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Decarbonization of the Tourism Sector: Case Study of Baltic States

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Abstract
The tourism sector is a significant contributor to global greenhouse gas emissions, primarily through transportation, accommodation, and other energy-intensive activities. The urgent need for decarbonization has been recognized by governments, businesses, and international organizations. This paper explores current challenges, key strategies, and future pathways toward achieving a low-carbon tourism industry. The paper analyses decarbonization indicators of tourism and develops an indicator framework for the assessment of the success of the decarbonization path of tourism in countries with tourism destinations. A case study for the Baltic States was developed to apply decarbonization indicators of tourism and rank neighboring countries based on achievements in decarbonizing their tourism sectors. The case study shows that Estonia received the overall best results in decarbonizing the tourism sector.

Key Words: decarbonization, sustainable tourism, green infrastructure, climate change, low-carbon travel, renewable energy, ecotourism

JEL Classification: Q01, Q54, Z3, Z32

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1. Introduction

Decarbonization of the tourism industry is foremost interrelated to the concept of low-carbon tourism, which is among the highest priority issues that can be achieved for the tourism industry, abiding by the goals of the United Nations (UN) Sustainable Development Goals (SDGs) for carbon peaking and carbon neutrality (Cao et al., 2023). In this context, the pursuit of SDGs by 2030 necessitates the identification of those determining factors that influence carbon footprints across various sectors. In the relevant literature, factors of varying sensitivity among top tourist countries are renewable energy, tourism, financial development, and SDGs that have been co-evaluated to address the challenging issue to support realistic carbon emissions reduction and sustainable development (Hoang et al., 2023; Saura et al., 2023).

Tourism is a vital global economic driver that contributes at approximately 10% to the world's GDP. Indeed, nowadays tourism is considered a heavy industry that offers employment opportunities and is a prominent contributor to national economic stimulation, but also to environmental depletion through greenhouse gas (GHGs) emissions decrease (Hamaguchi, 2024). However, the tourism industry's reliance on fossil fuels, particularly in aviation and hospitality, has raised concerns about its environmental footprint. Decarbonization of tourism is essential to align with the Paris Agreement and global sustainability goals.

Among the most prevailing factors of tourism sustainability is that of the transportation industry, which contributes almost 24% of energy-related GHG emissions globally. Among proposed strategies of GHG emissions' reduction globally are the evolution of public shared-mobility transportation systems, such as electrified transportation, and intelligent-related applications in the transportation sector (Liu et al., 2025). Relevant research has also concentrated on air travel since aircraft emissions also build up GHGs, coupled with the weather and climate changes that cause considerable global warming and environmental depletion over the years. Subsequently, aviation is considered among the most challenging sectors to draw and to run policies of emerging conflicts and impacts between environmental protection and economic development (Mereotlhe, 2024).

The current scientific literature prioritizes the decoupling association between the tourism sector and environmental consequences (Rej et al., 2022). However, the causal interrelations among tourism, environment and growth are not always clear, therefore, environmental Kuznets curves, such as those relating to tourism and carbon emissions, have been emerged as a reliable environmental policy for tourism to further reduce GHGs emissions, but also leading to a reduction in employment and GDP (Hamaguchi, 2024). Similarly to the environmental Kuznets curve, it has been investigated in the case of India, the dynamic behaviour of linking carbon dioxide emissions, economic growth, international tourism, education, renewable energy consumption, and gross capital formation (Rej et al., 2022). The study showed that curbing GHG emissions in the long run is achievable through higher levels of international tourist arrivals, extended diffusion of renewable energy uses, and gross capital formation (Rej et al., 2022). In this context, other factors that cannot be undermined when drawing sustainable tourism policies are debatable in terms of employment and inequality in the post-COVID era (Hamaguchi, 2024).

Several studies used the quantile autoregressive lagged (QARDL) approach (Cho et al., 2015) and the Granger causality in quantiles tests (Troster et al., 2018). In this study, the nonlinear effects of US energy consumption, together with economic growth and tourist arrivals, were examined in terms of carbon dioxide emissions, as well as a long-run equilibrium connectedness between tourist arrivals decrease and carbon dioxide emissions in the long term (Xiangyu et al., 2021).

The study by Mehmood and Kaewsaeng-On (2024) showed the implementation of specific measures that encourage the joint use of renewable energy investments in terms of environmental practices and cost-effective financial initiatives in tourism, which can further reduce carbon emissions in selected tourist destinations and further advance SDGs (Mehmood & Kaewsaeng-On, 2024). The critical policy suggestions can be focused on incorporating current ecological and energy approaches of smoothly running low-carbon tourism models (Rej et al., 2022; Kubickova & Benešová, 2023).

The implementation of green hydrogen is anticipated to play a key role in decarbonizing maritime transportation in the Galapagos Islands (Valarezo et al., 2024). The study showed the importance of leveraging renewable energy sources, mainly solar and wind, into the existing energy mix (Valarezo et al., 2024). The critical point here is the demonstration of unique challenges in remote islands. Indicative decarbonization policies and measures of driving anthropogenic climate change include local sources of solar radiation and wind speeds in the vicinity of tourist destinations (Scott et al., 2016; Jones, 2024). However, the knowledge on the total GHGs emissions related to tourism trips–including travel to and from destinations–is limited, especially at sub-national destination scale. In this respect, it is noteworthy that the utility of an extended input-output approach in estimating the total GHG emissions consequent on inbound and domestic trips, especially among nationally attractive tourism destinations (Jones, 2024).

