p-value	corr	abs(corr)
ITA	14.08	0.000	0.842	0.842

Notes: Under the null hypothesis of cross-section independence CD ~ N(0,1)

. xtcd EI

Average correlation coefficients & Pesaran (2004) CD test

Variables series tested: EI

Group variable: ID
Number of groups: 8
Average # of observations: 11.43
Panel is: unbalanced

Variable	CD-test	p-value	corr	abs(corr)
EI	0.91	0.361	0.055	0.411

Notes: Under the null hypothesis of cross-section independence CD ~ N(0,1)

```
. xtcd POP

 Average correlation coefficients & Pesaran (2004) CD test

 Variables series tested: POP
                                  Group variable: ID
                                Number of groups: 8
                      Average # of observations: 11.43
                                        Panel is: unbalanced

     Variable |   CD-test   p-value       corr   abs(corr)
   -----------+----------------------------------------------
          POP |     16.60     0.000      0.992      0.992
   ----------------------------------------------------------
 Notes: Under the null hypothesis of cross-section
        independence CD ~ N(0,1)
```

Appendix 3 Classical Assumtion Test

Normality

```
. swilk residuals

                   Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+------------------------------------------------------
   residuals |         71    0.99225      0.482    -1.587    0.94375
```

Heteroscedasticity

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of D.CO2

         chi2(1)      =    40.38
         Prob > chi2  =   0.0000
```

Autocorrelation

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(   1,        7) =     26.674
           Prob > F =      0.0013
```

Multicollinearity

```
 vif

    Variable |       VIF       1/VIF
-------------+----------------------
         ITA
         D1. |      1.07    0.934447
        GDPC
         D1. |      1.07    0.934535
          EI
         D1. |      1.04    0.965323
         POP
         D1. |      1.02    0.979315
-------------+----------------------
    Mean VIF |      1.05
```

Appendix 4 Common Effect Model (CEM)

```
. reg D.CO2 D.ITA D.GDPC D.EI D.POP

      Source |       SS           df       MS      Number of obs   =
-------------+----------------------------------   F(4, 67)        =     19
       Model |  .563228338         4  .140807084   Prob > F        =   0.0
    Residual |  .479555011        67  .007157537   R-squared       =   0.5
-------------+----------------------------------   Adj R-squared   =   0.5
       Total |  1.04278335        71  .014687089   Root MSE        =    .0

------------------------------------------------------------------------------
       D.CO2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interv
-------------+----------------------------------------------------------------
         ITA
         D1. |  -.0745187   .1430327    -0.52   0.604    -.3600131    .2109
             |
        GDPC
         D1. |   .5447394    .205845     2.65   0.010     .1338711    .9556
             |
          EI
         D1. |   1.204719   .1529473     7.88   0.000     .8994353    1.510
             |
         POP
         D1. |   1.825736   2.312922     0.79   0.433    -2.790877    6.442
             |
       _cons |   .0394526   .0339441     1.16   0.249       -.0283    .1072
------------------------------------------------------------------------------
```

Appendix 5 Fixed Effect Model (FEM)

```
. xtreg D.CO2 D.ITA D.GDPC D.EI D.POP, fe

Fixed-effects (within) regression               Number of obs     =         72
Group variable: ID                              Number of groups  =          8

R-sq:                                           Obs per group:
     within  = 0.5616                                         min =          9
     between = 0.4688                                         avg =        9.0
     overall = 0.5159                                         max =          9

                                                F(4,60)           =      19.22
corr(u_i, Xb)  = 0.1162                         Prob > F          =     0.0000

------------------------------------------------------------------------------
       D.CO2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ITA |
         D1. |  -.2614755    .1456675    -1.80   0.078    -.5528539    .0299028
             |
        GDPC |
         D1. |   .3476727    .2009301     1.73   0.089    -.0542474    .7495928
             |
          EI |
         D1. |   1.101446    .1365249     8.07   0.000     .8283559    1.374537
             |
         POP |
         D1. |   .4985727    3.427764     0.15   0.885    -6.357977    7.355122
             |
       _cons |    .075921    .0443062     1.71   0.092    -.0127046    .1645465
-------------+----------------------------------------------------------------
     sigma_u |  .05407429
     sigma_e |  .07338518

TEST  Thursday June 20 14:28:11 2024   Page 3

         rho |  .35189358   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(7, 60) = 4.15                       Prob > F = 0.0009
```

Appendix 6 Random Effect Model (REM)

```
. xtreg D.CO2 D.ITA D.GDPC D.EI D.POP

Random-effects GLS regression                   Number of obs     =         72
Group variable: ID                              Number of groups  =          8

R-sq:                                           Obs per group:
     within  = 0.5600                                         min =          9
     between = 0.5207                                         avg =        9.0
     overall = 0.5274                                         max =          9

                                                Wald chi2(4)      =      82.10
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
       D.CO2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ITA |
         D1. |  -.2147793    .1391175    -1.54   0.123    -.4874447     .057886
             |
        GDPC |
         D1. |   .4010238    .1942975     2.06   0.039     .0202077    .7818398
             |
          EI |
         D1. |   1.128239    .1352486     8.34   0.000     .8631571    1.393322
             |
         POP |
         D1. |   .9604582    2.876576     0.33   0.738    -4.677526    6.598443
             |
       _cons |   .0651007    .0420899     1.55   0.122    -.0173941    .1475954
-------------+----------------------------------------------------------------
     sigma_u |  .04816972
     sigma_e |  .07338518
         rho |  .30111734   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix 7
Hausman test

