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Article

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Administrative Sciences

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Suggested Citation: Leal, Fátima; Pinho, Micaela Moreira (2024) : Intelligent exchange of sustainable tourist habits among the EU member states, Administrative Sciences, ISSN 2076-3387, MDPI, Basel, Vol. 14, Iss. 6, pp. 1-17,
<https://doi.org/10.3390/admsci14060128>

This Version is available at:

<https://hdl.handle.net/10419/320944>

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Article

Intelligent Exchange of Sustainable Tourist Habits among the EU Member States

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Abstract: Despite much research being conducted within the scope of sustainable tourism, more progress has yet to be made in defining how close or far different countries are from achieving this goal. Consequently, this paper aims to evaluate and compare the commitment of citizens, as tourists, from the 27 member states of the European Union to sustainable tourism. A map of sustainability was developed through the use of machine learning algorithms. A cluster analysis was performed, followed by a sustainable rating. The main findings indicate the existence of three country segments among the European Union member states according to the involvement of its citizens as tourists with sustainable practices: highly committed, moderately committed, and uncommitted. Based on these segments, we proposed a recommendation system that suggests the top-five countries where tourists could exchange sustainable tourism habits based on the idea of contagion or imitation behaviours among individuals across an extensive set of everyday decisions. The results reveal significant variations in sustainable tourism practices across member states, highlighting both challenges and opportunities for harmonisation. By implementing this recommendation system, we facilitate the adoption of sustainable habits among tourists and stakeholders, driving a more unified approach to sustainability in the multiple tourism destinations. This study shows no convergence between the 27 European Union member states regarding sustainable tourism. Therefore, political policies are necessary so that all citizens converge on sustainable tourist habits and the European Union contributes, as a whole, to sustainable tourism.



Citation: Leal, Fátima, and Micaela Pinho. 2024. Intelligent Exchange of Sustainable Tourist Habits among the EU Member States. *Administrative Sciences* 14: 128. <https://doi.org/10.3390/admsci14060128>

Received: 26 April 2024

Revised: 3 June 2024

Accepted: 14 June 2024

Published: 19 June 2024



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Keywords: sustainable tourism; clustering; machine learning; tourists' sustainable behaviours; sustainability information availability; recommendation systems

1. Introduction

The planet is on fire and the world is in ‘great peril’, as the United Nations Secretary-General said in 2022. He recently encouraged the political leaders gathered for the Conference of Parties (COP) 28 (taking place while this article is being written) to get us out of ‘deep’ troubles. The economic progress that we benefit from was achieved without considering the Earth’s natural limits. Humanity has made selfish decisions in pursuit of its maximum well-being, ignoring the costs they sow along the way, jeopardising the well-being of future generations (their children and grandchildren). Recognising that society will collapse when these limits are exceeded has been one of the first movers toward sustainability. There has been a widespread call for a sustainable form of development. Sustainable development seeks to rediscover the balance between the economy, society, and the environment. Sustainable development was first defined in the Brundtland Report released in 1987 by the World Commission on Environment and Development, as a level of development that meets the needs of the present without compromising the ability of

future generations to meet their own needs [Jarvie \(2016\)](#). To signal their involvement and commitment to this cause, the United Nations developed the 2030 Agenda for Sustainable Development, comprising 17 sustainable development goals by 2030 [United Nations \(2015\)](#) by the 193 signatory countries. The tourism sector plays a vital role in this context.

Tourism is a highly significant economic sector globally and locally. This service sector has grown exponentially in recent years (except the pandemic years), becoming one of the world's largest industries. The positive economic impacts of tourism cannot be overstated. This sector generates revenues, creates jobs, and develops local communities while boosting other sectors such as transportation, hospitality, and retail. The tourism and travel industries represented 7.6% of the worldwide gross domestic product in 2022 [Eurostat \(2023\)](#), which will undoubtedly rise since the sector is still recovering from the COVID-19 pandemic. However, tourism benefits the state and simultaneously involves costs that translate into high flows of natural resources, excessive energy and water consumption, and increasing adverse environmental effects, including climatic change. According to the United Nations World Tourism Organisation (UNWTO) [Organization and Forum \(2019\)](#), tourism is estimated to contribute to 5.3% of worldwide carbon emissions in 2030.

