

ASSESSING INDIA'S NATIONAL TOURISM POLICY (2002-2024): AN EMPIRICAL ANALYSIS BASED ON THE TOURISM-LED GROWTH HYPOTHESIS (TLGH) APPROACH

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Abstract

The National Tourism Policy (2002) has significantly strengthened India's tourism industry and economy by positioning tourism as a catalyst for economic development. Therefore, this study examines tourism's contribution to India's economic growth and its long-term relationship with key indicators, including gross domestic product (GDP), employment, foreign exchange earnings (FEE), and tourist growth, using the Tourism-Led Growth Hypothesis (TLGH) approach. Based on secondary data from 2002 to 2025, the research employs descriptive statistics, regression analysis, and Johansen cointegration tests to explore these relationships. Findings indicate that tourist growth significantly enhances GDP growth, employment and FEE. Moreover, a long-term equilibrium relationship exists between tourism and the analyzed economic factors. These results align with the National Tourism Policy 2002's vision of leveraging tourism for national development. The study provides theoretical support for the TLGH by establishing a long-term relationship between tourism growth and key economic indicators, such as GDP, employment, and FEE. In practice, the findings guide policymakers in enhancing tourism strategies, investing in infrastructure, and promoting skill development to drive equitable job growth. The results also highlight opportunities for private investment and public-private partnerships, reinforcing tourism's role as a driver of sustainable economic growth in developing economies.

Keywords: Tourism Economic Development; Economic Growth; National Tourism Policy; Tourism Employment.

AVALIANDO A POLÍTICA NACIONAL DE TURISMO DA ÍNDIA (2002-2024): UMA ANÁLISE EMPÍRICA BASEADA NA ABORDAGEM DA HIPÓTESE DO CRESCIMENTO LIDERADO PELO TURISMO (HCLT)

Resumo

A Política Nacional de Turismo, de 2002, fortaleceu significativamente a indústria do turismo e a economia da Índia ao posicionar o turismo como um catalisador do desenvolvimento econômico. Portanto, este estudo examina a contribuição do turismo para o crescimento econômico da Índia e sua relação de longo prazo com indicadores-chave, incluindo o produto interno bruto (PIB), o emprego, as receitas cambiais (RC) e o crescimento turístico, utilizando a abordagem da Hipótese do Crescimento Liderado pelo Turismo (HCLT). Com base em dados secundários de 2002 a 2025, a pesquisa emprega estatística descritiva, análise de regressão e testes de cointegração de Johansen para explorar essas relações. Os resultados indicam que o crescimento turístico amplia significativamente o crescimento do PIB, o emprego e as RC. Além disso, existe uma relação de equilíbrio de longo prazo entre o turismo e os fatores econômicos analisados. Esses resultados estão alinhados com a visão da Política Nacional de Turismo de 2002 de utilizar o turismo como instrumento de desenvolvimento nacional. O estudo fornece suporte teórico à HCLT ao estabelecer uma relação de longo prazo entre o crescimento do turismo e indicadores econômicos-chave, como PIB, emprego e RC. Na prática, os achados orientam os formuladores de políticas públicas no aperfeiçoamento das estratégias turísticas, no investimento em infraestrutura e na promoção do desenvolvimento de competências para impulsionar um crescimento mais equitativo do emprego. Os resultados também evidenciam oportunidades para investimento privado e parcerias público-privadas, reforçando o papel do turismo como motor do crescimento econômico sustentável em economias em desenvolvimento.

Palavras-chave: Economia do Turismo; Desenvolvimento Econômico; Crescimento Econômico; Política Nacional de Turismo; Emprego Turístico.

EVALUACIÓN DE LA POLÍTICA NACIONAL DE TURISMO DE LA INDIA (2002-2024): UN ANÁLISIS EMPÍRICO BASADO EN EL ENFOQUE DE LA HIPÓTESIS DEL CRECIMIENTO IMPULSADO POR EL TURISMO (HCIT)

Resumen

La Política Nacional de Turismo, de 2002, fortaleció significativamente la industria turística y la economía de la India al posicionar el turismo como un catalizador del desarrollo económico. Por lo tanto, este estudio examina la contribución del turismo al crecimiento económico de la India y su relación de largo plazo con indicadores clave, entre ellos el producto interno bruto (PIB), el empleo, los ingresos por divisas (ID) y el crecimiento turístico, utilizando el enfoque de la Hipótesis del Crecimiento Impulsado por el Turismo (HCIT). Con base en datos secundarios de 2002 a 2025, la investigación emplea estadística descriptiva, análisis de regresión y pruebas de cointegración de Johansen para explorar estas relaciones. Los hallazgos indican que el crecimiento turístico incrementa significativamente el crecimiento del PIB, el empleo y los ID. Además, existe una relación de equilibrio de largo plazo entre el turismo y los factores económicos analizados. Estos resultados se alinean con la visión de la Política Nacional de Turismo de 2002 de aprovechar el turismo como instrumento de desarrollo nacional. El estudio aporta respaldo teórico a la HCIT al establecer una relación de largo plazo entre el crecimiento del turismo y los principales indicadores económicos, como el PIB, el empleo y los ID. En la práctica, los hallazgos orientan a los responsables de las políticas públicas en el fortalecimiento de las estrategias turísticas, la inversión en infraestructura y la promoción del desarrollo de capacidades para impulsar un crecimiento más equitativo del empleo. Los resultados también ponen de relieve oportunidades para la inversión privada y las asociaciones público-privadas, reforzando el papel del turismo como motor del crecimiento económico sostenible en las economías en desarrollo.

Palabras clave: Economía del Turismo; Desarrollo económico; Crecimiento económico; Política Nacional de Turismo; Empleo Turístico.

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1 INTRODUCTION

Tourism is widely regarded as a key driver of economic growth and development, as it generates employment opportunities across both formal and informal sectors, thereby increasing income levels and improving livelihoods (Jaswal, 2014). It also serves as a vital source of foreign exchange earnings (FEE), strengthening a country's balance of payments and encouraging investment in infrastructure such as transport, accommodation, and public services. Furthermore, tourism creates strong multiplier effects by stimulating direct, indirect, and induced economic activities across related industries, while enabling domestic firms to benefit from economies of scale (Andriotis, 2002; Lin & Liu, 2000; Schubert et al., 2011).

Since World War II, the travel and tourism industry has expanded impressively across developed nations. Although its significance to domestic economies was acknowledged as early as the mid-twentieth century, it did not receive substantial attention until the 1950s (Crouch & Ritchie, 1999). With the advancement of globalisation, tourism has evolved into an increasingly vital and competitive sector. Over recent decades, it has emerged as one of the world's largest and most dynamic industries, consistently exhibiting steady growth and playing a central role in global economic development.