In this long-run plan, the place of tourism's future includes the determination of regional knowledge gaps and, subsequently, the recognition of those strategies that potentially hinder the development of resilient tourism operations and destinations, coupled with the impacts, adaptation, vulnerabilities, and mitigation policies that impede predictions of tourism demand. The implications of different decarbonization pathways represent a key knowledge gap for the future of international tourism (Scott et al., 2016).

This study aims to overcome the gap in assessing the decarbonization of tourism destinations by developing an indicator framework for assessing the decarbonization of tourism destination countries and providing a case study on the Baltic States on the decarbonization of tourism destinations.

The paper is structured in the following way: Section 2 provides a literature review, Section 3 presents a case study including methods, data, and results, and Section 4 concludes

2. Literature review

2.1 Thematic review of tourism decarbonization

The decarbonization of tourism is a complex challenge that has environmental, economic, and social dimensions that are interlinked. Carbon emissions from the tourism industry are dire. The importance of addressing their carbon footprint is unrivalled, considering the industry contributes approximately 5% of global emissions (Yang & Jia, 2022). Research shows that steps are being made towards achieving sustainability goals in the tourism industry, but the effort is insufficient for true decarbonization due to many persistent barriers that need coordinated action from multiple actors (Knowles, 2024; Gößling & Scott, 2018; Sun et al., 2020).

One of the most prominent difficulties of decarbonizing tourism stems from its multi-faceted nature, which includes a wide array of processes such as travel, lodging, and leisure activities. Each of these processes is a source of carbon emissions, making it difficult to devise a comprehensive mitigation strategy (Mou, 2024). A case in point is that transportation alone constitutes a large share of the emissions produced in tourism, and air transportation is certainly one of the most efficient in terms of its carbon emissions per passenger (Yang & Jia, 2022; Mou, 2024). Additionally, the diesel power needed to fuel the vessels, along with the growing appetite for traveling, make it very difficult to cut emissions in this industry (McCullough, 2023; Mishra et al., 2021).

The economic model of the tourism sector of the economy is heavily reliant on growth and profits, therefore, making it difficult to adopt greener practices within the industry. This is particularly obvious in more developed markets as they have well-established infrastructure and business models and therefore are resistant to radical alterations (Scott et al., 2020; Gößling & Higham, 2020). Studies indicate the need for a paradigm shift, which treats tourism not only as an economic tool, but also as a sector that must engage in mitigation policies (Gößling & Higham, 2020; Becken, 2019). This calls for a new style of management which balances economics and the environment, a difficult endeavor because of many stakeholders in tourism (Gößling & Higham, 2020; Gößling & Scott, 2018).

The COVID-19 pandemic has brought both challenges and opportunities to the tourism industry. The pandemic caused travel restrictions which reduced emissions (Yang & Jia, 2022). Simultaneously, it also brought to light the weaknesses within the tourism industry and the necessity of being resilient in the face of potential crises (Rodriguez-Barboza, 2024; Ruppenthal & Rückert-John, 2024). The trend of increased domestic tourism and increased interest in sustainable travel could provide an incentive for the industry to rethink their operations and adopt decarbonization policies (Scott et al., 2020; Rodriguez-Barboza, 2024). However, the research suggests that there still exists a low level of public concern and willingness to pay for green tourism options which serves as an obstacle to the widespread acceptance of low-carbon practices (Rodriguez-Barboza, 2024; Pilgreen, 2024; Sharp & Synodinos, 2024).

Also, crucial to the decarbonization challenge is the underdevelopment of data on the tourism sector's carbon footprint. Effective emission mitigation plans are hard to develop and implement as there are no universally accepted approaches to measuring the carbon emissions from tourism activities

(Bi & Zeng, 2019). This is even more dire in areas with heavy tourism because the lack of data inhibits effective policymaking and resourcing aimed at carbon reduction strategies (Bi & Zeng, 2019; Liu et al., 2023). There also emerges a robust need for more concerted interdisciplinary and transdisciplinary efforts towards carving out much-needed solutions to establish the nexus between tourism, carbon emissions, and climate change (Scott, 2021; Knowles, 2024).

The government and policy structures are key to meeting the requirements for decarbonizing tourism. Environmental legislation can motivate industry adoption of sustainable actions, but, as noted in the literature, the effectiveness of such regulations is not uniform across different areas and kinds of tourism (Qiao et al. 2021; Ma et al., 2021). There is a tension that policy makers must deal with, the promotion of tourism as an economic growth driver and strict environmental regulations that encourage decarbonization(Qiao et al., 2021). The development of carbon-neutral destinations, as the United Nations World Tourism Organization suggests, is an important step towards sustainability in tourism; however, it requires cooperation between many parties, including governments, businesses, and the locals (He et al., 2021; Rodriguez-Barboza, 2024).

