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Article

Tourism, economy, and carbon emissions in emerging South Asian economies: A dynamic causal analysis

Tulsi Paudel[1], Wen Ya Li[1], Thakar Dhakal[2,*]

[1] Entrepreneurial Management College, Sanming University, Sanming 365000, Fujian Province, China
[2] Department of Life Sciences, Yeungnam University, Gyeongbuk 38541, Republic of Korea
*** Corresponding author:** Thakar Dhakal, thakur_dhakal2003@yu.ac.kr

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Abstract: This study analyzes the dynamic relationships between tourism, gross domestic product (GDP) per capita, exports, imports, and carbon dioxide (CO_2) emissions in five South Asian countries. A VAR-based Granger causality test is performed with time series data from Bangladesh, India, Nepal, Pakistan, and Sri Lanka. According to the results, both bidirectional and unidirectional relationships among tourism, economic growth, and carbon emissions are investigated. Specifically, tourism significantly impacts GDP per capita in Pakistan, Sri Lanka, and Nepal, yet it has no effect in Bangladesh or India. However, the GDP per capita shows a unidirectional relationship with tourism in Bangladesh and India. The unidirectional causal relationship from exports and imports to tourism in the context of India and a bidirectional relationship in the case of Nepal. In Pakistan, it is observed that exports have a one-way influence on tourism. The result of the panel Granger test shows a significant causal association between tourism, economic growth, and trade (import and export) in five South Asian economies. Particularly, there is a bidirectional causal relationship between GDP per capita and tourism, and a significant unidirectional causal relationship from CO_2 emissions, exports, and imports to tourism is explored. The findings of this study are helpful for tourism stakeholders and policymakers in the region to formulate more sustainable and effective tourism strategies.

Keywords: environmental pollution; greenhouse gas; tourist arrivals; South Asia; sustainable tourism; vector auto-regression model

1. Introduction

The tourism industry has undergone significant transformations over the past few decades. Improved transportation, easy cross-border regulations, rising bilateral trade, and disruptive technology are key to shaping the modern tourism industry. This rapid growth in the tourism industry significantly contributes to the world's economy. The increasing number of arrivals and a surge in the variety of economic activities drive long-term economic growth (Wu and Wu, 2019). According to UNTWO (2017), tourism contributes to almost 10% of the world economy and generates sizable jobs worldwide. Due to the upward trajectory of international trade volume, more people travel worldwide for business purposes (Kulendran and Wilson, 2000). Despite the positive economic impact, tourism has become a central concern for environmental pollution and degradation. On one side, tourism extensively contributes to the economy, quality of life, and other aspects. On the flip side, the escalating pollution encompassing CO_2 emissions, plastic usage, noise, solid waste and littering, oil and chemicals, along with various other forms of pollution, raises concerns among people. According to Gössling et al. (2013), increasing tourism activities are key contributors

to greenhouse gases and other environmental deterioration. Suresh et al. (2018) also highlighted the need to balance economic benefits with environmental concerns while delving into the nexus between the economy, climate, and tourism.

South Asia, the focus of our research, is known for its cultural richness and diverse tourism attractions, positioning it as an emerging hub for travel (Timothy and Nyaupane, 2009). From the majestic Himalayas to the tranquil waters of the Indian Ocean and from centuries-old temples to bustling markets, this region attracts travelers worldwide. Tourists predominantly visit India to experience its cultural richness, explore historical monuments like the Taj Mahal and immerse in spirituality. Sri Lanka has been attracting more tourists than other nations, attributed to its pristine beaches, historical heritage sites, and wellness offerings. Bangladesh's diverse landscape, featuring forests and vibrant cultural attractions, is a tourist favourite. Pakistan's landscape features majestic mountains, while its historical significance and immersive cultural experiences captivate tourists. Nepal, renowned for its Himalayan treks, spiritual sites, and natural beauty, has undeniable appeal for adventure enthusiasts and nature lovers. Together, these countries present an extensive array of motivations for travelers, encompassing adventure, spirituality, culture, and the majesty of the natural world (Amin, 2021). Tourism has proven to be one of the key drivers of economic growth in the region, creating employment opportunities, boosting trade, and fostering cultural exchange. In 2019, the tourism sector in South Asia contributed 6.7% to the regional GDP, creating almost 48.05 million jobs (WTTC, 2022).

Despite its large geographic area and significant population, South Asia lags in international trade. According to The World Bank (2023b), intraregional trade accounts for barely 5% of South Asia's total trade, compared to Association of Southeast Asian Nations (ASEAN), where intraregional trade makes up 25%. However, economic growth in the region is expected to outpace that in other parts of the world (The World Bank, 2023a). Imports have consistently exceeded exports in the region, highlighting a trade imbalance in South Asian economies. India, the region's most populous and geographically largest country, boasts the highest economy and is a significant exporter and importer, followed by Bangladesh, Pakistan, Sri Lanka, and Nepal.

Although South Asia economically benefits from tourism, the region is replete with vulnerable landscapes, such as the Himalayas, rainforests, lowlands, and coral reefs, susceptible to climate change and global warming. There are already signs of adverse impacts of climate change, including flooding, landslides, glacier melting, rising sea levels, and droughts, and with the temperature rise, there is a risk to biodiversity, disrupting ecosystems and threatening wildlife. Given that tourism contributes significantly to carbon emissions, it is vital to maintain a low carbon footprint during tourism activities to conserve the region's biodiversity and vegetation. Nepal et al. (2019), in their study in the context of Nepal, explored that carbon emissions from tourism activities negatively impact the local environment. Similar studies have been conducted in Asian countries such as Bangladesh, India, Pakistan, and Sri Lanka, indicating the adverse effects of tourism on the respective atmosphere (Chisti et al., 2020; Jayasinghe and Selvanathan, 2021; Mehamood et al., 2021; Naradda Gamage et al., 2017; Sharif et al., 2017).

The trade-off between tourism and the environment has been a focal point for scholars investigating the nexus of the economy, climate, and tourism (Suresh et al., 2018; Zhang and Zhang, 2020). However, there is still a need for a more comprehensive multivariate investigation to address this complicated concern involving the environment, economy, and inbound tourism. Particularly in the South Asian region, it is imperative to conduct such studies since the region is expecting more arrivals and vibrant economic growth in the near future. With the susceptibility to climate change and the potential environmental impact of tourism, South Asia needs insights into sustainable practices that balance economic growth with environmental preservation. There is a need to explore the relationship to manage the impact of tourism on the environment for the sustainability of both tourism and the economy, with a lesser impact on the environment (Suresh et al., 2018).

Furthermore, the absence of prior studies examining the relationship between tourism and trade within the region emphasized the necessity of this study to fill this knowledge gap. Thus we aim to find the answer to the following research questions within the context of South Asia:

1) How do economic indicators, tourism, and environmental factors interact?
2) What is the relationship between tourism and trade (import and export)?
3) What are the strategic implications for formulating sustainable tourism practices?

To find the answers to the above questions, we have designed a research framework that explores the underlying relationship among tourism (in terms of tourist arrivals), economic growth (measured by GDP per capita), trade (import and export), and environmental impact (CO_2 emissions) by using the Granger causality test. This study represents the first attempt to examine the interaction between tourism and trade, specifically import and export activities within South Asian countries. The findings carry strategic implications, offering significant insights into the development of sustainable tourism practices within the economies of the South Asian region.