Tourism has continued to demonstrate significant economic importance in recent years, with the World Travel and Tourism Council (WTTC) reporting that global travel and tourism contributed approximately \$11.7 trillion to global Gross Domestic Product (GDP) (about 10.3%) in 2025, surpassing pre-pandemic levels and highlighting the sector's resilience and growth. The sector is expected to support around 371 million jobs worldwide, reinforcing its role as a major source of employment and accounting for roughly 1 in 10 jobs worldwide (WTTC, 2025). Furthermore, it also remains a critical contributor to international trade, generating significant export earnings and strengthening countries' balance of payments (Scheyvens & Russell, 2012).

Additionally, domestic tourism continues to dominate overall tourism spending and plays a crucial role in fostering regional development, distributing economic benefits, and promoting national integration, particularly in developing economies (WTTC, 2025). The COVID-19 pandemic (2020–2021) severely disrupted global tourism systems, leading to an unprecedented decline in international mobility, tourism receipts, and employment across the sector (United Nations World Tourism Organization (UNWTO), 2021).

Nevertheless, the tourism industry has demonstrated strong recovery momentum in the post-pandemic period, supported by rising domestic tourism demand, accelerated digital transformation, and government policy interventions, thereby reaffirming its long-term growth potential (UNWTO, 2023; WTTC, 2024).

The Second Five-Year Plan, which came into effect in 1956, defined tourism in economic terms (Government of India, 1956). In 1966, after the India Tourism Development Corporation (ITDC) was formed, tourism was promoted as a "tourist holiday destination" (Ministry of Tourism, 2026c). In the year 1982, the Indian Government approved the first-ever Tourism Policy, which gave a six-point plan, i.e., Swagat

(Welcome), Suchana (Information), Suvidha (Facilitation), Suraksha (Safety), Sahyog (cooperation), and Samrachana (Infrastructure Development) for the development of tourism activities in India. The core aim of this policy was to promote balanced socio-economic progress, to endorse and safeguard the rich cultural heritage of India, and to create job opportunities (Ministry of Tourism, 1982).

However, the announcement of the National Tourism Policy 2002 has brought many changes in the tourism sector in India. This policy is based on a multi-faced approach, which facilitates the fast implementation of tourism projects and aims to boost economic growth by promoting infrastructure, new destination development, new tourist circuits, and encouraging public-private partnerships (Ministry of Tourism & Culture, 2002).

India is projected by the WTTC to become the fourth-largest travel and tourism market globally by 2027, following China, the United States, and Germany, reflecting its rapidly expanding tourism economy (Ministry of Tourism, 2026b; WTTC, 2025). The country currently boasts 44 UNESCO World Heritage Sites and more than 100 national parks, highlighting its rich natural and cultural heritage (UNESCO World Heritage Centre, 2026).

With a population exceeding 1.4 billion, India's cultural and natural diversity enhances tourism demand. International visitors are attracted to India for multiple purposes, including medical tourism, eco-tourism, religious tourism, cultural heritage exploration, and geographic diversity, as well as its beaches and heritage destinations (Ministry of Tourism, 2025, 2026b).

Since the formulation of the National Tourism Policy 2002, India's tourism sector has undergone several important policy and programmatic developments aimed at strengthening infrastructure, improving accessibility, and promoting both domestic and international tourism. Key initiatives such as the Incredible India campaign, the introduction and expansion of the e-Visa facility (2014 onwards), the Swadesh Darshan Scheme (2014) and its revamped version, Swadesh Darshan 2.0 (2022), along with the PRASHAD scheme and the Dekho Apna Desh campaign (2020), have significantly reshaped the tourism landscape (Ministry of Tourism, 2025).

More recently, policy discussions leading up to the Draft National Tourism Policy 2022 (Ministry of Tourism, 2022) have emphasised sustainability, digital transformation, and enhanced private-sector participation. These initiatives and policies collectively indicate a strategic policy shift toward making tourism a more integrated, growth-oriented sector of India's economy (Ministry of Tourism, 2025, 2026a).

Despite India's rapid expansion in the tourism sector and the implementation of major policy initiatives such as the National Tourism Policy 2002, there remains insufficient empirical consensus on whether tourism functions as a sustained driver of economic growth. The existing literature provides mixed and inconclusive evidence on the direction and strength of the causal relationship between tourism development and macroeconomic performance, particularly in the Indian context.

Moreover, most studies fail to adequately capture long-run dynamic relationships using updated datasets and robust econometric techniques within a unified Tourism-Led Growth

Hypothesis (TLGH) framework.

Within this theoretical context, the TLGH provides a robust analytical framework for examining the causal relationship between tourism development and economic growth. The hypothesis posits that tourism serves as an endogenous growth driver by generating FEE, stimulating employment, boosting income levels, and fostering infrastructure expansion.

Accordingly, tourism is conceptualised not merely as a consumption-oriented service sector but as a dynamic growth engine with strong intersectoral linkages and multiplier effects. For this purpose, the researchers posed two questions for this research study: whether tourism has contributed to economic growth in India.

Secondly, to determine whether there is a long-term, causal relationship among the study variables. Therefore, this study empirically examines the contribution of tourism to GDP growth, employment, and FEE, and whether tourism serves as a long-term engine of economic growth in India.

By doing so, it provides a more accurate and reliable analysis of the tourism–growth nexus in India. The study is also timely, as it evaluates tourism's economic contribution during a period of structural policy reforms and rapid sectoral expansion, thereby offering valuable insights for policymakers and contributing to the existing body of empirical literature on tourism-led economic growth.

2 THEORETICAL REVIEWS

The tourism industry is the fastest-growing service sector, with potential for expansion and diversification. Hence, it produces economic benefits in increasing the FEE household income, employment, and GDP growth (Dritsakis, 2004; Ramesh, 2010). As an engine of economic growth, tourism has been widely studied in developed and developing countries to a large extent (Badulescu et al., 2020). Hence, the growing literature on tourism and economic growth has been reviewed worldwide. An extensive literature review found that numerous researchers have studied four areas of tourism growth, each describing the causal relationships between tourism and the economic development of a particular region.

Firstly, tourism is a significant driver of economic growth, i.e., the tourism-led growth hypothesis. It reflects the export-led growth hypothesis, in which tourism plays a dynamic role in economic growth. The TLGH is supported if there is unidirectional causality from tourism to economic growth. Secondly, economic growth strongly contributes to tourism growth, i.e., the growth-led hypothesis. It is a conservation hypothesis that posits that a country's economic development plays a significant role in attracting tourist arrivals. In other words, economic growth is profound and supports the tourism sector. This hypothesis is supported by unidirectional causality from economic growth in tourism.