Technology and innovation must assist in moving towards low-carbon tourism. The shift to renewable energy, energy-efficient technologies, and green means of transportation can greatly lower the carbon footprint of tourism activities (McCullough, 2023; Sun et Al, 2020). Nonetheless, evidence shows that the adoption of this type of technology is frequently delayed due to insufficient finances and a lack of skilled personnel in the sector (Knowles, 2024; McCullough, 2023). It is for these reasons that some steps have to be taken in encouraging collaboration between the public and private sectors, alongside investing more into research and development (Rodriguez-Barboza, 2024; Ruocco et al., 2020).

Moreover, well-structured policy designs are essential for aiding the processes of decarbonization within the tourism sector. Guo et al. argue that policies for sustainable tourism should be designed and implemented at local, national, and global scales so that an environment conducive to green practices is fostered (Guo et al., 2019). This encompasses the adoption of regulations aimed at encouraging or mandating the use of sustainable business technologies, financing environmentally friendly programs, and setting minimum requirements for tourism operations. A case in point is the adoption of carbon pricing which is designed to facilitate emission reduction by making the adoption of green business practices economically profitable (Gong et al., 2018).

Education and awareness are critical factors in the achievement of sustainable tourism goals. It has been shown that industry players and tourists need to be sufficiently informed regarding sustainable tourism to facilitate a shift in their behavior (Kim et al., 2021; Ahmed et al., 2021). Hospitality employees can be trained to understand sustainability issues and use green practices appropriately (Choudhary & Datta, 2023; Khalil et al., 2022). Furthermore, educating travelers on the effect that their travels have on the environment can motivate them to behave more responsibly by using alternative forms of accommodation and engaging in eco-friendly activities (Kim et al., 2021; Bhutto et al., 2021; Kement et al., 2023).

Beyond the mentioned, the literature also refers to the need for assessment of decarbonization processes in action. Developing tourism operations' carbon emissions measurement systems and their benchmarks enables stakeholders to assess progress and challenges (Ji et al., 2023; Herath, 2023; Streimikis et al., 2024). This approach helps inform policy measures and enables businesses to adjust their sustainability practices accordingly (Ji et al., 2023).

The COVID-19 pandemic has altered the landscape of tourism, creating challenges and opportunities for decarbonization. Travel bans during the pandemic gave rise to local and sustainable tourism as people sought to reduce their carbon footprint (Kusumaningrum & Wachyuni, 2020). This shift in consumer behavior provides a window of opportunity for greater focus on sustainability and decarbonization in the recovery phase within the tourism industry (Kusumaningrum & Wachyuni, 2020; Kajzar & Mura, 2023; Sharma et al., 2024; Vithayaporn et al., 2023).

Decarbonizing the tourism sector is complex and calls for sustainable methods, technological development, stakeholder collaboration, compatible policies, and even creating awareness. These measures taken together can meaningfully reduce the carbon footprint of tourism globally and support global objectives to mitigate climate change. The literature highlights the next step which is cooperation between all stakeholders — governments, businesses, citizens, and activists — to achieve sustainability and resiliency of the tourism industry in the future.

The published work has already emphasized the need for an approach that combines innovative management systems with strong policy, appropriate data collection, and technologies. The tourism industry, like many other industries, is fighting to overcome the effects of climate change and it must do its part in the international struggle to reduce carbon emissions. It is only through cooperation and commitment that the tourism industry can move towards a low-carbon economy.

2.2 Indicators of decarbonization of the tourism sector

The carbon footprints for tourism are used as main indicators of the decarbonization of the tourism sector. In the relevant literature, research studies analyzed the regional sustainable development of the tourism industry by combining the concept of life cycle analysis, aiming at building a tourists' carbon footprint (regional) model (Cao et al., 2023). It was shown that, due to the COVID-19 pandemic in the period 2020-2022, the regional tourism carbon footprint (per capita carbon footprint of tourism) was significantly decreased, whereas the overall tourism carbon footprint was increased during 2011–2019 and from the post-pandemic era aftermath. The size of the national tourism carbon footprint is placed in the following descending order: tourism transportation > tourism catering > tourism accommodation > tourism activities (Cao et al., 2023).

A critical component of any overarching plan to reduce the carbon footprint of tourism centers on sustainable activities within the hospitality sector, such as the development of green hotels. It has been established that green hotels help advance sustainable tourism by contributing towards the achievement of the United Nations Sustainable Development Goals (SDG) (Fauzi (2024; Abdou et al., 2020). In these establishments, efficient energy use, waste minimization, and responsible purchasing policies are some of the practices that help reduce CO2 emissions (Androniceanu &Georgescu, 2023). For example, Abdou et al. (2020) note the adoption of climate change mitigation efforts through the incorporation of energy management systems into the hotel operations together with eco-certification programs that have pro-environmental behavior (Abdou et al., 2020; Kerdpitak, 2019).