2. Review of literature

2.1. Tourism and economic growth

Researchers have extensively employed two hypotheses to scrutinize the relationship between tourism and economic growth—these are the tourism-led economic growth hypothesis (TLGH) and the economic-driven tourism growth hypothesis (EDTH) (Rasool et al., 2021). The TLGH consistently advocates positive and causal relationships between tourism and economic growth, asserting that tourism triggers economic growth (Balaguer and Cantavella-Jordá, 2002; Zuo and Huang, 2018). In contrast, the EDTH posits that economic growth within a region facilities more tourism activities, consequently increasing the influx of arrivals (Oh, 2005; Rasool et al., 2021).

Extensive research has been conducted on the relationship between tourism and economic growth; however, empirical findings often exhibit inconsistencies. Balaguer and Cantavella-Jordá (2002) examined historical GDP, tourism receipts, and exchange rates in Spain, establishing a unidirectional relationship between tourism and

economic growth. Similarly, several other studies reported the unidirectional impacts of tourism on economic growth in different countries: Mauritania (Durbarry, 2004), Turkey (Gunduz and Hatemi, 2005), Mexico (Sanchez Carrera et al., 2007), Taiwan (Chen and Chiou-Wei, 2009), and Greece (Eeckels et al., 2012). Additionally, scholars have observed the coexistence of both the TLGH and EDTH in various regions, such as Greece (Dritsakis, 2004), Taiwan (Kim et al., 2006), Malta (Katircioglu, 2009), Barbados (Lorde et al., 2011), and Tanzania (Odhiambo, 2011), suggesting a bidirectional causal linkage between tourism and economic growth.

Furthermore, researchers have employed panel data analyses targeting specific regions or groups of nations to investigate the association between tourism and economic growth. Lanza et al. (2003) examined data from 13 Organisation for Economic Co-operation and Development (OECD) countries, unveiling a one-way correlation between economic growth to tourism. Çağlayan et al. (2012), utilizing panel data encompassing 135 countries, examined the relationship between tourism and GDP growth. Their findings revealed a unidirectional link from tourism to GDP growth in the Americas, Latin America, and the Caribbean. However, they identified a causality from GDP growth to tourism in East and South Asia and Oceania.

Similarly, Eugenio-Martín et al. (2004) identified a unidirectional connection between tourism to economic growth in 21 Latin American countries. Consistent outcomes have emerged in studies in the context of Sub-Saharan African countries (Fayissa et al., 2008), Pacific Island nations (Narayan et al., 2010), and Mediterranean countries (Dritsakis, 2012). The bidirectional relationship between tourism and economic growth has also been subjected to panel data analysis within specific groups of countries. For instance, Lee and Chang (2008) observed a bidirectional affiliation between tourism and economic growth in non-OECD countries. Additionally, other researchers have identified similar findings by analyzing panel data from diverse groups of countries (Nissan et al., 2011; Seetanah, 2011; Apergis and Payne, 2012; Çağlayan et al., 2012).

Limited studies have explored the correlation between tourism and economic growth within South Asian countries. In the study of Khalil et al. (2007) of Pakistan, they established a bidirectional causal connection between tourism revenue and economic growth (GDP). Similarly, the causal relationship between tourism and economic growth was reported by Mishra et al. (2011) in an Indian, Srinivasan et al. (2012) in Sri Lankan, and Nepal et al. (2019) in a Nepalese context. These studies collectively point to a positive unidirectional causal relationship between tourism and the economic growth of the respective country, highlighting the support for the TLGH hypothesis.

Conversely, some research indicates a causative link between economic growth and tourism in South Asia, portraying an economic-driven growth model (EDTH). Adnan and Ali (2013) observed a unidirectional linkage between Pakistan's GDP per capita to tourism receipts. Likewise, Selvanathan et al. (2021) identified a comparable unidirectional causality from GDP to tourism in Bangladesh, India, and Nepal.

In analyzing panel data encompassing a group of South Asian nations, limited studies have investigated the relationship between tourism and economic growth. For instance, Mohapatra (2018), in inspecting historical data from the South Asian

Association for Regional Cooperation (SAARC) nations, revealed a bidirectional relationship between economic growth and tourism. However, the study by Çağlayan et al. (2012) reported a unidirectional causality from economic growth to tourism. Similarly, Selvanathan et al. (2021) examined the interaction between tourism and GDP, concluding that tourism has a positive causal relationship towards GDP growth. A recent study by Wahab et al. (2023) reported that GDP positively contributes to tourism development in the South Asian region. It is noteworthy that prior studies differ regarding variable selection and analytical approaches, which often leads to inconsistent and divergent findings. Our study employs a vector auto-regression Granger causality test to establish a connection between tourism (tourist arrivals) and economic growth (GDP per capita). With consideration of the results of the previous research, we hypothesize the positive causal relationship between tourist arrivals and economic growth in South Asian countries.

2.2. Tourism and international trade (import and exports)

Previous researchers have posited and confirmed a significant linkage between tourism and trade. Tourism and trade are linked, as evidenced by the movement of consumers engaged in imports and exports between the countries (Khan et al., 2005; Santana-Gallego et al., 2011). This linkage is obvious in globalization, where individuals often travel to specific countries to explore potential business opportunities leading to export and import transactions (Massidda and Mattana, 2013). There is evidence of nexus between business visits and imports, as since entrepreneurs seek to expand their markets and establish international business ties, they are compelled to visit the host country (Khan et al., 2005). Due to the increased international trade has fueled business travel between nations and has also triggered leisure travel by individuals returning to these nations, thereby contributing to the growth of tourism (Khan et al., 2005). Keintz (1968) underscored that the total value of trade is a strong indicator of travel demand, citing the case of the United States. Moreover, Turner and Witt (2001), in their study of New Zealand data, confirmed the substantial influence of international trade on the demand for business travel.

While international travel and trade have held enduring interconnectedness, empirical evidence by various researchers varies according to the hypotheses and geographical contexts. Santana-Gallego (2010) reported a noteworthy causal link connecting tourist arrivals and total UK trade. In the case of the Canary Islands, Santana-Gallego et al. (2011) delved into bidirectional causal connections between trade and tourism. Within Australia, a bidirectional causal nexus between international travel and trade was identified with key trade partners—the United States, the United Kingdom, New Zealand, and Japan (Kulendran and Wilson, 2000).

Although the high correlation between tourism and trade, insufficient evidence exists for a causal link between international trade and travel in Singapore (Khan et al., 2005). Gunay (2010) documented bidirectional causality between imports and tourist arrivals, alongside a unidirectional causal linkage from tourist arrivals to exports in Turkey. Kadir and Jusoff (2010) in Malaysia, and Massidda and Mattana (2013) in Italy, explored unidirectional causal relationships from trade to tourism. A limited number of scholarly investigations have employed panel data analysis to

explore the association between tourism and trade, particularly imports and exports. For instance, Farooq et al. (2023) performed a panel analysis considering a combination of imports and exports as trade volume in Gulf Cooperation Council (GCC) countries and explored the inverse relationship between CO_2 emissions. However, their study did not mention the interrelationship between tourism and trade.

Despite South Asia's potential as a trade hub and popular travel destination, there exists a reluctance among researchers to examine the relationship between tourism and trade. Murshed et al. (2020) investigated regional trade integration's impact on inbound tourism demand in South Asia, revealing that a higher degree of intra-regional trade between economies positively influences tourism demand. Altaf (2021) identified a positive correlation between the import ratio and tourism arrivals, alongside a reasonably negative correlation between the export ratio and tourism arrivals in India. Similarly, Suresh et al. (2018) unveiled a bi-directional Granger causality between tourism and trade in the case of India.