Thirdly, tourism and economic growth drive each other. The feedback hypothesis is supported if there is bidirectional causality between tourism and economic development. This hypothesis denotes a reciprocal relationship between tourism and economic development. Lastly, the neutrality hypothesis posits that there is no causal relationship between

tourism and economic growth. Therefore, the neutrality hypothesis indicates that tourism does not affect economic development.

2.1 Tourism-Led Economic Growth Nexus in the World

The TLGH posits that tourism is a promising strategic driver of economic growth worldwide. Several empirical studies have used time-series and cross-sectional data to analyse the tourism industry's contribution to a country's economic growth through increased GDP, employment generation, FEE, and infrastructure development (Boyra Amposta, 2007; Brida et al., 2021; Brida et al., 2008; Brida & Fabbro, 2010; Brida & Rizzo, 2008; Gómez López & Barrón Arreola, 2019).

These studies generally support the TLGH, suggesting that tourism can act as a key driver of long-run economic expansion. However, the literature also highlights that the benefits of tourism are not automatic and must be managed carefully to ensure sustainability.

In particular, scholars emphasise the importance of balancing economic gains with environmental protection and social well-being, as uncontrolled tourism development may lead to environmental degradation, cultural impacts, and inequality (Gracielle et al., 2010; Kumail et al., 2021; Meurer & Lins, 2008; Ramos & Rodrigues, 2014; Richards, 2018; Takasago et al., 2011; Trentin & César Fratucci, 2011; Yangailo, 2025).

Brida et al. (2010) investigated the causal relationships between tourism growth, relative price, and economic expansion in Trentino, a region of northeast Italy bordering Switzerland and Austria, whereas, Croes and Vanegas, (2008) have examined the causal relationships between tourism development, economic expansion, and poverty reduction in the Nicaraguan economy.

Researchers across various countries have extensively examined the TLGH, providing empirical evidence from both developed and developing economies. Studies conducted in countries such as Turkey (Panahi et al., 2015; Zortuk, 2009), South Africa (Akinboade & Braimoh, 2010), Morocco and Tunisia (Belloumi, 2010; Bouzahzah & El Menyari, 2013), Pakistan (Manzoor et al., 2019), Malaysia (Chai et al., 2013; Kadir & Nayan, 2008; Tang, 2011; Yangailo, 2025), Azerbaijan (Gandilova, 2020), Romania (Surugiu & Surugiu, 2013), Aruba (Ridderstaat et al., 2013), Chile and Colombia (Brida et al., 2009; Brida & Rizzo, 2008; Brida et al., 2011), Mauritius (Ramesh, 2010), Lebanon (Tang & Abosedra, 2016), Singapore (Katircioğlu, 2011), Spain (Balaguer & Cantavella-Jordá, 2002; Nowak et al., 2007), Greece (Dritsakis, 2004), Macedonia (Petrevska, 2013), Mexico (Brida, Sanchez Carrera, et al., 2008), Southern African countries (Yangailo, 2025), and Uruguay (Brida, Lanzilotta, et al., 2008) have all contributed to this growing body of literature.

Methodologically, these studies have commonly employed econometric techniques such as the Johansen cointegration test, Granger causality tests, the autoregressive distributed lag (ARDL) model, and Vector error correction models (VECM) to examine both short-run and long-run relationships between tourism and economic

growth. Overall, the findings across most of these studies indicate a unidirectional or bidirectional causal relationship between tourism development and economic growth, thereby providing strong empirical support for the TLGH.

However, the empirical literature also presents mixed evidence regarding the TLGH. Some studies support the economic growth-led tourism hypothesis, suggesting that economic expansion itself stimulates tourism demand, as observed in Croatia (Payne & Mervar, 2010) and the Korean economy (Oh, 2005). In contrast, several studies provide evidence for a feedback (bidirectional) hypothesis, where tourism and economic growth mutually reinforce each other, as reported in Taiwan (Kim et al., 2006; Lee & Chien, 2008), Iran (Khoshnevis Yazdi et al., 2017), and China (Shan & Wilson, 2001).

On the other hand, a number of studies support the neutrality hypothesis, indicating no significant causal relationship between tourism and economic growth, as found in Turkey (Arslanturk et al., 2011; Ozturk & Acaravci, 2009) and in a broader set of developing countries (Ekanayake & Long, 2012).

Furthermore, several panel data studies employing multi-country datasets have produced diverse results across regions, including Mediterranean countries (Ren et al., 2019), transition economies (Chou, 2013), China's regional provinces (Wu & Wu, 2019a), African countries (Seetanah et al., 2011), and large cross-country samples covering 135 to 174 countries (Pablo-Romero & Molina, 2013; Ivanov & Webster, 2011).

Overall, these findings highlight that the tourism-growth nexus is context-specific and varies across countries, methodologies, and time periods. The practical importance of international tourism for economic growth and development has motivated a growing body of academic literature testing the TLGH. Also, most studies have found a positive association between tourism development and economic growth across countries.

2.2 Tourism-Led Economic Growth Nexus in India

In the Indian context, research on TLGH is still in its early stages. Although some studies have examined the relationship between tourism and economic growth, the application of the TLGH remains limited, and the findings are often mixed and inconclusive.

In particular, few studies have rigorously analysed the long-run causal relationship between tourism and economic growth within the policy frameworks, such as the National Tourism Policy 2002.

This highlights a clear research gap and the need for more robust empirical evidence on the tourism-growth nexus in India. Evidence from trends in foreign tourist arrivals (FTA) suggests strong potential for contributing to GDP, FEE, and employment generation (Vethirajan & Nagavalli, 2014).

Studies by Kakkar and Sapna (2012), Malik and Nusrath (2014), and Mir (2014) highlight a significant relationship between FTA, time, and revenue generation, confirming tourism as an important driver of economic development in India.

The sector's strong forward and backward linkages further stimulate employment opportunities and improve

living standards by supporting related industries, including transport, education, healthcare, and banking services. Palamalai, (2016) have empirically investigated India's tourism expansion, urbanisation, and economic growth. The study concluded that tourism expansion and economic growth are not mutually dependent. It also showed that one-way Granger causality runs from economic development to urbanisation and from urbanisation to tourism expansion in India.

Moreover, Rizal and Asokan (2014) have examined the theoretical aspects of emerging environmental issues in tourism development in India. The study revealed that environmental issues associated with tourism differ across regions and states. Issues such as carrying capacity, land degradation, pollution, deforestation, climate change, and solid waste are significant environmental impacts of tourism development.

Few studies in India have examined the TLGH using econometric approaches. For instance, Mishra et al., (2011) analysed tourism expansion and economic growth in India from 1978 to 2009 using cointegration and Granger causality tests, finding evidence of a long-run unidirectional causality from tourism to economic growth.