The impact of tourism on the environment began to be recognised in the late 1980s. [Nash and Butlers \(1990\)](#) created the concept of sustainable tourism to reduce the adverse effects of tourism activities. This topic is of the utmost importance for two main reasons. First, the tourism sector finds itself at a crossroads, as the continuity of the tourism industry depends on the health of the environment (e.g., healthy marine ecosystems are determinants for coastal and maritime tourism, while rich biodiversity and natural heritage are attractions in destinations) while simultaneously being a significant contributor to its destruction. Second, the tourism sector has the potential to contribute to the 17 Sustainable Development Goals (SDGs) (e.g., the tourism sector helps to eradicate poverty by creating jobs in local communities—SDG1—while the taxes it generates can be reinvested in the provision of health services, resulting in better health for all—SDG3).

Sustainable tourism aims to guarantee a balance between protecting the environment, maintaining cultural integrity and social justice ([Liu et al. 2013](#)), promoting economic benefits to meet the needs of the host population for better standards of living ([Park and Yoon 2009](#)), and encouraging and cultivating tourism in lesser-known and less-frequented destinations. In this debate on sustainable tourism, circular tourism is gaining prominence, and, based on the theory of the circular economy, its numerous advantages for achieving more sustainable tourism have been put forward [Axhami et al. \(2023\)](#); [Florido et al. \(2019\)](#). Tourists' pro-environmental behaviours are one of the main ways to achieve tourism sustainability, namely, through following certain practices such as reducing waste and water usage, choosing more ecological modes of transport, opting for local products, choosing less visited destinations, taking holidays outside the high season, and contributing to carbon-offsetting activities ([Li and Wu 2020](#); [Pronello and Gaborieau 2018](#); [Wu et al. 2021](#)).

Sustainable tourism has become an increasing field of research ([de Bruyn et al. 2023](#); [Streimikiene et al. 2021](#); [Yang et al. 2023](#)), although this proliferation of the literature presents weaknesses ([Liu et al. 2013](#)). One of the most important limitations is considering the sustainability of destinations exclusively through a supply perspective. There is a need to rethink human–environment relations since tourists, through their behaviours/attitudes, play a crucial role in achieving sustainable tourism. Therefore, the focus should shift from the sustainable tourism supply side toward the demand side. Reaching a new tourism model with a central value in sustainability depends on the importance that tourists give to sustainability and how they are committed to contributing to it. In this regard, research has shown that a possible way to integrate sustainability into the planning of tourism destinations is to attract tourists who are intrinsically interested in protecting the destination they visit and, consequently, behave responsibly ([Dolnicar 2006](#); [Kastenholz et al. 2018](#)). Therefore, to achieve sustainable tourism, it is necessary to determine the tourists' heterogeneity to define segments based on the behaviours and attitudes associated with the sustainability philosophy to be analysed. The segmentation of the tourism market

and the definition of the size and relevance of each segment ensure the formulation of policies that are the most appropriate and tailored to the markets' needs. Furthermore, data and information are paramount to achieving sustainable tourism, as this process is interactive. On the supply side, there is constant monitoring of impacts to, when necessary, introduce preventive and/or corrective measures [O'Mahony et al. \(2009\)](#). On the demand side, information concerning tourism destination sustainability may influence tourist travel planning [Streimikiene et al. \(2021\)](#) and make them more compelling with sustainable tourism [Tang et al. \(2022\)](#). Thus, information is crucial for implementing and monitoring sustainable tourism. Even so, a recent study reveals that, although the actors are more involved in monitoring tourism, their importance to environmental and social monitoring is lower than that given to economic monitoring [Dias et al. \(2023\)](#).

Although there are a few segmentation studies on sustainable tourism (described in the next section), this domain lacks research to segment travellers considering both (i) the availability of tourists to change tourism habits and (ii) the relevance of accessing trustworthy sustainable information for travel planning. Additionally, no research has been conducted to explore the sustainable behaviour of European Union tourists.

The present study aims to overcome these limitations and shed light on how to build an integrative framework of the state of sustainable tourism in the European Union (EU) to help formulate policies that lead all member states to achieve the same goal: to reach sustainable tourism in the EU as quickly as possible and thus become closer to reaching sustainable development as featured in the 2030 Agenda for Sustainable Development. The present paper intends to contribute to sustainable tourism development by providing information that contributes to the informed participation of all relevant stakeholders, namely, tourists, regulators, host community members, service providers, marketers, and strong political leadership, to ensure wide participation and consensus building.