Our study is the first to employ a Granger causality test using trade variables (import and export) to scrutinize the connection between tourism and trade in South Asian countries. We aim to individually analyze the causal relationships between tourism and import and export in each country and perform a panel analysis to ascertain whether tourism is interconnected with import and export within the region. With careful consideration of previous research, we assume a significant linkage between tourism and trade (import and exports) in South Asian economies.

2.3. Tourism and CO_2 emissions

The rapid expansion of the tourism industry has significantly contributed to the global economy while concurrently exerting an environmental impact through the excessive emission of carbon dioxide gas, primarily stemming from the escalating number of arrivals and departures (Gössling, 2002). Notably, the tourism sector's CO_2 emissions constitute around 8% of global emissions, and alarming projections indicate that due to the upward trajectory of travel, transport-related CO_2 emissions resulting from tourism are anticipated to surge by 25% by 2030, relative to the levels recorded in 2016 (UNWTO, 2022). A diverse array of studies has underscored the detrimental impact of tourism on the Earth's atmosphere. Given the intriguing nature of the relationship between tourism and emissions, numerous research has been undertaken to explore this relationship. However, findings are often found to be inconsistent when it comes to the degree and direction of the relationship due to varying assumptions and geographical context.

Most investigations have revealed a unidirectional causal association between tourism and CO_2 emissions (Aslan et al., 2021; Chishti et al., 2020; Katricioglu, 2009; Sharif et al., 2017). However, Zhang and Zhang (2020) argued that, in the context of China, a bidirectional causality prevails between tourism and carbon dioxide emissions. Seconding these results, numerous other researchers reported the two-way causal relationship between tourism and greenhouse gas emissions (Akadiri et al., 2020; Farooq et al., 2023; Nepal et al., 2019; Selvanathan et al., 2021). However, the degree and the direction of influence have always been a central discussion point for

the researchers. Still, the majority of researchers pointed out that tourism is one of the major sources of CO_2 emissions.

In the context of South Asia, limited research has been carried out, digging into the intricate interplay between tourism and carbon emissions. Most scholars agree that tourism has a unidirectional causal relationship with greenhouse gas emissions. For instance, Sharif et al. (2017) in Pakistan, Nepal et al. (2019) in Nepal, Jayasinghe and Selvanathan (2021) in India, and Rahaman et al. (2022) in Bangladesh identified a unilateral causal link between tourist arrivals and CO_2 emissions. However, in the case of Sri Lanka, Gamage et al. (2017) argued that tourism revenues negatively influence CO_2 emissions, thereby illustrating a unidirectional causality from CO_2 emissions to tourism. Similarly, Mehmood et al. (2021) stated the existence of an Environmental Kuznets Curve (EKC) between tourism and CO_2 emissions in Sri Lanka and Nepal; that is; initially, there will be an environmental impact, but with further development, impacts could eventually diminishes. While analyzing panel data from South Asian countries, the recent study by Wahab et al. (2023) found no causative link between international arrivals and CO_2 emissions.

Although extensive studies have investigated the complex relationship between tourism and CO_2 emissions, results vary due to differences in methodological approaches and the factors considered. Employing a multivariate approach, the need for additional research to examine the causal link between tourism and carbon emissions within the South Asian region becomes evident. This study seeks to address this gap by thoroughly examining individual countries in the region and subsequently conducting an analysis of panel data using the vector auto-regression (VAR) based Granger causality test. Considering the outcomes of previous studies, we assume that tourism causes CO_2 emissions in the context of South Asian countries.

The summary of the literature that has used panel data to diagnose the relationship between tourism economy and environment is presented in **Table 1**.

3. Methodology

Cross-panel time series data analysis is popular among researchers, especially when examining multivariate relationships within a certain geographical region or group (Zaman, 2023). Scholars have employed various econometric techniques, including the autoregressive distributed lag (ARDL), vector error correction model (VECM), and vector autoregression (VAR), to explain the causal interconnections among the examined variables. We use the VAR model to establish Granger causality relationships among the variables in our investigation. The VAR model offers unique advantages, especially when uncovering causal relationships involving cross-panel time series data. This versatile approach proves effective for examining causality within multivariate time series frameworks (Bose et al., 2017). Scholars endorse the VAR framework as applicable to stationary data, enhancing precision in predicting causal relationships when investigating Granger causality (Bose et al., 2017; Rossi and Wang, 2019; Suharsono et al., 2017).

Table 1. Studies conducted panel analysis incorporating tourism, economy, and environment within a specific group of countries or a region.

Authors	Variables	Method	Key findings	Region
Lee and Chang (2008)	Tourism receipt, exchange rate, economic growth	Heterogeneous panel cointegration test, panel causality test	Stronger impact of tourism on GDP in non-OECD countries compared to OECD countries. Tourism impacts on GDP in Sub-Saharan African countries. Unidirectional causality from tourism to economic growth in OECD countries and bidirectional in non-OECD countries. Weak causality relationships observed in Asia for tourism development and economic growth.	OECD and non-OECD (Asia, Latin America, and Sub-Saharan countries)
Fayissa et al. (2008)	Tourism receipt, GDP per capita, gross fixed capital formation, economic freedom index, school enrolment, foreign direct investment, net barter terms of trade, household consumption expenditure	Double log-linear Cobb-Douglass production	Tourism Receipts have significant contributions to GDP and economic growth. Physical and human capital investments also play a significant role in economic development. Tourism causes short-term economic growth.	Sub-Saharan African countries
Narayan et al. (2010)	Real GDP, real tourism exports	Fully modified ordinary least squares (FMOLS), Panel Granger causality	A positive relationship between tourism exports and GDP. A 1% increase in tourism exports leads to a 0.72% increase in GDP in the long run. In the short run, a 1% increase in tourism exports corresponds to a 0.24% increase in GDP.	Four Pacific Island countries (Fiji, Tonga, the Solomon Islands, and Papua New Guinea)
Dritsakis (2012)	Real GDP per capita, tourism receipt, tourist arrivals, nominal effective exchange rate	Fully modified ordinary least squares (FMOLS)	The significant impact of tourism on economic growth. Variability in the impact of tourism on economic growth among different countries. Regional effects contribute to shaping the relationship between tourism and economic growth.	Seven Mediterranean countries
Çağlayan et al. (2012)	Tourism revenue, gross domestic product (GDP)	Panel Granger causality test	Bidirectional causality between Europe's tourism revenue (TR) and gross domestic product (GDP). Unidirectional causality from GDP to tourism revenue in America, Latin America & Caribbean, and the world. Reverse direction of causality from tourism revenue to GDP in East Asia, South Asia, and Oceania. No causal Relationship in Asia, Middle East and North Africa, Central Asia and Sub-Saharan Africa.	135 countries across the world
Zaman et al. (2016)	Tourism expenditure, tourism receipt, tourist arrivals, energy use, CO_2 emissions, GDP per capita, gross fixed capital formation, total health expenditure	Principle component analysis, panel two-stage least square method, Granger causality test	Existence of the EKC curve. Existence of tourism-induced emissions. Existence of energy-induced emissions. Existence of investment-induced emissions. The existence of economic growth led to tourism development. Existence of investment-led tourism development. The existence of health expenditure led to tourism development.	East Asia and Pacific, European Union, High-income OECD countries, non-OECD countries
Bilen et al. (2017)	Real GDP, international tourism receipt	Panel Granger causality test	Bidirectional temporary and permanent causality between tourism and economic growth. Unidirectional causality from tourism to economic growth. Bidirectional causal relationship between tourism and economic growth.	12 Mediterranean countries

Table 1. (*Continued*).