Similarly, Sharma, (2018) investigated the relationship between GDP and tourism receipts over the period 1991–2017 and reported significant long-run associations using cointegration and Granger causality techniques. In addition, Dash et al. (2018) employing the ARDL approach for 1973–2013, found that tourism positively influences India's economic growth in both the short- and long-run, thereby supporting the TLGH.

However, not all studies confirm this relationship. Georgantopoulos, (2013); and Ghosh, (2011), using ARDL and cointegration methods for 1980–2006, found no evidence of a long-run relationship between international tourist arrivals and economic growth, thus rejecting the TLGH.

In contrast, Tang et al., (2016) reported a feedback hypothesis, indicating a bidirectional relationship between tourism and economic growth in India. Overall, the findings remain mixed, highlighting the need for further empirical investigation.

2.3 Tourism Contribution to GDP Growth, Employment, and FEE

A substantial body of literature highlights tourism's significant contribution to key macroeconomic indicators, including GDP, employment, and FEE. Crouch and Ritchie, (1999) establish that tourism enhances economic performance through strong inter-sectoral linkages, increased demand, and improved competitiveness.

Many empirical studies have used GDP and international tourism receipts (ITR) as primary indicators of economic growth, while real exchange rates (RER) capture tourism competitiveness and demand dynamics (Ohlan, 2017; Ozturk & Acaravci, 2009). These studies consistently confirm that tourism expansion contributes positively to national income.

In addition, tourism contributes to productivity improvements and economies of scale, particularly in the hospitality sector (Lin & Liu, 2000). The sector's ability to stimulate infrastructure development and regional economic activity further strengthens its role in economic growth (Badulescu et al., 2020). In developing economies, tourism is also linked to poverty reduction and inclusive growth (Croes & Vanegas, 2008; Scheyvens & Russell, 2012).

In the Indian context, Abhyankar and Dalvie, (2013) highlight the strong growth potential of both domestic and international tourism, emphasising that increasing tourist inflows significantly enhance GDP, employment, and foreign exchange earnings. This is further supported by studies such as Ohlan, (2017); and Palamalai, (2016), which show that tourism development, along with policy support and urbanisation, contributes to sustained economic growth in India. Recent empirical evidence by Singh and Alam, (2024) also confirms that tourism expansion plays a critical role in India's macroeconomic performance.

Tourism is widely recognised as a labour-intensive sector, generating both direct and indirect employment across industries such as hospitality, transport, and services (Akinboade & Braimoh, 2010; Belloumi, 2010; Takasago et al., 2011). Furthermore, tourism contributes significantly to FEE, which helps stabilise the balance of payments (Matthew et al., 2021). Studies using FTA as a proxy for tourism demand (Aktar et al., 2014; Ghosh, 2011; Mishra et al., 2011) demonstrate a strong, positive relationship between tourist inflows and FEE.

However, recent literature highlights that the tourism-growth relationship is influenced by moderating factors, including institutional quality, geographical location, and external shocks such as the COVID-19 pandemic (Adedoyin et al., 2022; Baidoo et al., 2022; Gössling et al., 2020). These findings suggest that while tourism has strong growth potential, its actual contribution depends on broader economic, institutional, and global conditions.

2.4 Tourism as a Long-term Engine of Economic Growth

The TLGH provides a theoretical framework for understanding tourism as a long-term driver of economic growth. According to this hypothesis, tourism promotes economic development through foreign exchange earnings, employment generation, investment, and multiplier effects (Brida et al., 2014; Brida & Rizzo, 2008). A large number of studies support the validity of TLGH for long-term economic growth in the country.

For instance, Almeida (2023); Badulescu et al. (2020); and Brida et al. (2010) find evidence of a long-run relationship between tourism development and economic growth. Similarly, Wong et al. (2024) demonstrate that tourism and economic growth can mutually reinforce each other. Kumar and Patel (2024) and Liu et al. (2024) further highlight the dynamic nature of the tourism-growth relationship, particularly in the presence of structural breaks and extreme events.

Comprehensive reviews and meta-analyses (Alcalá-Ordóñez et al., 2024; Roy & Medhekar, 2025) confirm that while TLGH is widely supported, its validity varies across countries and time periods. Additional empirical evidence

from top tourist destinations (Raifu & Afolabi, 2024; Sofuoğlu, 2022) also supports tourism's role as a long-term growth engine.

In the Indian context, the growth potential of tourism, as highlighted by Abhyankar and Dalvie, (2013), reinforces the argument that tourism can sustain long-term economic expansion. Tourism contributes not only through direct income generation but also through indirect and induced effects, creating multiplier impacts across sectors. Policy evolution and institutional support (Dayananda K C & Leelavathi, 2016) further enhance tourism's long-term growth potential.

A comprehensive review of the existing literature reveals a clear research gap. First, although several studies in India and other countries have examined tourism development, including the growth and performance of the tourism industry (Abhyankar & Dalvie, 2013; Dash et al., 2018), economic evaluation of tourism (Mir, 2014), and broader tourism development trends (Malik & Nusrath, 2014). These studies largely focus on descriptive or sectoral analyses rather than causal modelling frameworks.

Second, while a limited number of studies have applied the TLGH framework in India and comparable contexts (Manzoor et al., 2019; Mishra et al., 2011; Sharma, 2018; Tang et al., 2016), the overall empirical evidence remains fragmented and contextually limited. This indicates that the applicability of the TLGH in the Indian context remains underexplored, underscoring the need for further investigation.

Moreover, existing studies employ different and often non-comparable time periods, such as 1980–2010 (Zortuk, 2009), 1988–2008 (Brida & Rizzo, 2008), and 1978–2009 (Mishra et al., 2011), 1995-2016 (Rout et al., 2018) leading to inconsistent findings across studies.

Other methodological concerns, such as publication bias and model specification issues, have been raised (Fonseca & Sánchez-Rivero, 2020; Song & Wu, 2022). In addition, the role of tourism in relation to the elasticity of economic growth has not been adequately examined within major policy frameworks, particularly the National Tourism Policy 2002. These limitations collectively expand the scope for further research and highlight the need for a more robust, policy-relevant empirical investigation using the TLGH approach.

3 METHODOLOGY

3.1 Data Sources and Variables

The study is based on time-series data collected from secondary sources. The required data were obtained from reliable and widely used databases, including the WTTC and the Ministry of Tourism, Government of India. In addition, supporting data and contextual insights were gathered from published journal articles, reports, and other academic sources. The dataset spans 24 years, from 2002 to 2025, providing a sufficient time horizon to analyse the long-run relationship between tourism growth and economic performance. The use of secondary data ensures consistency, reliability, and comparability of the variables across the study period.