Therefore, the current research aims to explore, through machine learning (ML), tourist segmentation by the 27 EU member states based on their sustainable travel habits and the availability of trustworthy sustainable information in tourism destinations. This study builds on secondary data from the Flash Eurobarometer 499—'Attitudes of Europeans towards Tourism' ([GESIS 2022](#)), concerning 25,711 citizens from the 27 European Member States. The study takes place in two phases. First, a clustering analysis is conducted to group the data (countries) based on similarities in tourism sustainability ([Rokach and Maimon 2005](#)). Afterwards, to confirm the cluster analysis results, a sustainability rating by country is calculated. This aims to attribute a certain degree of sustainability to each European country based on tourist habits. In the second phase, an analysis per respondent is carried out. Here, the profile of each respondent is analysed and compared with the previous results to allocate each respondent to the previously defined clusters of countries. The allocation decisions or recommendations are processed by employing content-based filtering, which calculates the similarity between countries and the corresponding respondents. The intention is to create a 'behavioural contagion effect' based on the hypothesis defended in the literature that individuals mimic each other in everyday life, which may have significant environmental consequences ([Zorell 2020](#)).

The main results suggest the existence of three countries' segments according to the involvement of its citizens, as tourists, with sustainable practices: (i) highly committed (sustainable level 3); (ii) moderately committed (sustainable level 2); and (iii) uncommitted (sustainable level 1). Considering these three segments, for each respondent, five countries were recommended where the behaviour contagion effect can be increased regarding sustainability. This study is relevant to the sustainable tourism literature since it is the first to segment the 27 EU member states' tourism paths through a combination of quantitative methods.

The remainder of the paper is structured as follows. Section 2 addresses the literature related to segmentation analysis in tourism sustainability. Section 3 describes the proposed method. Section 4 discusses the experimental results. Section 5 discusses the results

comparing with the literature. Section 6 presents the concluding remarks. Finally, Section 7 details the implication of this work in the tourism domain.

2. Related Work

As global tourism expands, the imperative for sustainable practices within the industry becomes increasingly critical. Sustainable tourism aims to minimise environmental impacts, support local economies, and preserve cultural heritage, ensuring that tourism development meets the needs of present generations without compromising the ability of future generations to meet their own needs. The literature on sustainable tourism is vast and multifaceted, encompassing various strategies and approaches designed to promote sustainability across different segments of the tourism market and the role of technology in multiple SDGs.

This paper addresses an intelligent exchange of sustainable tourism habits by employing a segmentation analysis and a recommendation system. Sustainable tourism and segmentation explore the diverse market segments within the tourism industry and how tailored sustainable practices can effectively address the unique needs and behaviours of different tourist groups. By understanding the distinct characteristics and motivations of various segments, stakeholders can develop targeted strategies that enhance the adoption of sustainable practices. Recommendation approaches for sustainable tourism delves into the technological and methodological advancements in recommendation systems to promote sustainable tourism behaviours. This includes examining how ML and data-driven recommendation systems can personalise travel experiences to encourage eco-friendly choices and the broader implications of these technologies in fostering a contagion effect of sustainability within the tourism sector.

2.1. Sustainable Tourism and Segmentation

With tourism being a significant contributor to economic growth and cultural exchange in the European Union, there is an increasing emphasis on understanding and promoting sustainable tourism practices. Sustainable tourism is an important topic within a broader spectrum of sustainable development. However, the increasing existing research showed its complexity since just a small tiny percentage of the research focuses strictly on sustainability. Roberts et al. (2022) present a meta-analysis of tourism sustainability research highlighting the emergence of new research studies in the field. Thus, it has been recognised that sustainable tourism requires a more critical and comprehensive analysis Butler et al. (2003).

Sustainable tourism requires a permanent monitoring of impacts, employing preventive and/or corrective measures or initiatives that aim to reduce environmental impact and support local communities. However, (López-Sánchez and Pulido-Fernández 2016) state that sustainable tourism should focus on the visitors. In this regard, there is increasing empirical literature concerning sustainable tourism segmentation to group tourists using multiple characteristics. By definition, market segmentation is a process of dividing individuals into subgroups based on specific characteristics approaching multiple contexts.