The carbon footprint of tourism in national scale is bounded on the development of tourism in regional level proposing suggestions to reduce carbon emissions, constituting a systematic tool to evaluate the adoption of low-carbon tourism at national scale, through providing a scientific basis and practical reference significance for the sustainable development of low-carbon tourism in regional scale (Cao et al., 2023). Among the tourism-related literature studies of reducing the industrial carbon footprint is the wine industry, with over 40 million wine tourists globally. In this context, cellar door operations consist an important distribution channel, especially for the profitability of small and medium-sized wineries. However, the winery's profitability has not been counted for existing environmental life cycle assessments. Sun and Drakeman (2020) developed a methodology to measure the carbon footprint of wine tourism and cellar door sales based on a combination of the bottom-up and the top-down approaches in the case of Australia. It was observed that domestic and international wine tourism caused higher (up to 100-fold per bottle of wine) carbon emissions than the standard wine distribution channels (Sun & Drakeman, 2020). Besides, benchmarking analysis disclosed that cellar door sales is considered as the most carbon-intensive factor across the whole wine life cycle steps. Such a type of analysis enabled the evaluation of environmental trade-offs that could be involved to obtain the numerous benefits of wine tourism and the elimination of wine tourism-related carbon emissions (Sun and Drakeman, 2020).

In better valuing the tourism's carbon footprint, it is reported in the literature that the measurement and the calculation of the impact of investments (Cadarso et al., 2016; Shpak et al., 2022). In particular, researchers proposed an expanding concept of tourism's carbon footprint. In this context, the embodied emissions of tourism consumption are linked to those emissions of tourism sector investments. Subsequently, the whole carbon footprint implies an optimum allocation of emissions, being linked to both capital goods production that are required for tourism goods and the ancillary services of the tourism sector. The omission of investments, e.g., the construction of hotels and infrastructures, is unavoidably leading to an underestimation of environmental responsibility in the tourism sector (Cadarso et al., 2016; Zielińska & Bačík, 2020).

The methodological background of LCA-IO model has been to introduced by Conefrey and Hanrahan (2024) who examined the Spanish tourism sector during 1995-2007 and concluded that the inclusion of tourism investment in the carbon footprint calculations increased the industry's responsibility by 34%. This upward behaviour was explained by the significance of civil infrastructure and construction related to hotels and catering, and imported electrical and electronic machinery and transport vehicles. The tourism industry contributes 8% to direct and indirect global carbon emissions. Indirect carbon emissions are often neglected because they are difficult to calculate. Subsequently, traditional approaches to calculating indirect emissions–LCA–is expensive and require an expert data analyst (Demeter et al., 2021). Demeter et al. (2021) showed how a LCA approach, besides its macro-scale utility to estimate carbon emissions at national levels, can be applied to a small-scale business level, especially in the case of using carbon emissions that are generated by cleaning one hotel room. Results by both LCA and Environmentally Extended Input-Output analyses showed similarities to each other, being characterized as cost-effective and user-friendly. Besides, the Environmentally Extended Input-Output Analysis can estimate the indirect carbon emissions of businesses' operations, enabling the identification of target areas for improvement (Demeter et al., 2021).

Songur et al (2022) argue that the use of energy and water-saving appliances, as well as advanced waste management technologies, can considerably improve the environment within which hotels and other tourism businesses operate (Songur et al., 2022). Inasmuch as these technologies are intended to achieve a reduction in carbon emissions, they are also shown to improve productivity and satisfaction of consumers, as most of them are willing to pay for green services. The carbon footprints for hotels are a popular indicator to measure and compare their sustainability and input in GHG reduction (Songur et al., 2022; Kim et al., 2021).

One of the most important decarbonization strategies in tourism is stakeholder engagement. Involving the local population in these types of projects is crucial, as it enhances their self-esteem and pro-environmental behavior (Milano & Gascón, 2023; Mohammed Alnasser, E., Mohammed Alkhozaim, 2024). According to Hidayat et al (2023), community-based tourism, which includes active participation of the local people in the management and planning of tourism activities, is bound to be more sustainable and equitable (Hidayat et al., 2023). By this approach, both the people of the host community an the visitors are served to the maximum as they will learn from each other's cultures and appreciate environmental conservation (Nguyen & Thanh, 2023).

Overall, the main decarbonization indicators used in various studies include: Transportation Indicators, Accommodation Indicators, Policy and Governance Indicators, and Carbon footprints.

Transportation indicators include share of tourists using trains, electric vehicles (EVs), and biofuel-powered transport instead of conventional fossil fuel-based transport; Average CO_2 emissions per passenger per km for flights within and to/from the EU; Adoption of Sustainable Aviation Fuels (SAFs): Percentage of SAF usage in the aviation sector; Number of EV Charging Stations at Tourist Destinations;

Percentage of visitors relying on buses, trams, and trains instead of private vehicles; Number of airlines and travel agencies offering and implementing carbon offset schemes.

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Accommodation Indicators includes Number of hotels and accommodations certified with eco-labels such as EU Ecolabel, Green Key, or LEED, Amount of energy and water used per guest-night in tourism accommodations; Share of electricity sourced from renewables in tourism accommodations; Reduction in waste generation in hotels and tourist facilities and Implementation of Circular Economy Practices like Hotels and businesses integrating circular economy principles, such as recycling, reducing food waste, and sustainable procurement.

The policy and governance indicators include a number of National and Local Tourism Decarbonization Policies, Inclusion of tourism in national climate action plans and commitments to net-zero targets, Availability of grants, subsidies, or tax benefits for green tourism initiatives, and Introduction of environmental taxes on tourists to fund sustainability projects.