The selection of variables in this study is grounded in the existing literature on the TLGH, which has examined the relationship between tourism development and economic growth across countries using a variety of indicators. Prior research has commonly employed GDP as a proxy for economic growth, alongside ITR (Akinboade & Braimoh, 2010; Belloumi, 2010; Brida et al., 2009; Habibi et al., 2018; Ohlan, 2017; Ozturk & Acaravci, 2009; Sharma, 2018).

Furthermore, several studies have incorporated FTA as a key indicator of tourism demand and growth, often alongside GDP and tourism receipts (Ghosh, 2011; Manzoor et al., 2019; Mishra et al., 2011; Wu & Wu, 2019b). Taken together, these measures provide a comprehensive understanding of the tourism-growth nexus.

Based on this established empirical framework, the present study adopts a modified set of variables tailored to the Indian context in addition to employment. Specifically, economic growth is measured using three indicators: (i) real GDP contribution of tourism (at constant prices, in US\$ billions), (ii) employment generated by the tourism sector (in thousands), and (iii) FEE from tourism (in US\$ billions). These variables capture the direct and indirect economic contributions of tourism.

On the other hand, tourism growth is proxied by FTA, measured in millions, which reflects the volume of international tourism demand. The choice of FTA as the independent variable is supported by its widespread use in the literature as a reliable indicator of tourism expansion. Thus, the study models the relationship between tourism growth (FTA) and economic performance (GDP contribution, employment, and FEE), providing a comprehensive framework for analysing tourism-led growth dynamics in India.

3.2 Analytical Techniques

The study uses regression analysis to assess the impact of tourism growth on economic indicators, including GDP, employment, and FEE. The Johansen cointegration test is applied to examine the long-run relationship among the variables using time-series data. Previous studies, such as Manzoor et al. (2019); and Ren et al. (2019), have used correlation and regression analysis to examine the relationship between tourism and economic growth. Thus, the combination of regression analysis and cointegration provides a robust framework for analysing both short-run effects and long-run relationships in EViews 8.

4 RESULTS ANALYSIS

This section is divided into four sub-sections, where the first section consists of descriptive statistics, the second section is used to check for stationarity of data through the unit root test, the third section provides the results of regression analysis, and the fourth section is used for testing and interpreting the results of the Johansen cointegration test. The analyses of the data are as explained below.

4.1 Descriptive Statistics

These statistics describe the basic features of the data used for the present study.

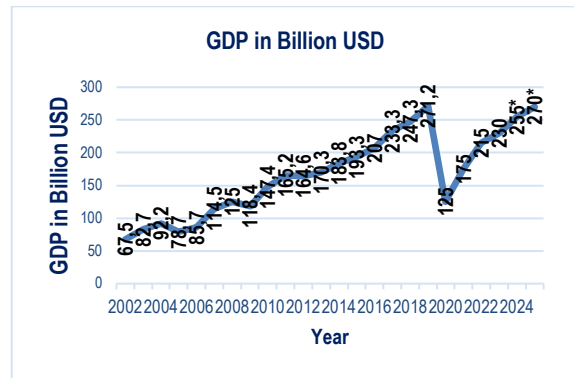


Figure 1. Variable GDP- Gross Domestic Product (202-2024).
 Source: Author's Compilation through Secondary Data.
 Note: * Denotes Provisional Values.

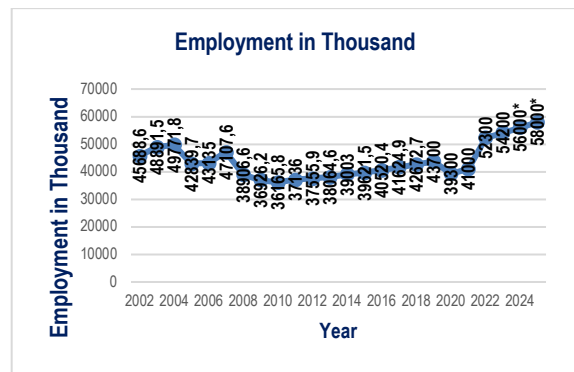


Figure 2. Variable EMPL- Employment (202-2024).
 Source: Author's Compilation through Secondary Data.
 Note: * Denotes Provisional Values.

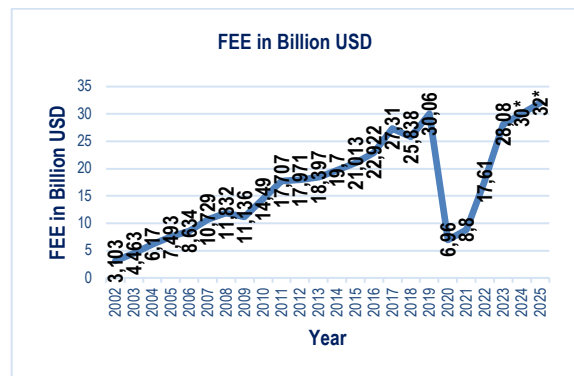


Figure 3. Variable FEE- Foreign Exchange Earnings (202-2024).
 Source: Author's Compilation through Secondary Data.
 Note: * Denotes Provisional Values.

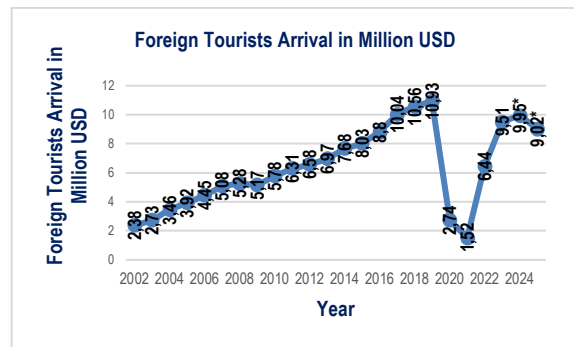


Figure 4. Variable FTA- Foreign Tourist Arrival (202-2024).
 Source: Author's Compilation through Secondary Data.
 Note: * Denotes Provisional Values.

Graphical analysis is used to examine the trends and patterns over time. The trend graphs clearly illustrate the growth trajectories of tourism indicators, highlight fluctuations, and capture significant structural changes, such as the decline during the COVID-19 period and the subsequent recovery.

The dataset presents annual time-series data from 2002 to 2025 on key tourism and economic indicators in India, including tourism's contribution to GDP (in USD billion), employment (in thousands), FEE (in USD billion), and FTA (in millions). The data indicate a steady, consistent growth trend from 2002 to 2019, reflecting the expanding role of tourism in economic development through increased income generation, employment opportunities, and foreign-exchange inflows.

However, a significant decline is observed in 2020 and 2021, primarily due to the COVID-19 pandemic, which severely disrupted global travel and tourism. This led to a sharp fall in GDP contribution, FEE, and tourist arrivals. From 2022 onwards, the data shows a strong recovery, with all indicators improving gradually. By 2024–2025, most variables approach or return to pre-pandemic levels, although foreign tourist arrivals show slight fluctuations.