Authors	Variables	Method	Key findings	Region
Dogan and Aslan (2017)	Carbon dioxide emissions real gross domestic product (GDP), square of real GDP, energy consumption, trade, tourism	Dynamic ordinary least square estimation (DOLS)	The long-run relationship between carbon dioxide emissions, real GDP, the square of real GDP, energy consumption, trade, and tourism. Energy consumption and trade openness positively affect CO_2 emissions. Tourism has a negative impact on CO_2 emissions. Confirmation of the EKC phenomenon for OECD countries.	OECD countries
Dogan and Aslan (2017)	CO_2 emissions, real income, energy consumption, tourism	Fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS), panel Granger causality	Energy consumption contributes to CO_2 emissions. Real income and tourism mitigate CO_2 emissions. One way causality from tourism to CO_2 emissions. Two-way causality between CO_2 emissions and energy consumption. Bidirectional causality between real income and CO_2 emissions.	EU and Candidate countries
Mohapatra (2018)	Tourism receipts, tourism expenditure, economic growth	Panel Granger causality tests, fully modified ordinary least squares (FMOLS)	Bidirectional causal link between economic growth and tourism expenditure. Tourism receipts influence economic growth. A negative effect of tourism expenditure on growth.	SAARC countries
Akadiri et al. (2020)	Tourist arrivals, real GDP per capita, CO_2 emissions, globalization index	Panel Granger non-causality test	Existence of cross-sectional dependence across the island nations. Unidirectional causality from globalization, tourism, and economic growth to carbon emission. Carbon emissions are not sensitive to globalization, tourism and economic growth. The direction of causality varies across the nations.	Island territories in the Caribbean
Amin et al. (2020)	GDP, energy use, tourist arrivals	Panel Granger non-causality test	Existence of cross-sectional dependence. Unidirectional causality from tourism to economic growth and energy consumption. One-way causality from energy consumption to economic growth. Unidirectional causality from tourism to energy consumption.	South Asian countries
Selvanathan et al. (2021)	Tourism, energy consumption CO_2 emissions, gross domestic product (GDP)	Autoregressive distributed lags (ARDL) vector error-correction model (VECM), fully modified ordinary least squares (FMOLS), Granger causality	Tourism positively contributes to GDP, CO_2 emissions, and energy demand in the long run. An increase in GDP improves tourism. Increased CO_2 emissions do not discourage tourism in South Asia. Complex Inter-Relationship between tourism, energy consumption, CO_2 emissions, and economic growth in South Asia.	South Asian countries
Aslan et al. (2021)	Tourism, energy consumption, CO_2 emissions, capital formation, GDP	Quantile regression model, Dumitrescu-Hurlin panel causality test	Unidirectional causality from tourism to capital formation, CO_2 emissions, and energy consumption. Bidirectional causality between GDP and tourism, capital formation and GDP, CO_2 emission and energy consumption, energy consumption and GDP, and CO_2 emissions and energy consumption.	17 Mediterranean countries
Gao et al. (2021)	CO_2 emissions, energy consumption, GDP, tourism receipts	Polynomial regression, panel causality test, fully modified ordinary least squares (FMOLS)	Tourism-induced EKC hypothesis for three out of nine countries. A long-run equilibrium relationship for the examined variables. Bidirectional causality between GDP and tourism development in Northern Mediterranean countries. One-way causality from tourism development to economic growth in southern and global panels. Unidirectional causality from tourism to CO_2 emissions.	18 Mediterranean countries

Table 1. (*Continued*).

Authors	Variables	Method	Key findings	Region
Mehmood et al. (2021)	CO_2 emissions, GDP per capita, tourism arrivals, energy use, globalization	Autoregressive distributed lag approach (ARDL)	Existence of EKC between tourism and CO_2 emissions in Nepal and Sri Lanka. Globalization enables the tourism industry to in lowering CO_2 emissions. GDP and energy use increase CO_2 emissions in South Asia. No EKC exists between globalization and South Asian countries.	South Asian countries
Muhammad et al. (2021)	Tourism arrivals, CO_2 emissions, governance, foreign direct investment, energy consumption	Stochastic impact of regression on population affluence and technology model (STIRPAT), Granger non-causality test, panel dynamic ordinary least square method	Tourism has a positive and governance has a negative influence on CO_2 emissions. Tourism has a negative and governance has a positive impact on energy use. Two-way causality between tourism and CO_2 emissions. One way causality from governance to CO_2 emissions. Unidirectional causality from energy use to tourism.	13 Muslim countries
Rasool et al. (2021)	GDP per capita, international tourism receipts, financial development	Panel autoregressive distributive lag (ARDL) method, panel Granger causality test	Tourism growth and financial development both influence economic growth. Bidirectional causality between tourism and economic growth. Bidirectional causality between economic growth and financial development.	BRICS countries
EI Menyari (2021)	CO_2 emissions, real income per capita, tourist arrivals, electricity consumption	Fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (dols), dynamic seemingly unrelated regression (DSUR), Granger causality	Electricity consumption positively impacts CO_2 emissions. Tourism negatively impacts CO_2 emissions. Existence of the EKC curve. One-way causality from real income, electricity consumption and tourism to CO_2 emissions. Unidirectional causality from electricity consumption to income and tourism arrivals. Two-way causality between real income and tourism arrivals.	North African countries: Morocco, Algeria, Tunisia and Egypt
Farooq et al. (2023)	CO_2 emissions, GDP growth, FDI trade (export + import), tourism expenditure, tourism receipt, electricity production, population density, domestic credit	Dynamic least square, fully modified ordinary least square models (FMOLS)	Economic growth, foreign investment, tourism investment, electricity production, and population density positively influence CO_2 emissions. Trade volume and banking development negatively affect CO_2 emissions. Weaker environmental regulations attract more foreign investment and result in higher pollution levels.	Six GCC countries
Rahman et al. (2023)	Population, economic growth (gdp), renewable energy, nuclear energy, fossil fuels, greenhouse gas	Cross-sectional autoregressive distributive lags (CS-ARDL)	The impact of GDP and population is insignificant in the short run. GDP has a long-run impact on emissions. Fossil fuels significantly contribute to GHG. Renewable and nuclear energy plays a significant role in reducing GHG.	South Asian countries
Wahab et al. (2023)	GDP, human capital, globalization, financial risk, tourist arrivals, CO_2 emissions	Quantile regression analysis	GDP impacts tourism positively. Human capital has a stronger influence on attracting tourists. Globalization has varying impacts depending upon the level of globalization in the country. Bidirectional linkage between GDP, HCI, and tourism. No causation between tourism and CO_2 emissions.	South Asian countries
Voumik et al. (2023)	GDP per capita, renewable energy, energy intensity, urbanization, population, tourist arrivals, CO_2 emissions	Stochastic impacts by regression on population, affluence, and technology (STIRPAT), cross-sectional autoregressive distributed lag (CS-ARDL)	CO_2 emissions increase due to population, income, energy intensity and urbanization. Tourism minimizes the CO_2 emissions. The use of renewable energy reduces CO_2 emissions.	40 Asian countries

3.1. Variables and data

The time series data span from 1995 to 2019 and were extracted from the World Development Indicators (WDI), a publicly accessible data repository provided by the World Bank (The World Bank, 2022). Four indicator variables—tourism, economic growth, environmental pollution, and import/export were considered to reveal the underlying relationships. Historical time series data were collected for South Asian nations: Bangladesh, India, Nepal, Pakistan, and Sri Lanka. Refer to **Table 2** for a detailed overview of the variables considered. The variables representing tourism and economic growth include international tourism arrivals and GDP per capita. In terms of trade, the indexes of imported goods and exports were utilized. Additionally, CO_2 emissions were employed as a proxy variable to indicate environmental pollution.