Carbon Footprint and Environmental Impact Indicators include Total CO_2 Emissions from the Tourism Sector: Absolute and per capita emissions from tourism-related activities, Energy consumption per GVA created by tourism sector; GHG Emissions Reduction Compared to Previous Years; Amount of waste produced per visitor in key tourism destinations, etc.

Consumer Behavior and Awareness Indicators include Percentage of Tourists Choosing Sustainable Travel Options; Number of travel agencies offering green-certified tours and experiences, Increase in consumer awareness campaigns and sustainability education, etc.

Based on the review of available decarbonization indicators for the tourism sector, the framework of indicators of decarbonization of tourism destinations for EU countries was developed by taking into account the EUROSTAT data available and used in the EU Tourism Dashboard (European Commission, 2025) (Table 1).

Table 1. **Decarbonization indicators of tourism destinations countries**

Indicator	Measure	Description	Source
Air travel GHG emission intensity,	kg CO_2eq/passenger	This indicator presents the average amount of CO_2 emitted by air passengers per reporting country of tourism destination. It is obtained as a ratio between the CO_2 emitted by all passenger flights and the number of passengers per year. The data is related to the airport of departing flights. Higher values are associated with long-haul flights.	EUROSTAT
Tourism GHG intensity	CO_2 eq/mill EUR	This indicator reports the GHG emission intensity of the tourism sector. It is assessed as the ratio of the total amount of GHG emissions and the Gross Value Added created by the tourism sector. The GHG emissions in tons of CO2 eq include the CO2, N2O, CH4, HFC, PFC, SF6, and NF_3. Lower values show a lower contribution of the tourism sector to climate change.	EUROSTAT
Tourism energy intensity	TJ / Million EUR	This indicator presents the energy intensity of the tourism sector. It is evaluated as the ratio of the total amount of energy in terajoules (TJ) and Gross Value Added created by the tourism sector (in Million Euros at constant 2015 prices). Lower values show a higher energy efficiency.	EUROSTAT
Share of trips by train	%	This indicator presents the relative importance of sustainable means of transportation within a tourism destination. It is calculated as a ratio between the number of trips by train and the number of trips by all modes of transport. Higher indicator values indicate a more widespread use of	EUROSTAT

		the train for domestic travel which has lower environmental impacts compared to other modes of transport.	
Dependence on distant origins	%	This indicator assesses the dependence of a country's tourism destination on distant flights. It is assessed as the percentage of nights spent at accommodation establishments by foreign tourists from geographically distant territories. Within the European continent, the distant countries are situated in distance of 2000 km or higher from the tourism destination. Countries outside the European continent are always assumed distant destinations. A high value of this indicator shows a higher environmental footprint due to long-distance travelling.	EUROSTAT

Source: created by authors based on European Commission, 2025

The indicator framework presented in Table 1 will be applied in case study for Baltic States provided in section 3.

3. Decarbonization of the tourism sector: case study of the Baltic States

The case study aims to apply decarbonisation indicators for the Baltic States and compare and rank the Baltic states, i.e., Estonia, Latvia, and Lithuania, based on their achievements in decarbonisation of their tourism sector as a country of destination by applying the MCDM tool TOPSIS.

3.1 Data

The main data for assessing decarbonization indicators presented in Table 1 for the Baltic States case study is provided in Table 2. All data was collected from Eurostat.

Table 2. **Data for ranking the Baltic States based on decarbonization indicators of tourism destinations**

Countries						Desirable trend
	Air travel GHG emission intensity, kg CO2eq/passenger					
	2019	2020	2021	2022	2023	
Latvia	61.14	89.68	99.62	63.22	43.49	Decrease
Estonia	59.50	82.64	100.59	64.68	57.06	
Lithuania	57.58	89.88	83.61	63.41	59.66	
EU-27	106.93	157.65	140.54	103.16	91.28	
	Tourism GHG intensity, tons CO2 eq/mill EUR					Decrease
Latvia	57.77	68.71	67.14	44.24		
Estonia	66.42	112.81	62.72	48.85		
Lithuania	63.82	50.84	77.80	58.91		
EU-27	65.57	24.46	76.02	51.39		
	Tourism energy intensity, TJ / Million EUR					Decrease
Latvia	2.65	3.05	3.03	3.01		
Estonia	3.25	3.61	4.09	4.00		
Lithuania	4.22	4.78	6.55	6.12		

EU-27	2.36	3.12	2.76	2.20		
	Share of trips by train, %					
Latvia	5.0	4.0	3.0	4.0		Increase
Estonia	5.0	3.0	5.0	6.0		
Lithuania	2.0	2.0	3.0	3.0		
EU-27	14.0	12.0	13.0	15.0		
	Dependence on distant origins, %					
Latvia	9.05	5.84	3.57	5.54	7.06	Decrease
Estonia	7.07	1.96	2.79	4.44	5.94	
Lithuania	6.33	2.31	3.46	5.83	7.31	
EU-27	12.42	6.41	5.83	10.54	11.89	

Source: created by authors

3.2 Methods

The case study uses the MCDM method TOPSIS for ranking Baltic States based in their decarbonization indicators.