A segmentation strategy enables the determination of the number of segments and the classification criteria used for profiling the segment members. The relevance of segmentation is widely acknowledged Tkaczynski et al. (2009), and the literature has proposed many bases to segment tourism markets. In tourism, segmentation profiling has considered geographic, demographic, socioeconomic, psychographic, or behavioural characteristics, as proposed by Kotler and Armstrong (2010). It allows the creation of homogeneous tourist groups, to serve them accordingly and to develop effective tourism policies Mazanec and Dolnicar (2020).

With this regard, Bassi and Martín (2024) investigated the willingness of citizens from the 27 EU countries to alter their travel and tourism habits toward more sustainable behaviours, contributing to the recent literature on the interplay between tourism and sustainability. By applying a multilevel analysis to account for the hierarchical structure of the data (citizens within countries), the study identified seven distinct groups of European

citizens based on their willingness to adopt sustainable tourism practices. These groups were profiled using sociodemographic variables, allowing for a detailed description of typical citizens in each cluster. [Mathrani et al. \(2023\)](#) explored the performance of Asian countries in different dimensions of Sustainable Development Goals (SDGs). Specifically, they proposed a clustering analysis to analyse Asia sustainability, finding that West and South Asian countries perform better than other Asian regions. Similarly, [Çağlar and Gürler \(2022\)](#) employed a clustering approach to analyse 110 countries worldwide regarding socioeconomic and politico-cultural structure. [Penagos-Londoño et al. \(2021\)](#) proposed three segments based on economic, sociocultural, and environmental dimensions of perceived sustainability using tourists from Chile and Ecuador, employing a clustering method for segmentation. [López-Sánchez and Pulido-Fernández \(2016\)](#) analysed data from tourists in Western Costa del Sol, Spain, to measure “sustainable intelligence” through latent class analysis. Lastly, [Kastenholz et al. \(2018\)](#) used a scale to assess sustainable travel behaviour at a rural destination, covering environmental, cultural, social, and economic sustainability dimensions. Their hierarchical cluster analysis reveals two segments: active preservers of nature and culture, and local nature, culture, and community seekers.

In fact, most segmentation studies in tourism use socio-demographic, psychographic, and behavioural characteristics to segment tourists concerning destination sustainability and trustworthiness ([Bassi and Martín 2024](#); [Carvache-Franco et al. 2022](#); [Cooper et al. 2018](#); [Kastenholz et al. 2018](#); [López-Sánchez and Pulido-Fernández 2016](#); [Nickerson et al. 2016](#)). However, according to [Tkaczynski et al. \(2009\)](#), demographic factors are questionable given their low accuracy in predicting actual consumer behaviour, claiming that no research has considered which variables tourism stakeholders use for segmentation. Meanwhile, ([Glyptou et al. 2022](#)) have proposed a segmentation approach using different indicators that measure sustainable performance such as environmental footprint, destination dependency on tourism, and locals’ prosperity. [Glyptou et al. \(2022\)](#) analysed Mediterranean countries regarding sustainability to formulate environmental footprint, destination dependency, and locals’ prosperity indicators.

2.2. Recommendations Approaches for Sustainable Tourism

Promoting sustainable tourism has become an increasing priority on global agendas due to its environmental, economic, and social implications. In this context, recommendation systems, together with ML techniques, can have an important role in this challenge. Recommendation systems are algorithms designed to suggest relevant items to users. These items can range from products, services, and content to destinations and activities in the context of tourism. Recommendation systems analyse patterns in user behaviour to provide personalised suggestions. They are widely used in e-commerce, streaming services, and social media to enhance user experience by tailoring recommendations to individual needs. Recommendation applications rely on ML, enabling systems to learn and improve from experience without being explicitly programmed. ML algorithms use statistical techniques to identify patterns in data, make predictions, and improve decision-making processes over time. In the context of recommendation systems, ML techniques such as collaborative filtering, content-based filtering, and hybrid approaches are employed to enhance the accuracy and relevance of recommendations [Ricci et al. \(2011\)](#).

Collaborative filtering makes recommendations based on the preferences and behaviours of similar users. There are two main types of collaborative filtering: (i) user-based and (ii) item-based. While user-based recommends items that users with similar tastes and preferences liked in the past, item-based recommends items similar to those that the user has liked. In turn, the content-based filtering approach recommends items based on the attributes of the items and the user’s past interactions. For example, if a user likes eco-friendly hotels, the system will recommend other hotels with similar features. It relies on analysing item descriptions and user profiles to match preferences. Finally, hybrid approaches combine collaborative and content-based filtering to leverage the strengths of each method and improve recommendation accuracy. Hybrid systems can use various

strategies, such as combining the results of both methods or switching between methods depending on the context [Fátima Leal et al. \(2021\)](#).