Overall, the dataset highlights the long-term growth potential of tourism, its sensitivity to external shocks, and its strong resilience and capacity to recover. Despite fluctuations in recent years following the implementation of the National Tourism Policy 2002, the sector has demonstrated a consistent upward trend in growth and development.

4.2 Unit Root Test

For time-series analysis, it is essential to examine whether the data are stationary, as non-stationary series can produce misleading or spurious regression results, often characterised by high R-squared values, significant t-statistics, and low Durbin–Watson statistics. Therefore, the initial step is to test for unit roots and, if necessary, transform the data to achieve stationarity through differencing or other methods. In this study, stationarity is assessed using standard unit root tests such as the Augmented Dickey–Fuller (ADF) test (Dickey & Fuller, 1981) and the Phillips–Perron (PP) test (Phillips & Perron, 1988) which are widely used to determine the integration order of time-series variables before proceeding with further econometric analysis. The hypothesis to test the series is $H_1: \phi \neq 0$; the data are stationary.

In this case, if the calculated t-value of the variable is greater than the ADF critical t-value, or the P value is below 5% at a 0.05 significance level, then H_1 is to be accepted. Thus, the data is stationary and vice versa (Dickey & Fuller, 1981). On the other hand, the PP test is used to adjust for higher-order serial correlation in a given time series. Phillips and Perron, (1988) adopted a non-parametric method. The test regression for the PP test is the autoregressive (1) process (Phillips & Perron, 1988).

Table 1 shows that all variables are non-stationary at the level ($p > 0.05$), but become stationary after first differencing ($p < 0.05$). This confirms that the variables are

integrated of order one, i.e., $I(1)$, making them suitable for further analysis.

Table 1. The result of the ADF Test.

Variables	t-statistics	At Level (P Value)	t-statistics	First Difference (P Value)
TOUR	-1.85	0.650	-5.92	< 0.001
GDP	-2.10	0.520	-4.87	< 0.001
EMPL	-1.67	0.720	-6.15	< 0.001
FEE	-1.94	0.600	-5.34	< 0.001

Source: Author's Compilation.

Note: TOUR- Tourism Growth, GDP- Gross Domestic Product, EMPL- Employment, FEE- Foreign Exchange Earnings

Table 2 presents the PP test results, which are consistent with the ADF findings. All variables are non-stationary at the level ($p > 0.05$) but become stationary at the first difference ($p < 0.05$). This confirms that the series is integrated of order one, $I(1)$. Thus, $H_1 (\phi \neq 0)$ is supported at the first difference and is suitable for further analysis.

Table 2. Result of the PP Test.

Variables	t-statistics	At Level (P Value)	t-statistics	First Difference (P Value)
TOUR	-1.72	0.690	-6.08	< 0.001
GDP	-2.05	0.550	-5.11	< 0.001
EMPL	-1.58	0.740	-6.42	< 0.001
FEE	-1.88	0.620	-5.56	< 0.001

Source: Author's Compilation.

Note: TOUR- Tourism Growth, GDP- Gross Domestic Product, EMPL- Employment, FEE- Foreign Exchange Earnings

4.3 Simple Regression Analysis

It is a model that involves only one independent variable. It states that the true mean of the dependent variable changes at a constant rate as the value of the independent variable increases or decreases (Rawlings et al., 1998). The regression model assesses the relationship between dependent variables and independent variables. The simple linear model is expressed using the following equation.

$$Y = a + bx + \epsilon.$$

Where Y is the dependent variable, x is the independent variable, a is the constant, b is the slope, and ϵ is the residual. The present study uses a simple regression model in which GDP, Employment, and FEE are the dependent variables, and FTA (i.e., Tourism Growth) is the independent variable. The simple regression analysis is presented in Tables 3, 4, and 5 below.

Table 3. Analysis of the Contribution of Tourism Growth to GDP.

Dependent Variable: ΔGDP^1				
Variable	Coefficient	P Value	R-squared	Adjusted R-squared
C	-0.8452	0.813	0.4123	0.3748
$\Delta TOUR$	24.6735	0.005		

Source: Author's Compilation.

¹ ΔGDP : First Difference of Gross Domestic Products

H₂: Tourism growth significantly contributes to GDP.

The proposed model can be expressed as $\Delta GDP = \beta_0 + \beta_1 \Delta TOUR + \epsilon$.

The regression results in Table 3 show the contribution of tourism growth to GDP. It shows that the coefficient for $\Delta TOUR$ (24.6735) is positive and statistically significant ($p = 0.0052 < 0.05$), indicating that increased tourism growth is associated with a significant rise in GDP.

Specifically, a one-unit increase in foreign tourist arrivals results in approximately 24.67 unit increase in GDP growth. The constant term is insignificant ($p = 0.8125$), suggesting no meaningful baseline effect. The R-squared value (0.4123) indicates that about 41.23% of the variation in GDP is explained by tourism growth, reflecting a moderate relationship. Thus, H_2 is supported.

Table 4. Analysis of the Contribution of Tourism Growth to Employment.

Dependent Variable: $\Delta EMPL^1$				
Variable	Coefficient	P Value	R-squared	Adjusted R-squared
C	112.4587	0.732	0.3654	0.3247
$\Delta TOUR$	1850.6721	0.009		

Source: Author's Compilation.

¹ $\Delta EMPL$: First Difference in Employment

H_3 : Tourism growth significantly contributes to employment.

The proposed model can be expressed as $\Delta EMPL = \beta_0 + \beta_1 \Delta TOUR + \varepsilon$.

Table 4 presents the analysis of tourism growth's contribution to employment. The coefficient of $\Delta TOUR$ (1850.6721) is positive and statistically significant ($p = 0.0091 < 0.05$), implying that tourism growth has a strong positive effect on employment.

This suggests that an increase in tourist arrivals significantly contributes to job creation in the economy. The constant term remains insignificant ($p = 0.7321$). The R-squared value (0.3654) indicates that approximately 36.54% of the variation in employment is explained by tourism, showing a moderate impact. Thus, H_3 is supported.

Table 5. Analysis of the Contribution of Tourism Growth to FEE.

Dependent Variable: ΔFEE^1				
Variable	Coefficient	P Value	R-squared	Adjusted R-squared
C	-0.5236	0.841	0.4589	0.4235
$\Delta TOUR$	2.9874	0.004		

Source: Author's Compilation.

¹ ΔFEE : First Difference of Foreign Exchange Earnings

H_4 : Tourism growth significantly contributes to foreign exchange earnings.

The proposed model can be expressed as $\Delta FEE = \beta_0 + \beta_1 \Delta TOUR + \varepsilon$.