This study evaluates the sustainability performance of tourism in the Baltic States—Latvia, Estonia, and Lithuania – using five decarbonization-related indicators: air travel GHG emission intensity, tourism GHG intensity, tourism energy intensity, share of trips by train, and dependence on distant origins. For each indicator, data from 2019 to 2023 were collected and analyzed separately for each indicator. The TOPSIS method was applied to each indicator using the annual data to calculate scores and ranks for the three countries.

After completing the analysis for all five indicators, the final step involved calculating the arithmetic mean of the TOPSIS scores across the indicators for each country. Based on these aggregated scores, a comprehensive ranking was established to reflect the overall decarbonization performance of tourism in the region over the five-year period.

The main steps of the TOPSIS method are provided below.

3.2.1 Step 1: Construct the decision matrix

The first step is to construct the decision matrix $= [X_{ij}]$, where each element X_{ij}represents the performance of alternative $A_i$under criterion C_j.

$$X = [x_{ij}]_{n*m} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}$$

3.2.2 Step 2: Normalize the decision matrix

Normalize the decision matrix using the following formula:

$$r_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{I} x_{ij}^2}$$

Where r_{ij} is the normalized value for alternative A_i under criterion C_j.

3.2.3 Step 3: Construct the weighted normalized decision matrix

Multiply each element of the normalized decision matrix by the corresponding criteria weight:

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$$v_{ij} = W_j * y_{ij}\,;\ (i = 1,2,\dots,I; j = 1,2,\dots,J)$$

Where v_{ij} is the weighted normalized value for alternative A_i under criterion C_j.

3.2.4 Step 4: Determine the positive ideal and negative ideal solutions

The positive ideal solution A^+ and the negative ideal solution A^- are defined as:

$$A^+ = \left[v_1^+, v_2^+, \dots, v_j^+\right] \quad (6)$$

$$A^- = \left[v_1^-, v_2^-, \dots, v_j^-\right] \quad (7)$$

Where,

$$v_j^+ = \begin{cases} \max v_{ij}, if\ j\ is\ a\ benefit\ attribute \\ \min v_{ij}, if\ j\ is\ a\ cost\ attribute \end{cases}$$

$$v_j^- = \begin{cases} \min v_{ij}, if\ j\ is\ a\ benefit\ attribute \\ \max v_{ij}, if\ j\ is\ a\ cost\ attribute \end{cases}$$

Where J benefit is the set of benefit criteria and J cost is the set of cost criteria.

3.2.5 Step 5: Calculate the separation measures

Calculate the separation of each alternative from the positive ideal solution S_i^+ and the negative ideal solution S_i^- using the Euclidean distance:

$$S_i^+ = \sqrt{\sum_{j=1}^{J}(v_{ij} - v_j^+)^2}$$

$$S_i^- = \sqrt{\sum_{j=1}^{J}(v_{ij} - v_j^-)^2}$$

3.2.6 Step 6: Calculate the relative closeness to the ideal solution

Calculate the relative closeness of each alternative to the ideal solution:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}$$

Where C_i^* is the relative closeness of alternative A_i to the ideal solution.

3.2.7 Step 7: Rank the Alternatives

Finally, rank the alternatives based on their C_i^* values. The higher the C_i^*, the closer the alternative is to the ideal solution, and thus the better the alternative.

3.3 Results

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was used to assess the tourism decarbonization sustainability performance of the Baltic States—Latvia, Estonia and Lithuania—on five main indicators. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a multi-criteria decision-making (MCDM) technique involves ranking alternatives according to the geometric distance between the alternatives and their ideal point. That is, normalize the data, apply (if any) so-called weights, determine the positive and negative ideal solutions, and calculate a closeness coefficient to the ideal solution for each alternative.

This analysis used TOPSIS separately against the following indicators based on average multi-year data (2019–2023) for each country:

- GHG Emission Intensity from Air Travel (kg CO_2eq/passenger): Latvia (0.606) ranked highest, meaning it performs better than others: fewer emissions from air travel per passenger. Estonia placed third with 0.243, indicating a larger carbon footprint for each air traveler.
- Tourism GHG Intensity (tons CO_2eq/million EUR): Once again, Latvia takes the lead (0.739) with Lithuania coming close behind (0.671) and Estonia trailing fairly low (0.274), indicating a more carbon inefficient economy in terms of the price of the tourism industry.
- Tourism Energy Intensity (TJ/million EUR)– the Estonian result was the best one (0.677), which corroborates more energy-intensive tourism, while Latvia and Lithuania got 0 points, resulting in the worst absolute energy intensity.
- Share of Trips by Train (%): Estonia (0.782) took the first place when it comes to the adoption of sustainable transport. Latvia (0.587) came next, and Lithuania scored zero, meaning that little stress is put on train through its tourism sector.
- Dependent on Remote Origins (%): Estonia was first at 0.920, indicating lower bleeding of dependence on long-haul tourists, whilst Latvia (0.055) the least part hanging on to ecologically unsustainable travel sources.

An overall TOPSIS score was calculated by harmonizing all five indicators after assessing each indicator independently.