Recommendation systems serve an important role in promoting sustainability by suggesting sustainable activities and less popular destinations to users. These systems utilise ML algorithms to suggest destinations and activities that minimise environmental impact and promote the local economy. [Banik et al. \(2023\)](#) demonstrate that including sustainable options in intelligent suggestions encourages tourists to choose sustainable and less popular areas. [Adaji and Adisa \(2022\)](#) present a review of the use of persuasive technologies to influence sustainable behaviour. The main findings indicate that the majority of applications focus on energy conservation and sustainable food management, leaving a research gap in the domain. In addition, [Felfernig et al. \(2023\)](#) surveyed recommendation systems platforms that support the achievement of the 17 Sustainability Development Goals. The study has identified research issues for sustainability as sustainable evaluation metrics, nudging, contextual explanations, consequence-based explanations, and constraint-based recommendations. In this paper, we employ recommendation systems as a nudge for sustainable tourism, i.e., provoking an intelligent exchange of sustainable tourism habits among EU members. This idea is supported by the empirical literature ([Centola et al. 2018](#); [Fieldhouse and Cutts 2012](#); [Partheymüller and Schmitt-Beck 2012](#); [Zorell 2020](#)) concerning health-related behaviours, consumer trends, electoral behaviours, and public opinions, which have revealed that conscious imitation and unconscious contagion of attitudes and behaviours happen across an extensive set of everyday decisions.

2.3. Contributions

The literature on tourism sustainability analysis reveals a lack of fundamental studies in EU countries. In this context, this paper contributes a clustering analysis that groups the EU countries into three different clusters using the Eurobarometer survey on the attitudes of Europeans towards tourism. In addition, we propose a sustainability-level approach that rates each country considering their tourist habits. Table 1 compares illustrative approaches regarding the sustainable analysis, the countries contemplated, and the representation of the results. As far as we know, none of these approaches offer an analysis of EU member states or a cartographic representation of the results. Although multiple recommendation systems have been developed to promote sustainable tourism, we found a research gap in recommending tourists from countries where sustainability values are deeply developed to less sustainable countries and vice versa. With those recommendation, the main contribution is to create a contagion effect regarding sustainable habits. The contagion effect of sustainable tourism fosters widespread adoption of eco-friendly practices, leading to significant environmental conservation and promoting local cultures and economies [Bothos et al. \(2015\)](#). By encouraging sustainable tourism practices, destinations can create a ripple effect that enhances the tourist experience and ensures long-term benefits for local communities and ecosystems [Bothos et al. \(2015\)](#).

Table 1. Comparison of the literature concerning sustainability analysis.

Approach	Analysis	Countries	Contagion Effect
Bassi and Martín (2024)	multilevel latent class	EU	No
Mathrani et al. (2023)	clustering	Asian	No
Çağlar and Gürler (2022)	clustering	110 worldwide	No
Glyptou et al. (2022)	clusters	Mediterranean	No
Penagos-Londoño et al. (2021)	clustering	Chile and Ecuador	No
López-Sánchez and Pulido-Fernández (2016)	latent class	Western Costa Del Sol	No
Kastenholz et al. (2018)	hierarchical cluster	Portugal	No
Our Proposal	clustering statistical	EU countries	Yes

3. Proposed Method

This paper proposes a segmentation of sustainable tourist beliefs from the 27 EU member states and an intelligent exchange of sustainability tourism habits among the EU member states using data from 25,711 participants from the 27 EU member states. The data were collected in October 2021 through the Flash Eurobarometer 499 (GESIS 2022). Figure 1 introduces the proposed solution, which encompasses (i) inputs from the Flash Eurobarometer survey on Attitudes of Europeans towards tourism; (ii) a data analysis module; and (iii) a recommendation module. The data analysis module comprises a cluster analysis produced through ML algorithms and, to confirm this segmentation, a country's tourism sustainability rating was calculated using statistical analysis.

Based on this data analysis, a content-based recommendation system is produced to allocate each respondent to the five countries where they can influence or be influenced by the local tourist habits.