Table 5 presents the analysis of tourism growth's contribution to FEE. The coefficient for $\Delta TOUR$ (2.9874) is positive and statistically significant ($p = 0.0038 < 0.05$), indicating that tourism growth significantly increases FEE. A rise in tourist arrivals leads to higher foreign currency inflows.

The constant term is statistically insignificant ($p = 0.8417$). The R-squared value (0.4589) suggests that about 45.89% of the variation in FEE is explained by tourism growth, indicating a stronger relationship than with GDP and employment. Thus, H_4 is supported.

4.4 Johansen Co-Integration Test

This test is used to integrate several I (1) time-series data. It determines the long-term relationships among variables and can handle multiple time series. In contrast, the Engle-Granger test can switch only one cointegration relationship (Johansen & Juselius, 1990). After deciding on data stationarity, the next step is to identify the lag length.

The Schwarz criterion is the most commonly used criterion for measuring data stationarity because it is scientifically proven (Lütkepohl, 1985) and its critical values are less biased than those of other criteria. We determine the lag length using (Schwarz, 1978) criterion at lag 3 (Johansen & Juselius, 1990). We have used two test statistics, i.e., the maximum eigenvalue and the trace statistics, to test whether the variables have a long-term relationship. The hypotheses are as follows:

- $H_5: \beta \neq 0$, there is a long-term relationship between tourism growth and GDP.
- $H_6: \beta \neq 0$, there is a long-term relationship between tourism growth and employment.
- $H_7: \beta \neq 0$, there is a long-term relationship between tourism growth and FEE.

The Johansen cointegration test requires that variables be non-stationary at the level but integrated in the same order, typically at first or second difference. In the tourism study, tourism growth, GDP, employment, and FEE are found to be non-stationary at the level and become stationary at the first difference, indicating that all variables are integrated of order one, i.e., I(1).

Therefore, these variables satisfy the necessary conditions and are suitable for further analysis using the Johansen cointegration test; the results are presented in Tables 6 and 7.

Table 6. Johansen Cointegration Test (Trace) on $\Delta EMPL$, ΔFEE , ΔGDP , and $\Delta TOUR$ at Lags Interval 1 to 3.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesised	Eigenvalue	Trace	Critical Value	P Value
None *	0.6821	72.4587	47.8561	< 0.001
At most, 1 *	0.5413	45.2376	29.7971	< 0.001
At most, 2 *	0.3987	23.1145	15.4947	0.003
At most, 3 *	0.2154	8.4562	3.8415	0.004

Source: Author's Compilation.

Table 6 shows the results of the Trace test for "None" (72.4587), which is greater than the critical value (47.8561) with a $p < 0.001$. Similarly, for "At most 1" (45.2376 > 29.7971, $p < 0.001$) and "At most 2" (23.1145 > 15.4947, $p = 0.003$), indicating additional cointegrating relationships. Even at "At most 3" (8.4562 > 3.8415, $p = 0.004$). This suggests the presence of multiple cointegrating relationships among GDP, employment, FEE, and tourism growth, confirming a long-run equilibrium relationship between the variables.

The maximum eigenvalue test in Table 7 shows that the statistic for "None" (27.2211) is slightly below but close to the critical value (27.5843), with $p = 0.047$. For "At most 1" (22.1231 > 21.1316, $p = 0.033$) and "At most 2" (14.6583 > 14.2646, $p = 0.042$). At "At most 3" (8.4562 > 3.8415, $p = 0.004$).

Table 7. Johansen Cointegration Test (Maximum Eigenvalue) on Δ EMPL, Δ FEE, Δ GDP, and Δ TOUR at Lags Interval 1 to 3.

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesised	Eigen value	Max-Eigen	Critical Value	P Value
None *	0.6821	27.2211	27.5843	0.047
At most, 1 *	0.5413	22.1231	21.1316	0.033
At most, 2	0.3987	14.6583	14.2646	0.042
At most, 3 *	0.2154	8.5462	3.8415	0.004

Source: Author's Compilation.

This shows that H_5 , H_6 , and H_7 are supported at the 0.05 significance level by the Trace and Maximum Eigenvalue tests, indicating that the variables are cointegrated in the long run. Thus, both tests consistently indicate a stable long-term equilibrium relationship among tourism growth, GDP, employment, and foreign exchange earnings.

5 DISCUSSION AND IMPLICATIONS

5.1 Discussion

The study is framed within the context of India's National Tourism Policy 2002, which marked a significant shift in recognising tourism as a strategic sector for economic development, and the TLGH, which posits that tourism expansion drives overall economic growth. In line with TLGH, this study examines the short- and long-run impact of tourism growth on GDP, employment, and FEE.

The results indicate a positive and statistically significant impact of tourism growth on GDP, supporting H_1 and validating the core premise of the TLGH. This suggests that increased tourist arrivals stimulate economic activity and national income. The finding is consistent with earlier studies such as Brida et al., (2008); and Brida et al., (2008), which highlight tourism as a key contributor to economic expansion.

In the Indian context, similar evidence is provided by Ohlan, (2017); and Palamalai, (2016), both confirm that tourism significantly enhances economic growth. Moreover, recent reviews Alcalá-Ordóñez et al., (2024); and Roy and Medhekar, (2025) reaffirm that a majority of empirical studies support the TLGH. However, some contradictory evidence by Fonseca and Sánchez-Rivero, (2020); and Song and Wu, (2022) suggests that the tourism-growth nexus may vary across model specifications and country-specific dynamics.

The findings also show that tourism growth positively affects employment generation, supporting H_2 and aligning with the TLGH framework, which posits that tourism stimulates labour-intensive sectors. This is consistent with studies such as Scheyvens and Russell, (2012); and Takasago et al., (2011), which emphasises tourism's role in job creation and poverty reduction.

Additionally, Crouch and Ritchie, (1999) highlight tourism's contribution to broader societal prosperity through employment generation. The results further indicate that tourism expansion leads to indirect employment in allied sectors such as transport, retail, and infrastructure. However, some studies argue that employment effects may be uneven

or seasonal (Badulescu et al., 2020; Wu & Wu, 2019a) indicating partial or context-dependent support for TLGH.

The results confirm a strong positive and significant relationship between tourism growth and FEE, supporting H_3 . This implies that increased tourist inflows enhance foreign exchange reserves and improve the balance of payments. The finding is consistent with Aktar et al., (2014); and Matthew et al., (2021), who highlight tourism as a major source of foreign currency earnings. Similarly, Croes and Vanegas, (2008); and Lin and Liu, (2000) emphasise tourism's contribution to external sector stability. *This supports the TLGH argument that tourism contributes not only to domestic growth but also to international financial strength. Nevertheless, the magnitude of this relationship may depend on external conditions such as global demand and exchange rate fluctuations.*

The study also confirms a long-term equilibrium relationship among tourism growth, GDP, employment, and FEE, thereby supporting H_5 , H_6 , and H_7 . This strongly validates the TLGH in the Indian context, suggesting that tourism and economic variables move together over time. These findings are consistent with Brida et al., (2010); Habibi et al., (2018); and Sofuoğlu, (2022), who also report long-run relationships between tourism and economic growth. Further support is provided by Baidoo et al. (2022); and Raifu and Afolabi, (2024), who confirm the persistence of the tourism-growth nexus across regions.