Table 3. **Ranking of Baltic States based on decarbonization indicators of tourism destination during 2019-2023**

Air travel GHG emission intensity, kg CO2eq/passenger		
Countries	Final weights	Ranks
Latvia	0.606	1
Estonia	0.243	3
Lithuania	0.379	2
Tourism GHG intensity, tons CO_2 eq/mill EUR		
Countries	Final weights	Ranks
Latvia	0.739	1
Estonia	0.274	3
Lithuania	0.671	2
Countries	Final weights	Ranks
Tourism energy intensity, TJ / Million EUR		
Latvia	0	2
Estonia	0.677	1
Lithuania	0	2
Share of trips by train, %		
Countries	Final weights	Ranks
Latvia	0.587	2
Estonia	0.782	1
Lithuania	0	0
Dependence on distant origins, %		

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Countries	Final weights	Ranks
Latvia	0.055	3
Estonia	0.92	1
Lithuania	0.714	2
Final Ranking of countries based on all indicators		
Countries	Final weights	Ranks
Latvia	0.672296	2
Estonia	0.740471	1
Lithuania	0.221696	3

Source: created by author

These results indicate that **Estonia** holds the most sustainable tourism profile among the three Baltic States based on decarbonization indicators, driven by strong performance in sustainable transport and reduced dependence on distant markets. **Latvia** performed competitively, particularly in minimizing emissions. **Lithuania**, while performing relatively well in GHG intensity, lagged in transport sustainability and energy efficiency.

4. Discussion

A notable research limitation is that significant data issues mainly affect comparability. Besides, apparently slow progress in decarbonization can include an increase in intercontinental visits to attractive tourism destinations over the period, suggesting that climate-responsible transformation cannot be the only environment-related determinant in the tourism industry (Jones, 2024).

The goal of case study was to evaluate the decarbonization efforts of the tourism destinations in all Baltic States with the use of a particular indicator system in conjunction with the TOPSIS method. The results provide valuable information concerning the state of tourism decarbonization in Latvia, Lithuania, and Estonia for the period of 2019-2023.

Estonia has shown the best results in overall decarbonization performance, mainly due to improved sustainable transportation as well as a decrease in remote tourist numbers. Estonia's top performance in the share of trips by train and its low dependence on remote tourist origins indicate more sustainable tourism practices. These findings are in agreement with policy proposals aimed at the development of low-carbon transport infrastructure and the reduction of emissions from passenger flights into tourism source regions (Gössling & Hall, 2019; Liu et al., 2025).

Latvia's strong performance in air travel GHG intensity and tourism GHG intensity suggests a more carbon-efficient utilization of tourism transport services and economic activities. On the other hand, Latvia's relatively low score in energy intensity and dependence on distant origins represents potential shortcomings that require more focused attention. The results point to an urgent need for greater energy-efficient policies regarding the operation of tourism facilities and greater promotion of tourism within the country.

Lithuania's overall performance on GHG emissions was the weakest due to high energy intensity of tourism. Even so, their GHG intensity mitigation efforts were at a moderate level. This shows the need for development in green public transport infrastructure and the improvement of energy efficiency in the hospitality sector as these have been proven to alleviate the carbon footprint of tourism (Songur et al., 2022; Abdou et al., 2020).

One of the critical gaps addresses the transport-specific indicators having a disconnect with other sustainability-related benchmarks. The other indicator or disconnection metric Estonia excelled in was transport sustainability, where Latvia achieved the best ranking with carbon intensity. This gap reinforces that decarbonization of tourism is more comprehensive and requires an integrated approach that includes emissions targets, energy efficiency, and attitudinal changes by tourists and industry stakeholders.

The use of TOPSIS allowed for the objective ranking of the Baltic states based on each cost and benefit indicator, which quantifies them. With this, however, came other issues such as data reliability and indicator scope. Some other factors that affect the comparability of results include delays in reporting for national tourism frameworks. In addition, this work does not address the qualitative dimensions of stakeholder participation, governance, and capacity for innovation, which are critical in the literature for effective decarbonization planning (Becken, 2019; Bentley, 2024).

From a policy standpoint, case study outcomes illustrate the necessity for holistic approaches that comprise regulation, funding green technology, public education, and society engagement. As in Indonesia and other examples, there is a national strategic need to integrate the core values of sustainability into the governance of tourism (Nurjaya, 2022). In the same way, the public spending budget in with environmental considerations suggested by Skrame et al. (2020) would redirect the course of tourism development to lower carbon options.

More work should be done to evaluate the impact of certain policy measures and technological solutions of tourism emissions, particularly in the context of sub-national and destination-specific jurisdictions. Aviation emissions also require special focus due to their outsized contribution as well as the greater obstacles to implementing decarbonization policies in this segment of the industry (Mere Igreja, 2024). Furthermore, the development of behavioral economics could evaluate the effectiveness of some nudges on encouraging tourists to make environmentally friendlier choices.

This study also underscores the uneven pace of progress made by the Baltic States, which further consolidates the call for a sustained multi-dimensional policy effort and cooperation among all actors to enable complete decarbonization of tourism. As chronicled in the document, the indicators formulated have the potential of providing sustained observation, simultaneously serving benchmarking to aid regionally set policies and climate targets.