Table 2. Variable definitions.

Variables	Definitions	Sources (The World Bank, 2022)
GDP	GDP per capita (Current, US$)	Word development indicators
TA	International inbound tourist arrivals (person)	Word development indicators
CO_2	Carbon dioxide emission (millions of tons)	Word development indicators
GE	Goods exports (BoP, current US$)	Word development indicators
GI	Goods imports (BoP, current US$)	Word development indicators

The selected variables hold significance in addressing the research question of this study and exploring the intricate interactions within the South Asian region. Tourism plays a crucial role by contributing significantly to GDP and employment; however, growing concerns about rising atmospheric pollution are associated with this sector. The rapid economic growth in the region and the promotion of international trade have implications for overall growth and global integration. Through this analysis, we aim to comprehensively understand underlying dynamics in the South Asian context, tailoring insights to the region's unique challenges and opportunities.

3.2. Model formation and Granger causality test

Initially, a descriptive analysis of the unprocessed input data from each country was conducted. Subsequently, an assessment for the stationarity of the time series data was undertaken using the Augmented Dickey-Fuller test, as outlined by Dickey and Fuller (1979). A differentiation process was applied for non-stationary data sets to transform them into stationary sequences. Data normalization is the pre-processing approach to improve data quality and model performance (Singh and Singh, 2020). We also normalized the data as Equation (1), whereby each feature's minimum and maximum values were mapped to 0 and 1, respectively.

$$\text{Normalization } (Z) = \frac{x - \min(x)}{\max(x) - \min(x)} \quad (1)$$

where x represents vector data for normalization, subsequently, multivariate Granger causality was evaluated based on the VAR model at lag "m", as detailed in Equations (2) and (3) (Granger, 1969).

$$X(t) = \sum_{j=1}^{m} A_{11j} X(t-j) + \sum_{j=1}^{m} A_{12j} Y(t-j) + \varepsilon(t) \quad (2)$$

$$Y(t) = \sum_{j=1}^{m} A_{21j} X(t-j) + \sum_{j=1}^{m} A_{22j} Y(t-j) + n(t) \; \forall \; t = 1,2,.. \quad (3)$$

where X and Y denote stationary variables such as GDP, TA, CO_2, GE and GI, m stands for the number of lags, matrix A is the coefficient of the model, e_1 and e_2 represent uncorrelated noise series for each time series (i.e., $E[e_1 e_s] = 0 = E[n_t n_t],\ s \neq t$ and $E[\varepsilon_t \varepsilon_s] = 0$ for all t, s). If the inclusion of Y (or X) terms in the first (or second) equation leads to a reduction in the variance of ε (or n), it is inferred that Y (or X) Granger-(G)-causes X (or Y). Two-sided F-tests were performed to test the Null hypothesis (Ho), which states that there is no evidence of a Granger causal relationship between X (or Y) and Y (or X).

Determination of the number of lags was achieved by utilizing the Akaike Information Criterion (AIC), wherein a lower value indicated a superior fit (Liew, 2004). The partial autocorrelation function (PACF) was tested to identify the most significant high spike, thereby enabling the selection of the appropriate lag. After implementing the optimal lag model according to the VAR framework, a causality analysis was performed using the computational capabilities of the "bruce R" package within the R environment (Bao, 2021). The results were subsequently analyzed using the F-statistics values from the Granger causality test. The detailed workflow of the current study is presented in **Figure 1**.

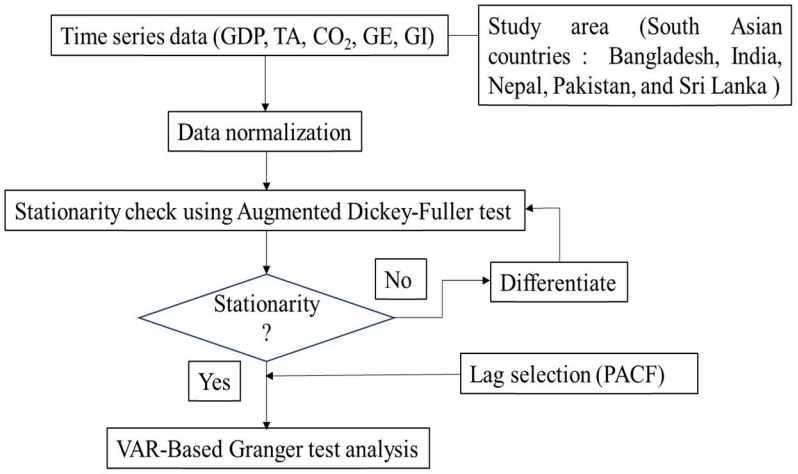


Figure 1. Study workflow.

4. Results

4.1. Descriptive analysis

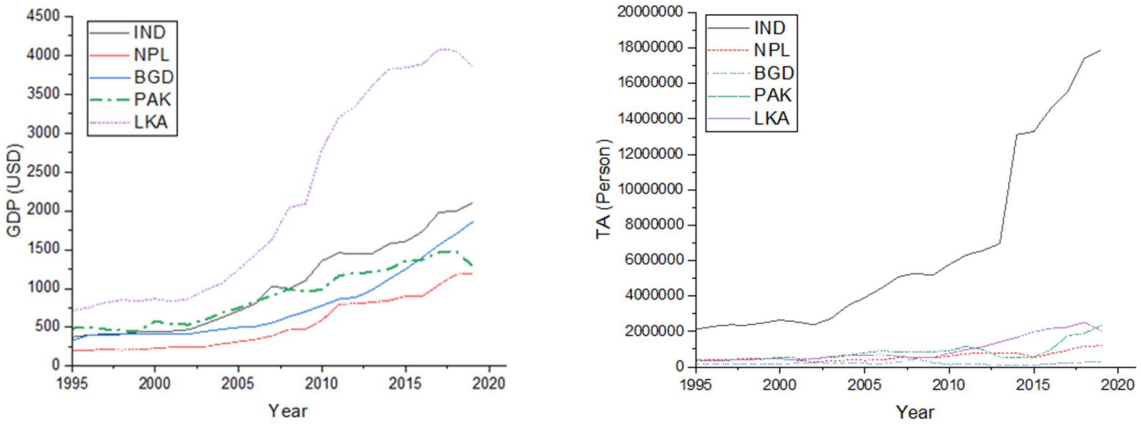
Based on the descriptive data analysis spanning from 1995 to 2019, Sri Lanka (US$2141.5) has consistently maintained its position as a GDP per capita leader within South Asia, followed by India (US$1037.39) and Pakistan (US$901.41). Regarding travel arrivals, the highest visitor visited India (6.67×10^6 persons), followed by Sri Lanka (9.79×10^5 persons), Pakistan (8.22×10^5 persons) and Nepal (5.83×10^5 persons). The average CO_2 emission was highest in India (1531.64 million tons), followed by Pakistan (145.48 million tons) and Bangladesh (47.83 million tons). The average GE was highest in India (US$\$1.68 \times 10^{11}$), followed by Bangladesh (US$\$1.70 \times 10^{10}$). Similarly, India's average GI was the highest (US$\$2.47 \times 10^{11}$), followed by Pakistan (US$\$2.76 \times 10^{10}$). Overall, among the observed features and countries, India

is the dominating country except in GDP, and Nepal was in the minority except for TA (**Table 3**, **Figure 2**).

Table 3. Descriptive result of variables.