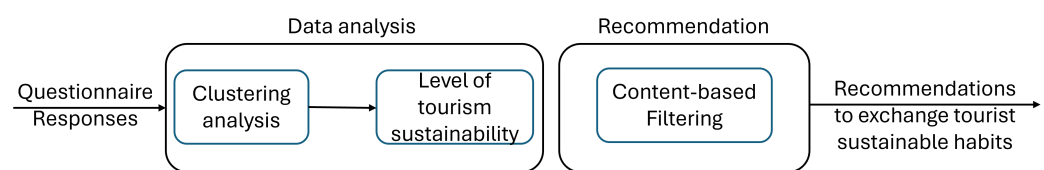


Figure 1. Recommendations to exchange sustainable culture in EU member states.

3.1. Clustering Analysis

The current work employs a clustering approach to analyse the countries in terms of sustainability, considering tourist sustainable habits and the availability of trustworthy sustainable information in tourism destinations. Clustering is an unsupervised ML technique that is used to group similar data points. It aims to identify inherent patterns, structures, or relationships within a dataset. This process involves partitioning a set of objects into subsets, or clusters, where objects within the cluster share common characteristics. Standard clustering methods include *k*-means clustering, hierarchical, and density-based clustering. Due to its simplicity, efficiency, and interpretability, *k*-means has been a widely used clustering algorithm. The simplicity and computational efficiency are suitable for large datasets, enabling rapid exploration of clustering solutions. Additionally, *k*-means produces clusters that are easy to interpret. Moreover, *k*-means converges quickly, especially with well-chosen initial centroids, making it efficient for practical applications. Furthermore, its availability in widely used ML libraries ensures easy accessibility for researchers.

k-means is a widely used clustering algorithm in unsupervised ML. The main goal is to partition a dataset into *k* clusters, each representing a group of data points with similar characteristics where *k* stands for the predetermined number of clusters that algorithm detects. To determine the optimal number of clusters, we use the Elbow method. It is a graphical tool used in data analysis that resembles an Elbow, where the optimal number of clusters is situated. The *k*-means algorithm operates as follows (Hastie et al. 2009):

1. Randomly select *k* data points as the initial cluster centroids;
2. Assign each data point to the cluster whose centroid is closest based on distance metrics, e.g., Euclidean distance;
3. Recalculate the clusters' centroids by taking the mean of all data points assigned to each cluster;
4. Repeat Steps 2 and 3 until convergence, i.e., when the centroids do not suffer changes or when a specified number of iterations is reached.

In the present study, we employ *k*-means to group the 27 EU member-state countries regarding their tourists' willingness to change travel and tourism habits to become more sustainable and the availability of trustworthy sustainable information in tourism destinations.

3.2. Level of Tourism Sustainability—Sustainability Rating

The definition of a sustainability rating through statistical analysis is another method of grouping countries that validates the clustering methodology presented above and is pursued through ML. This method quantifies the questions using a scale between 1 and 3.

Our approach is based on a standard average (μ) according to Equation (1), where q_n^c indicates the value of the country c of the question n , and C is the total number of countries. Therefore, for both questions, we calculate the standard average (μ) considering the number of answers per country, according to Equation (1):

$$\mu_n = \frac{1}{C} \sum_{c=1}^C q_n^c \quad (1)$$

Then, to obtain the statistically sustainable level of each question, we calculate the average of the numbers above and below μ , obtaining μ^+ and μ^- . Finally, a question obtains the statistical level $sl_{q_n}^c$, according to Equation (2):

$$sl_{q_n}^c = \begin{cases} 1 : q_n^c < \mu_n \\ 2 : \mu \leq q_n^c < \mu_n^+ \\ 3 : q_n^c \geq \mu_n^+ \end{cases} \quad (2)$$

The final level is the average of the statistical levels per question, as depicted in Equation (3), where N is the number of questions:

$$\mu = \frac{1}{N} \sum_{n=1}^N \mu_n \quad (3)$$

3.3. Content-Based Filtering

Content-based filters in recommendation systems match users with items. They create profiles based on past interactions and make recommendations based on the similarity between the users' content and items, i.e., regardless of other profiles. In this paper, we calculate the similarity among countries and respondents using cosine similarity, as depicted in Equation (4):

$$\cos(\mathbf{t}, \mathbf{e}) = \frac{\mathbf{t} \cdot \mathbf{e}}{\|\mathbf{t}\| \|\mathbf{e}\|} = \frac{\sum_{i=1}^n t_i e_i}{\sqrt{\sum_{i=1}^n (t_i)^2} \sqrt{\sum_{i=1}^n (e_i)^2}} \quad (4)$$

The cosine similarity corresponds to the cosine of the angle formed between t (profile of the respondent/tourist) and c (profile of the country). The nearer the results approach one, the more appropriate the country is for recommendation.