However, some studies present contradictory or conditional evidence. For instance, Adedoyin et al. (2022) argue that institutional quality significantly moderates the tourism-growth relationship, while Kumar and Patel, (2024) highlight the role of structural breaks. Similarly, Gössling et al. (2020); and Liu et al. (2024) emphasise the impact of external shocks such as pandemics, which can temporarily disrupt the long-run equilibrium. These perspectives suggest that while cointegration exists, its stability may be influenced by macroeconomic and global conditions

Overall, the empirical results strongly support the TLGH, confirming that tourism acts as a key driver of economic growth, employment generation, and foreign exchange earnings in India. This aligns with a broad body of literature by Almeida, (2023); Badulescu et al., (2020); Singh and Alam, (2024); and Wong et al., (2024), which recognises tourism as a strategic sector for sustainable development. At the same time, the presence of mixed and conditional findings in the literature highlights that the tourism-growth relationship is dynamic, context-specific, and sensitive to external and institutional factors, rather than universally uniform.

5.2 Theoretical Contribution

The study's findings make important theoretical contributions to the TLGH. Firstly, the study strengthens the validity of the TLGH, which posits that tourism growth can drive economic development, particularly in emerging economies. Evidence of a long-term relationship between employment, GDP, FEE, and tourism expansion aligns with the theoretical underpinnings of TLGH. Secondly, the study reinforces the theory that the growth of certain sectors, particularly tourism, has multiplier effects on other sectors of

the economy, including employment, trade, and service industries. This approach extends beyond traditional views of economic growth to incorporate the unique dynamics of tourism-related employment and foreign exchange earnings.

Thirdly, using regression analysis and the Johansen cointegration test to analyse short-term and long-term relationships between key variables provides valuable insight into the application of econometric models. The findings offer an opportunity to refine models that predict economic growth based on sector-specific growth, adding another layer to macroeconomic theory and to how interdependencies between sectors are understood.

5.1 Implications

The study's findings have important practical implications for policymakers and stakeholders. Firstly, the strong positive relationship between tourism and GDP indicates that tourism expansion directly contributes to national income generation. Increased tourist arrivals lead to higher spending on accommodation, transportation, food services, entertainment, and local products, thereby stimulating multiple sectors of the economy. This creates a multiplier effect, where initial tourist spending generates additional economic activity across industries. Therefore, the policymakers should focus on long-term investments in infrastructure development, smart tourism technologies, destination branding, and integrated tourism circuits. Enhancing accessibility through better roads, airports, and digital platforms will not only attract more tourists but also ensure sustained GDP growth. Tourism can thus be strategically used as a tool for economic diversification and regional development, especially in less-developed areas.

Secondly, tourism is inherently a labour-intensive sector, generating employment at multiple levels, such as direct, indirect, and induced. Direct employment includes jobs in hotels, travel agencies, and tour operations, while indirect employment arises in sectors such as transport, handicrafts, agriculture, and construction. Therefore, policymakers and other stakeholders in the tourism industry should emphasise skill development, vocational training, and the promotion of tourism-tailored entrepreneurship. Initiatives such as promoting rural, eco-, and heritage tourism can create employment in remote regions, thereby reducing regional inequalities. Additionally, supporting micro, small, and medium enterprises (MSMEs) in tourism can further enhance job creation and inclusive growth.

Thirdly, the significant positive impact of tourism on FEE highlights its importance in strengthening the country's external sector and balance of payments. International tourists bring foreign currency into the economy, which helps build foreign exchange reserves and stabilise the domestic currency. This is particularly important for a developing country like India, where maintaining a stable external position is crucial. The implication is that the government should implement policies to attract more international tourists, such as expanding e-visa facilities, improving global marketing campaigns, and enhancing international air connectivity. Encouraging foreign direct investment (FDI) in tourism infrastructure, including hotels, resorts, and transport systems, can further boost foreign exchange inflows.

Overall, these sector-specific implications reinforce the importance of tourism within the TLGH framework, where tourism growth acts as a catalyst for sustained economic growth. These findings also align with recent policy directions, such as the Draft National Tourism Policy 2022, which emphasises sustainable development, digital transformation, and global competitiveness, ensuring that tourism continues to play a vital and resilient role in India's long-term economic strategy.

6 CONCLUSIONS

The travel and tourism industry is often described as an ever-evolving marvel of the economy. It is seen as a crucial sector for economic recovery because trade flows generated by a thriving tourism industry significantly impact business and consumer confidence. Therefore, it should be at the centre of policies aiming at reinvigorating economic growth. International tourism has a significant service-export component and huge potential for job creation. As a result, the tourism industry has the potential to become one of the most critical drivers of economic recovery and development. The Indian government can take specific steps to implement new techniques and strategies, such as infrastructure development, management and development of tourist circuits, more structured accommodation and transformation facilities, and effective destination planning, to help the economy grow.

In conclusion, the study affirms the theoretical notion that tourism contributes significantly to economic growth and has wide-ranging practical implications for enhancing India's economic strategy. The long-term relationship between tourism and GDP, employment, and FEE provides a strong case for integrating tourism-focused policies into broader economic planning, especially in a globalised and competitive market. The growth of this sector presents a significant opportunity for both sustainable development and economic diversification, ultimately benefiting the country's economy.

However, the study is subject to certain limitations, including reliance on secondary time-series data and the exclusion of external shocks such as global crises or pandemics that may influence tourism dynamics. Additionally, the analysis is limited to a selected set of variables, and the relatively small sample size further constrains the robustness of the findings. Moreover, the absence of advanced econometric models, such as ARDL, VAR, or VECM, limits the study's ability to fully capture the multidimensional and dynamic nature of tourism's economic impact.

Therefore, future research can expand the scope by incorporating additional variables such as environmental sustainability, technological advancements, and regional-level data, as well as by applying advanced econometric techniques and post-pandemic datasets. Such extensions would provide deeper insights into the evolving role of tourism in economic development, particularly amid context of emerging global challenges and opportunities.

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Term	Definition	Author 1	A2
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims	x	x
Methodology	Development or design of methodology; creation of models	x	x
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components	x	

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Validation	Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs	x	x
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data	x	x
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection	x	x
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools	x	x
Data Curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse	x	x
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