Country		GDP	TA	CO_2	GE	GI
Bangladesh	Min	329.42	1.04×10^5	21.04	3.73×10^9	6.06×10^9
	Max	1855.74	4.67×10^5	94.22	3.87×10^{10}	5.60×10^{10}
	Mean	776.37	2.10×10^5	47.83	1.70×10^{10}	2.24×10^{10}
	SD	456.20	7.67×10^4	21.78	1.23×10^{10}	1.63×10^{10}
India	Min	373.77	2.12×10^6	762.12	3.12×10^{10}	3.80×10^{10}
	Max	2100.75	1.79×10^7	2625.97	3.32×1011	5.19×10^{11}
	Mean	1037.39	6.67×10^6	1531.64	1.68×10^{11}	2.47×10^{11}
	SD	585.08	5.25×10^6	617.63	1.19×10^{11}	1.89×10^{11}
Nepal	Min	203.98	2.75×10^5	2.22	3.50×10^8	1.24×10^9
	Max	1194.96	1.20×10^6	16.97	1.11×10^9	1.29×10^{10}
	Mean	536.04	5.83×10^5	5.23	7.89×10^8	4.48×10^9
	SD	338.32	2.53×10^5	3.93	2.10×10^8	3.54×10^9
Pakistan	Min	454.28	3.69×10^5	83.61	7.62×10^9	9.52×10^9
	Max	1482.21	2.34×10^6	238.31	2.63×10^{10}	5.68×10^{10}
	Mean	901.41	8.22×10^5	145.48	1.69×10^{10}	2.76×10^{10}
	SD	357.21	5.01×10^5	44.88	6.93×10^9	1.56×10^{10}
Sri Lanka	Min	714.23	3.15×10^5	5.81	3.80×10^9	4.78×10^9
	Max	4077.04	2.52×10^6	23.03	1.19×10^{10}	2.22×10^{10}
	Mean	2141.50	9.79×10^5	13.51	7.62×10^9	1.17×10^{10}
	SD	1328.81	7.02×10^5	5.13	2.79×10^9	6.38×10^9

GDP = GDP per capita (current USD), TA = tourist arrivals, CO_2 = CO_2 emission (millions of tons), GE = goods export (BoP, current US$), GI = goods import (BoP, current US$).



(a) **(b)**

Figure 2. (*Continued*).

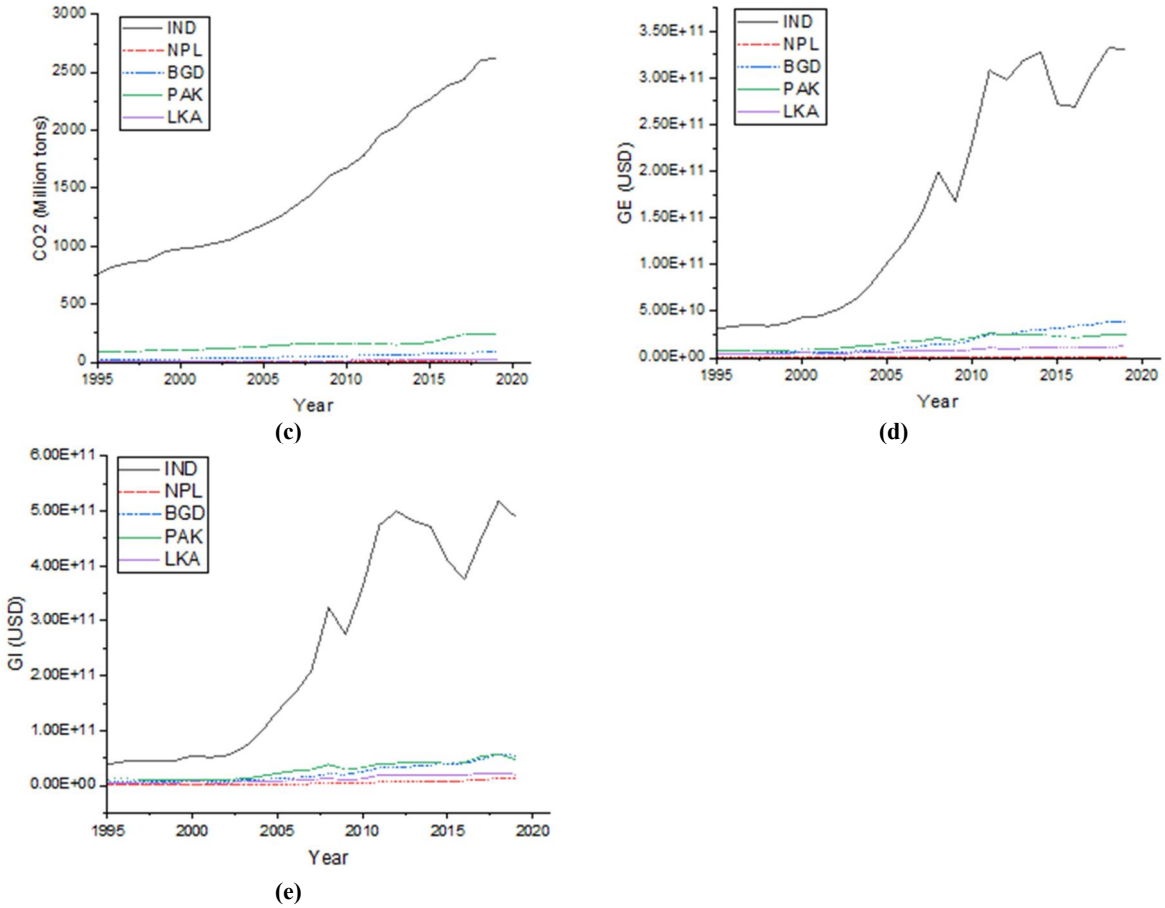


Figure 2. Time series data of **(a)** GDP (USD), **(b)** tourist arrival (person), **(c)** CO_2 emission (million tons), **(d)** goods export (USD), **(e)** goods import (USD) for examined South Asian countries: Bangladesh (BGD), India (IND), Nepal (NPL), Pakistan (PAK), and Sri Lanka (LKA).

4.2. Granger causality test

The outcomes of the Granger causality test reveal distinct patterns, and the *F*-statistics value determines their statistical significance. Specifically, a bidirectional causal connection between tourism and GDP per capita is evident in Nepal, Pakistan, and Sri Lanka. Conversely, Bangladesh exhibits a unidirectional causative link from GDP per capita to tourism. Moreover, no discernible linkage between tourism and GDP per capita emerges in the case of India. Furthermore, the findings demonstrate a one-way causality between tourism and CO_2 emissions in Bangladesh and Nepal and a unidirectional causal relationship between CO_2 emissions and tourism in India. Remarkably, the rest of the nations under scrutiny exhibit no detected causality between tourism and carbon emissions (**Table 4**).

In the context of Nepal, the interrelation between tourism and imports is revealed as bidirectional. Conversely, our investigation revealed a unidirectional causal linkage between imports and tourism in Bangladesh and India. In the case of Pakistan and Sri Lanka, we observed no noticeable connection between tourism and imports. Conversely, concerning tourism and exports, we identified bidirectional causality in Nepal, whereas India and Pakistan exhibited a one-way causal relationship from exports to tourism. Conversely, no distinct linkage between tourism and exports surfaced in Bangladesh and Sri Lanka. The Granger causality test's comprehensive

details, including *F*-statistics, are presented in **Table 4**, while a succinct overview is summarized in **Table 5**.

Table 4. Granger casual relationships (*F*-statistics).