4. Experiments and Results

The experiments use the answers of 25,711 European Union citizens retrieved from the Flash Eurobarometer 499 (GESIS 2022). Specifically, these experiments involve two different data analysis methods to explore the level of sustainability of the EU based on citizens' travel habits and the availability of trustworthy sustainable information in tourism destinations. While clustering analysis groups the countries in the cluster using k -means, the statistical sustainability level rates the country's level of sustainability by applying an ordinal scale between 1 and 3. These ordinal scales combined with individual respondents' profiles are then used to allocate each respondent to a group of countries.

4.1. Dataset

The Eurobarometer survey on Attitudes of Europeans towards tourism aims to analyse the long-term impact of COVID-19 on EU citizens concerning travelling behaviours. Furthermore, the survey approaches the importance of sustainability to improve the tourism

experience. For this Flash Eurobarometer, a representative sample of citizens aged 15 and over was interviewed in each of the 27 member states of the EU.

Between 18 and 28 October 2021, 25,714 interviews were conducted over the telephone (landline and mobile phones). The present paper uses two questions from the Flash Eurobarometer 499. Only questions that dealt with the topic of sustainable tourism were selected. The first question (5th question in the survey) collects information on participants' willingness to change travel and tourism habits in favour of sustainability through 10 items. The second question (7th in the survey) gathers respondents' perceptions of the availability of trustworthy information concerning the destination practices of sustainability through five items. A detailed description of both questions is summarised in Table 2.

Table 2. Questionnaire description.

Variable Description	Categories	Scale
Question 1—q1. 'Are you prepared to change your travel and tourism habits to be more sustainable? If so, in which of the following ways?'	0—No * 1—Yes	Nominal
q1.1. Pay more to protect the natural environment		
q1.2. Pay more to the benefit of the local community		
q1.3. Take holidays outside of the high tourist season		
q1.4. Travel to less visited destinations		
q1.5. Contribute to carbon-offsetting activities (e.g., plant trees)		
q1.6. Consume locally sourced products on holiday		
q1.7. Choose transport options based on ecological impact		
q1.8. Reduce waste while on holiday		
q1.9. Reduce water usage on holiday		
q1.10. I am not prepared to change my habits		
Question 2—q2. 'How easy or difficult it is for you to find trustworthy information for your travel planning on the following aspects?'	Likert Scale **: 1 = 'Very difficult'; 2 = 'Rather difficult'; 3 = 'Rather easy'; 4 = 'Very easy'.	Ordinal
q2.1. Carbon footprint of transportation options		
q2.2. Eco-friendly tourism activities at the destination		
q2.3. Sustainability certifications of the accommodations		
q2.4. Sustainability commitments of destinations		
q2.5. Local sourcing of food in restaurants		

* Since multiple answers were possible, a NO answer was used for the item(s) not chosen by the participant and a Yes was used for that (those) item(s) that the respondent chose. ** We used the inverted scale of the questionnaire for better graphical interpretation.

4.2. Clustering

The clustering analysis groups the countries whose tourists had similar answers for both questions of the Flash Eurobarometer 499. To obtain the optimal number of clusters, we employ the Elbow method. This method indicates that this dataset holds three different levels of involvement of EU respondents, such as tourists with sustainable practices. Table 3 summarises detailed information about the profile of each cluster to both questions. The results indicate that most respondents from each of the three clusters were unprepared to change their travel and tourism habits (the 10th item in the first question). Therefore, the 27 EU member states can be grouped into three clusters: Cluster 1—respondents uncommitted to sustainability, Cluster 2—moderately committed respondents, and Cluster 3—highly committed respondents. The countries that compose each cluster are described in the first column of Table 4. Figure 2 maps the three clusters.

The mapping of the clusters allows us to visualise that, in general, citizens surveyed in almost all countries revealed difficulties obtaining credible information on sustainability when planning their travel. Moreover, the results suggest that respondents who were more prepared to change their travel and tourist behaviours in favour of sustainability were also

those that found it easier to gather sustainable and trustworthy information when planning their travel.