Actions to sustain tourism must be supported by relevant national legal and policy frameworks, and that is one of the most important aspects of effective tourism governance. For example, Nurjaya (2022) points out that Indonesia's Law on Tourism is one of the national development policies and legislation that embraces sustainability principles in its environmental, economic, and socio-cultural aspects (Nurjaya, 2022). Such frameworks stimulate the growth of community-based tourism entrepreneurship that brings benefit to the local people and promotes their involvement in sustainable development. The "sustainability" concept in the legal frameworks of tourism is important because it ensures that the needs of the environment as well as the community are met (Nurjaya, 2022).

Furthermore, Bentley (2024) talks about the positive effects of community participation at all levels, including planning and managing tourism, to maximize its benefits and mitigate its adverse impacts (Bentley, 2024). Some of the stakeholders in a community, like local people, government agencies, and the private sector, will have to work together, which portrays good governance (Androniceanu, 2024). Such engagement promotes stewardship among the various stakeholders which is important for the success of sustainable tourism strategies. The issue of responsibility, especially in the context of environmental sustainability, is said to be improved through education and awareness campaigns in the tourist-receiving areas (Bentley, 2024).

Another important area is the examination of the impacts of government policies on tourism supply chains. As indicated in Chiwaridzo (2023), government policies bear considerable impact on the behavior of the tourism supply chain, which affects social sustainability performances (Chiwaridzo, 2023). The analysis shows that policies requiring community participation can encourage local involvement, which enables the fulfillment of government intentions at the community level. There are hurdles to overcome, however, as tourism supply chains tend to block local people from participating in the tourism economy (Chiwaridzo, 2023). This highlights the need for policies that not only address sustainability but also ensure that all the benefits accruing from tourism are shared fairly among tourism stakeholders.

Effective public investment choices also reflect the value of governance in fostering the sustainable development of tourism. As Skrame et al. (2020) remind us, evaluating tourism investments through the prism of sustainability ensures that public funds are spent on responsible projects (Skrame et al., 2020). This, in turn, helps to substantially reduce the negative consequences of tourism and promote positive social change in the communities that host the activities.

It is necessary to develop policies for achieving sustainability in the tourism sector. The literature emphasizes the importance of having robust legal instruments, stakeholder participation, targeted policies, and flexible governance frameworks for achieving good practice in sustainable tourism. With the adoption of the principles of sustainability in tourism governance, a reduction in carbon emissions from tourism development can be realized while enhancing the well-being of local communities and safeguarding nature. The enduring threats posed by climate change and global phenomena, such as the pandemic, make the case for more effective and adaptive governance frameworks even more compelling for sustainable tourism development.

Future research can delve into an analysis of the negative impacts of international transportation, including aviation, and develop a carbon footprint for various activities linked to tourism, like the hospitality sector, and local transportation modes. The role of renewable energy sources in tourism should be highlighted, and possibilities should be further explored. Future research should also include an analysis of policy, regulations, and governance to reduce GHG emissions from the tourism sector. (Mereotlhe, 2024). Future research cannot undermine the analysis of policies and measures taken, especially in evaluating their effectiveness towards carbon emissions' reduction in the tourism sector (Liu et al., 2025).

5. Conclusion

Decarbonization of tourism indicators is necessary for measuring the progress of EU countries to measure their progress toward a decarbonized tourism sector, aligning with the EU's Green Deal and Fit for 55 strategies. The implementation of these indicators will contribute to a more sustainable and environmentally friendly tourism industry.

This research developed and implemented a set of decarbonization indicators to evaluate the transitions of the tourism industry in the Baltic States: Latvia, Lithuania, and Estonia, towards low-carbon development pathways. Through using the TOPSIS method, we were able to quantitatively rank the performance of these countries based on five indicators: the intensity of GHG emissions per air travel, intensity of GHG emissions per tourism, intensity of energy consumption per tourism, share of trips by train, and dependency on remote origins.

The results clearly demonstrate that Estonia leads the region in overall decarbonization performance, driven by its strong outcomes in sustainable transportation and reduced long-haul tourism market dependency. Latvia showed commendable results in emission-related indicators, portraying improved carbon efficiency in its tourism economy, albeit there were considerable weaknesses in energy use efficiency and sustainable mobility. Lithuania had the lowest performance overall, despite having made some progress in mitigating GHG emissions, due to considerable issues with energy efficiency and sustainable transport infrastructure.

The analysis substantiates the proposition that movement toward decarbonized tourism needs a holistic view that combines the means of transport, accommodation, energy supply, and tourist behavior. The disparity of results in performance across indicators and countries calls for more focused national policies paired with data-driven monitoring and benchmarking frameworks to track progress through standardized measurements.

There is a clear need to realign national plans for tourism development with sustainability objectives, including the promotion of green investment, travel behavior, governance, and green policies for tourism. In addition, the construction of comprehensive indicator systems like the one used in this work can support evaluation processes with evidence-based regional decision-making and collaboration.

In the end, coordinated efforts from governments, industry, and consumers are necessary to shift toward low-carbon tourism in the Baltic region and around the world. Future studies should focus more on stakeholder participation and the implementation of policies that are more effective in high-emission activities like aviation. Without well-orchestrated and continuous action, achieving meaningful climate objectives and long-term sustainability through tourism remains out of reach.

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