Country	Indicators *Y*|*X*	GDP	TA	CO_2	GE	GI
BGL	GDP	–	4.46***	0.24	2.83	2.43
	TA	0.06	–	4.95***	0.05	3.69
	CO_2	3.66	1.02	–	0.14	5.29***
	GE	20.00***	1.32	31.86***	–	48.45***
	GI	3.43	8.65***	7.65***	20.44***	–
IND	GDP	–	1.32	5.01***	5.93***	18.59***
	TA	0.48	–	0.06	0.51	0.59
	CO_2	5.00***	10.44***	–	7.22***	31.73***
	GE	0.87	18.42***	0.64	–	5.61***
	GI	0.86	10.14***	1.52	4.64***	–
NPL	GDP	–	2.34	4.57***	0.03	1070***
	TA	8.26***	–	6.28***	6.83***	9.15***
	CO_2	0.23	0.17	–	1.97	0.08
	GE	4.58***	4.04***	0.51***	–	0.18
	GI	8.30***	8.16***	3.60	0.75	–
PAK	GDP	–	23.55***	4.57***	0.11	0.39
	TA	3.93***	–	0.51	0.2	0.75
	CO_2	0.09	1.34	–	0.26	0.54
	GE	0.29	10.26***	5.25***	–	5.75***
	GI	8.34***	0.97	9.73***	9.04***	–
SRL	GDP	–	6.11***	3.12	0.04	0.14
	TA	8.48***	–	0.37	1.16	1.39
	CO_2	3.19	1.60	–	0.02	0.06
	GE	8.05***	2.31	0.18	–	9.14***
	GI	4.36***	2.90	3.15	2.03	–

BGL: Bangladesh, IND: India, NPL: Nepal, PAK: Pakistan, SRL: Sri Lanka; GDP = GDP per capita, TA = tourist arrivals, CO_2 = CO_2 emission, GE = goods export, GI = goods import; *** $p < 0.05$.

Table 5. Summary of Granger causality for each country.

Bangladesh	India	Nepal	Pakistan	Sri Lanka
GDP > TA	GDP > CO_2, GE, GI	GDP > CO_2, GE, GI	GDP > TA, CO_2	GDP > TA
TA > CO_2	TA > N/A	TA > ALL	TA > GDP	TA > GDP
CO_2 > GI	CO_2 > ALL	CO_2 > N/A	CO_2 > N/A	CO_2 > N/A
GE > GDP, CO_2, GI	GE > TA, GI	GE > GDP, TA, CO_2	GE > TA, CO_2, GI	GE > GDP, GI
GI > TA, CO_2, GE	GI > TA, GE	GI > GDP, TA	GI > GDP, CO_2, GE	GI > GDP

GDP = GDP per capita, TA = tourist arrivals, CO_2 = CO_2 emission, GE= goods export, GI = goods import

Our panel analysis has revealed a bidirectional relationship between tourism and GDP per capita across South Asian countries. Additionally, a unidirectional causal

connection has been identified between CO_2 emissions to tourism within the region. Similarly, a one-way causal relationship exists between both imports and exports to tourism in South Asian region (**Table 6**).

Table 6. Granger causality with panel data for South Asian economies.

Y*|*X	**GDP**	**TA**	**CO_2**	**GE**	**GI**
GDP	–	8.55***	5.20***	0.19	1.82
TA	4.34***	–	3.69	3.58	1.05
CO_2	1.71	6.94***	–	4.08***	4.89***
GE	0.36	5.34***	2.47	–	0.95
GI	4.46***	10.61***	2.21	0.66	–

GDP = GDP per capita, TA = Tourist arrivals, CO_2 = CO_2 emission, GE= Goods export, GI = Goods import; *** $p < 0.05$

5. Discussion and conclusion

5.1. Discussion

Our study comprehensively examines the intricate relationship between tourism, economic growth, CO_2 emissions, import, and export within the context of South Asian countries. The time series data from World Bank for Bangladesh, India, Nepal, Pakistan and Sri Lanka was analyzed using VAR and Granger causality test. The outcomes highlight a range of relationships between tourism and other key indicators, offering distinct insights and implications across the five nations in the South Asian region.

In the context of Bangladesh, our investigation revealed a causal relationship between GDP per capita and imports, both serving as drivers for tourism. This finding supports the existence of the economic-driven tourism hypothesis, suggesting that economic growth and import activities play a role in influencing tourist arrivals. However, Bhuiyan et al. (2021) reported a contrasting tourism-led economic growth scenario, asserting that tourist arrivals contribute to the nation's economy. Furthermore, we identified a causal linkage between tourism and carbon dioxide emissions, underscoring the significant contribution of the tourism sector to atmospheric pollution, supporting the previous results by Rahaman et al. (2022) and Chishti et al. (2020). Furthermore, an additional intriguing revelation pertains to the influence of imports on tourism arrivals within the context of Bangladesh. This finding underscores that imports in Bangladesh exert a substantial and noteworthy influence on the influx of business arrivals. Consequently, it becomes evident that the realm of international trade holds a discernible impact on the dynamics of the tourism industry within the borders of Bangladesh. Despite having the lowest number of arrivals among South Asian nations, Bangladesh's flourishing economy underscores the tourism sector's favorable prospects. Consequently, fostering private sector investment in sustainable tourism becomes imperative, encompassing initiatives such as eco-friendly accommodations, integrating renewable energy, innovative technologies, and low-emission public transportation. Effective governmental policies should prioritize attracting domestic and foreign investment through subsidies, tax incentives, and other

economic inducements for entrepreneurs interested in venturing into sustainable, eco-friendly tourism enterprises.

In the context of India, our analysis did not reveal any evidence of causality between tourism and GDP per capita. However, results indicated the causal link between trade (imports, exports) and tourism, aligning with the economic-driven tourism growth hypothesis. With India's status as one of the world's largest economies, the volume of imports and exports (i.e., trade) plays a pivotal role in shaping international tourist arrivals. We also observed a causality between CO_2 emission and tourism in the case of India. Considering India's position as the top economy and the most populous country in the region, a significant proportion of carbon emissions indicate heightened energy consumption. Our results do not support the results from prior studies (Jayasinghe and Selvanathan, 2021; Mishra et al., 2011; Selvanathan et al., 2021), where they indicated that tourism drives both economic growth and CO_2 emissions in India. Despite its large area and abundant tourist attractions, India struggles to attract sufficient inbound tourists. Thus, the prominent relationship between trade and tourism underscores the importance of a policy framework within India's tourism sector that positively impacts inbound business visitors. Moreover, India should allocate resources thoughtfully to enhance tourism infrastructure, encompassing efficient transportation and accommodations. Given the already elevated carbon emissions in the country, proactive efforts by the government, in collaboration with the private sector, are crucial to promote environmentally friendly and sustainable tourism practices.

In the context of Nepal, our analysis unveiled a range of causal relationships between tourism, GDP per capita, CO_2 emissions, imports, and exports. Our findings underscore a robust interrelation between tourism and economic growth, consistent with prior studies (Chishti et al., 2020; Selvanathan et al., 2021). Specifically, tourist arrivals, GDP per capita, imports, and exports exhibit bidirectional causality, supporting both tourism-led and economic-driven tourism growth hypotheses. Moreover, the linkage observed between tourism and CO_2 emissions signifies that tourism not only serves as a foundation for economic expansion but also contributes to significant carbon emissions. This aligns with the findings of Nepal et al. (2019), opposing the outcomes presented by Chishti et al. (2020) and Selvanathan et al. (2021). Despite Nepal's abundant natural beauty and immense potential for the tourism sector, the country grapples with the challenge of attracting substantial international arrivals. To harness its tourism potential, Nepal should prioritize enhancing its infrastructure and explore sustainable methods to promote tourism. The mounting impact of climate change in Nepal's Himalayan region further underscores the urgency for sustainable tourism practices. Therefore, we suggest Nepal's tourism planners and policymakers take proactive steps towards fostering sustainability by implementing eco-friendly tourism strategies.