```
hausman fe re

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe           re          Difference          S.E.
-------------+----------------------------------------------------------------
         ITA |
         D1. |  -.2614755    -.2147793        -.0466962        .0431894
        GDPC |
         D1. |   .3476727     .4010238        -.0533511        .0511996
          EI |
         D1. |   1.101446     1.128239        -.0267932        .0186243
         POP |
         D1. |   .4985727     .9604582        -.4618855        1.864103
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        3.52
                Prob>chi2 =      0.4755
```

Appendix 8
Breusch-Pagan Lagrangian Multiplier Test

```
Breusch and Pagan Lagrangian multiplier test for random effects

        CO2[ID,t] = Xb + u[ID] + e[ID,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                     CO2 |   .9125764       .9552886
                       e |   .0195883       .1399583
                       u |   .1237854       .3518315

        Test:   Var(u) = 0
                             chibar2(01) =   127.23
                          Prob > chibar2 =   0.0000
```

Appendix 9
Random Effect Model with Driscoll Kraay standard error

```
. xtscc D.CO2 D.ITA D.GDPC D.EI D.POP, re
(8 missing values generated)

Regression with Driscoll-Kraay standard errors   Number of obs     =        72
Method: Random-effects GLS regression            Number of groups  =         8
Group variable (i): ID                           Wald chi2(4)      =    113.62
maximum lag: 2                                   Prob > chi2       =    0.0000
corr(u_i, Xb) = 0 (assumed)                      overall R-squared =    0.5274

------------------------------------------------------------------------------
             |             Drisc/Kraay
     __00000K|      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ITA |
         D1. |  -.2147793   .0740398    -2.90   0.020    -.3855154   -.0440433
             |
        GDPC |
         D1. |   .4010238   .0473862     8.46   0.000     .2917509    .5102966
             |
          EI |
         D1. |   1.128239    .258139     4.37   0.002     .5329699    1.723509
             |
         POP |
         D1. |   .9604582   2.136925     0.45   0.665      -3.9673    5.888216
             |
       _cons |   .0651007   .0197693     3.29   0.011     .0195125    .1106888
-------------+----------------------------------------------------------------
     sigma_u |  .04816972
     sigma_e |  .07338518
         rho |  .30111734   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix 10
Fixed Effect Model with Driscoll Kraay standard error

```
. xtscc D.CO2 D.GDPC D.ITA D.EI D.POP, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        72
Method: Fixed-effects regression                 Number of groups  =         8
Group variable (i): ID                           F(  4,        8)  =     62.56
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.5616
```

__00000K	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
GDPC D1.	.3476727	.0958855	3.63	0.007	.1265604	.568785
ITA D1.	-.2614755	.0893043	-2.93	0.019	-.4674116	-.0555395
EI D1.	1.101446	.2136213	5.16	0.001	.6088346	1.594058
POP D1.	.4985727	1.201656	0.41	0.689	-2.272451	3.269596
_cons	.075921	.0158706	4.78	0.001	.0393232	.1125187

Appendix 11
Common Effect Model with Driscoll-Kraay standard error

```
. xtscc D(CO2) D(ITA) D(GDPC) D(POP) D(EI)

Regression with Driscoll-Kraay standard errors   Number of obs     =        72
Method: Pooled OLS                               Number of groups  =         8
Group variable (i): ID                           F(  4,        8)  =     19.98
maximum lag: 2                                   Prob > F          =    0.0003
                                                 R-squared         =    0.5401
                                                 Root MSE          =    0.0846
```

__00000K	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
ITA D1.	-.0745187	.0621753	-1.20	0.265	-.2178952	.0688579
GDPC D1.	.5447394	.0876636	6.21	0.000	.3425869	.7468919
POP D1.	1.825736	2.131946	0.86	0.417	-3.090542	6.742013
EI D1.	1.204719	.2778345	4.34	0.002	.5640318	1.845407
_cons	.0394526	.0237749	1.66	0.136	-.0153724	.0942777

Appendix 12
Random Effect Model with Driscoll-Kraay standard errors (adding more variables)

```
Regression with Driscoll-Kraay standard errors   Number of obs     =        69
Method: Random-effects GLS regression            Number of groups  =         8
Group variable (i): ID                           Wald chi2(7)      =    556.37
maximum lag: 2                                   Prob > chi2       =    0.0000
corr(u_i, Xb) = 0 (assumed)                      overall R-squared =    0.7272
```

__00000K	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
ITA D1.	-.2705848	.1058259	-2.56	0.034	-.5146196	-.0265499
GDPC D1.	.4197034	.0894985	4.69	0.002	.2133194	.6260874
GMA	.0721262	.0190279	3.79	0.005	.0282477	.1160047
POP D1.	2.652719	1.557051	1.70	0.127	-.9378463	6.243285
EI D1.	.9137207	.1467702	6.23	0.000	.575268	1.252173
IC	-.0798129	.0159933	-4.99	0.001	-.1166934	-.0429323
TRADE D1.	-.3649689	.2074272	-1.76	0.117	-.8432969	.1133591
Mobile D1.	-.1966041	.1050463	-1.87	0.098	-.4388412	.045633
VA D1.	.0540341	.0485607	1.11	0.298	-.0579472	.1660153
_cons	.0491154	.0288879	1.70	0.128	-.0175001	.115731
sigma_u	0					