The bidirectional causality between tourism and GDP per capita in Pakistan signifies the concurrent support for tourism-led growth and growth-driven hypotheses. Our finding, which underscores tourism's substantial contribution to Pakistan's economy, aligns with the conclusions drawn by Khalil et al. (2007). Notably, our study reveals a unidirectional causal linkage between exports to tourism in Pakistan. This

suggests a growing export industry, which in turn attracts a greater number of inbound business travelers. Thus, trade also can play a substantial role in Pakistan's tourism development.

In contrast to prior studies (Chishti et al., 2020; Muhammad et al., 2021; Selvanathan et al., 2021), our results do not support a causal relationship between tourism and CO_2 emissions in Pakistan, as tourism appears to elevate carbon emissions. Despite the tremendous tourism potential, Pakistan registers comparatively fewer international tourist arrivals compared to other nations in the region. To bolster inbound tourism, Pakistan should undertake initiatives to diversify its tourism sector, encouraging increased investment with adaptable regulatory frameworks. Moreover, leveraging the nexus between trade and tourism, Pakistan could benefit from tailored measures promoting export activities that, in turn, attract more business travelers. As tourism is promoted, concerted efforts by the government and private sector are imperative to implement sustainable and environmentally conscious practices.

In the context of Sri Lanka, our investigation unveiled bidirectional causality between tourism and GDP per capita, thereby supporting both the tourism-led and economic-driven hypotheses. This implies a mutual interaction where economic growth significantly influences tourism and vice versa. This indicates that Sri Lanka stands to gain substantial economic growth from a high volume of tourist arrivals, while the converse also holds– that economic growth propels tourism activities within the country. However, in the study of Srinivasan et al. (2012), they reported a unidirectional causality from tourism to economic growth in Sri Lanka. We did not establish a strong connection between tourism and CO_2 emissions in Sri Lanka, which is inconsistent with the result of Selvanathan et al. (2021). Similarly, there was no connection of trade with tourism either. Compared to its regional counterparts, Sri Lanka has harnessed the benefits of tourism; however, its tourism potential remains underutilized in terms of visitor numbers. The country's susceptibility to global warming and climate change underpins the urgency for Sri Lankan tourism stakeholders to employ innovative strategies to attract tourists and adopt more sustainable tourism practices.

The panel Granger analysis results highlight tourism's significant contribution to economic growth within the South Asian region. The observed bidirectional causality between tourism and GDP per capita lends support to both the tourism-led and economic-driven tourism growth hypotheses. This alignment with prior researchers' findings (Çağlayan et al., 2012; Chishti et al., 2020; Mohapatra, 2018; Selvanathan et al., 2021) underscores the consensus that tourism plays a pivotal role in propelling the South Asian economies. This outcome underscores tourism's pivotal role in South Asia's economic growth, with the region's rapid economic expansion translating into an augmented influx of visitors. This trend portends a promising trajectory for the region's prospects. Notably, the recognized unidirectional causality between trade variables—specifically, imports and exports—and the realm of tourism underscores the substantial influence of international trade in stimulating the arrival of tourists to the region. This observation highlights the capacity of international trade, encompassing its principal components of imports and exports, to attract tourists to the area. Consequently, it becomes imperative for nations within the region to devise

strategies that incorporate recreational opportunities tailored to cater to business tourists, thus catalyzing the advancement of the tourism sector. It is important to highlight that our study represents the first investigation into the relationship between trade dynamics and tourism within this geographical region.

In the process of examining the interrelation between tourism and CO_2 emissions, no significant impact of tourism on CO_2 emissions was observed (Wahab et al., 2023). However, the outcomes underscore a unidirectional causative link between CO_2 emissions to the tourism sector. This finding contradicts assertions put forth by prior researchers; for instance, Farooq et al. (2023) in their investigation of GCC countries, Muhammad et al. (2021) in their analysis encompassing 13 Muslim nations, Selvanathan et al. (2021) with regards to South Asia, and Dogan and Aslan (2017) concerning the European Union and its candidate countries. Nevertheless, when considering distinct national contexts, a contrary trend was identified. Zhang and Zhang (2020) detected a scenario in China where CO_2 emissions influenced tourism, and Eyuboglu and Uzar (2019) reported analogous circumstances for Turkey. The delineation of the relationship between CO_2 emissions and tourism assumes paramount significance, given the heightened vulnerability imposed by global warming and climate change. As such, regional authorities are urged to champion sustainable tourism methodologies and formulate strategies that underscore reduced carbon footprints and diminished environmental detriments.

Despite being rich in natural and cultural attractions, the South Asian region struggles to attract a substantial number of international visitors. Several factors contribute to this underperformance, including inadequate tourism infrastructure, inflexible government policies, and insufficient promotion of tourism offerings. By fostering collaboration among regional governments, South Asian nations can harness the potential of tourism while concurrently striving to maintain low carbon emissions. Given the region's shared cultural and traditional ties, promoting intra-regional tourism activities (as highlighted by Murshed et al., 2020) could yield substantial benefits. We recommend a cohesive commitment within the intra-regional framework, wherein governments and relevant stakeholders within South Asia jointly espouse sustainable and ecologically conscious tourism practices. This concerted effort is imperative to mitigate the deleterious impact of tourism on the delicate biodiversity and vegetation inherent to these regions.

5.2. Limitations and future research

Our study acknowledges several limitations that could be subjects of future research endeavors. The current investigation centered on four variables: tourism, economic growth, imports, and exports. However, there are additional relevant variables, including globalization, tourism receipts, duration of stay, energy consumption, urbanization, and foreign direct investment, that warrant exploration in subsequent studies. Expanding the scope to incorporate a broader array of South Asian nations or extending the analysis to Pacific countries could provide further insights. Furthermore, future research avenues could include regional comparative analyses such as South Asian and Pacific countries. The complex dynamics between the tourism economy and environmental factors provide room for additional studies employing

diverse econometric models and methodologies, including qualitative and quantitative, integrating with the latest AI and machine learning techniques.

5.3. Conclusion

We investigated the complex and dynamic interrelationships between tourism, economic growth, trade (imports and exports), and CO_2 emissions within the context of five emerging countries in South Asia: Bangladesh, India, Nepal, Pakistan, and Sri Lanka. We employed various analytical techniques, including the Augmented Dickey-Fuller test, VAR (Vector Auto-Regression), Pearson multivariate correlation, and Granger causality test, utilizing time series data obtained from World Bank from 1995 to 2019. The findings highlighted the significant interplay between tourism and economic development within the region. However, the results of this study demonstrated the concerning rise in carbon emissions associated with tourism, emphasizing the urgency for legislative interventions to promote sustainable tourism practices. Furthermore, the study unveils the relationship between tourism and trade, stressing the significant impact of imports and exports on inbound tourism within the South Asian region. South Asian tourism stakeholders must prioritize the development of environmentally friendly policies that strike a balance between economic growth and environmental preservation. Given the region's imminent rapid economic growth, there is a compelling need for further studies that expose various facets of the economy, tourism, and the environment. These investigations should extend to include other potential factors that can influence the region's future growth significantly.

Author contributions: Conceptualization, TP and TD; methodology, TP and TD; software, TD and WYL; validation, WYL and TP; formal analysis, TP and TD; investigation, WYL; resources, WYL; data curation, TD and WYL; writing—original draft preparation, TP; writing—review and editing, TP, TD and WYL; visualization, TD; supervision, WYL; project administration, WYL; funding acquisition, TP. All authors have read and agreed to the published version of the manuscript.

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