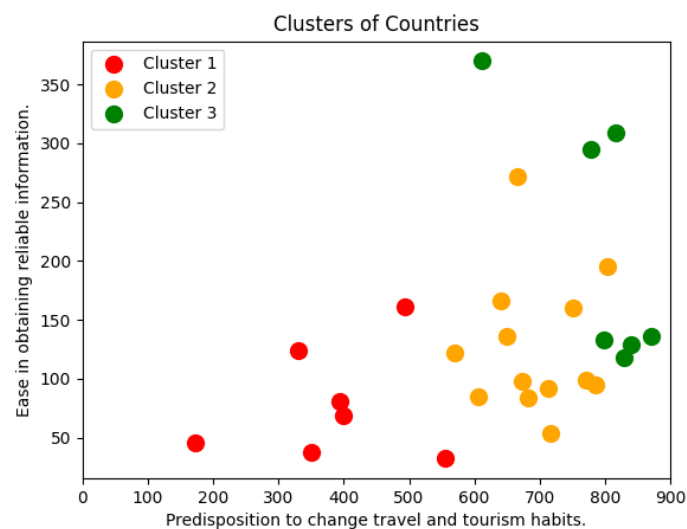


Figure 2. Countries' clustering.

Table 3. Profile of the clusters.

Question	Cluster 1	Cluster 2	Cluster 3
q1.1	342	678	827
q1.2	388	701	847
q1.3	307	553	698
q1.4	346	601	770
q1.5	368	684	862
q1.6	237	445	638
q1.7	385	695	792
q1.8	254	512	707
q1.9	411	671	857
q1.10	695	890	846
q2.1	116	193	288
q2.2	78	128	213
q2.3	85	188	268
q2.4	95	178	233
q2.5	58	117	131
Average	250	433	541

The minimum of each question per cluster is marked in bold. Respondents reveal less willingness to consume locally sourced products on holiday. Information about local sourcing of food in restaurants is the most difficult to find.

It is also clear that saving water during holidays (ninth item in the first question), choosing more environmentally friendly means of transport (seventh item in the first question), and contributing to carbon-offsetting activities (fifth item in the first question) were behaviours that respondents were most likely to change regardless of the cluster to which they belonged. Furthermore, respondents who are moderately and very committed to tourism sustainability are still willing to pay more for the benefit of the local community (second item in the first question). In the opposite direction (and contrary to what would be expected from the previous conclusion), respondents from all the clusters denote less willingness to consume locally sourced products on holiday (sixth item in the first question), which can be explained by the fact that this is considered, by respondents from all clusters, the information that is most difficult to find (fifth item in the second question).

Table 4. Comparison between clusters and their sustainability level.

Country	Cluster	Sustainability Level
Luxembourg	1	1
Cyprus	1	1
Malta	1	1
Romania	1	2
Greece	1	2
Sweden	1	2
Austria	2	2
Latvia	2	2
Croatia	2	2
Poland	2	2
Germany	2	2
Finland	2	2
Spain	2	2
Czech Republic	2	2
Slovakia	2	2
Slovenia	2	2
Ireland	2	2
France	2	3
Netherlands	2	3
Hungary	2	3
Belgium	3	2
Estonia	3	3
Denmark	3	3
Italy	3	3
Portugal	3	3
Bulgaria	3	3
Lithuania	3	3

Finally, for all the clusters, information concerning eco-friendly tourism activities at the destination was considered the second-most difficult to obtain (second item in the question). In contrast, information related to the carbon footprint of transportation was considered easiest to assess, followed by information about the sustainability certifications of the accommodations (third item in the second question) in Clusters 2 and 3 and the sustainable commitment of the destination (fourth item in the second question) in Cluster 1.

4.3. Level of Sustainability

A level of sustainability was calculated using a statistical approach. This statistical approach aims to test the cluster analysis that grouped the EU member states into three different clusters through ML. The main goal is to attribute a sustainability level by country that is between 1 and 3, where 1 is the worst case, i.e., which represents the lowest level of sustainability rating, and 3 is the best (or highest) sustainability. Colours described this sustainability rating: red represents the first level (worse), orange represents the second level, and green represents the highest level of sustainability. Figure 3 depicts the sustainability rating of the 27 EU member states.

Table 4 presents the sustainability levels assigned to each country (last columns) and compares the ordering of clusters and the levels of sustainability by country. The results generally show a concordance between the clusters defined by the ML approach and the levels of sustainability defined by statistical analysis. Therefore, we may rely on the clustering analysis to group the 27 EU member states by tourism sustainability.

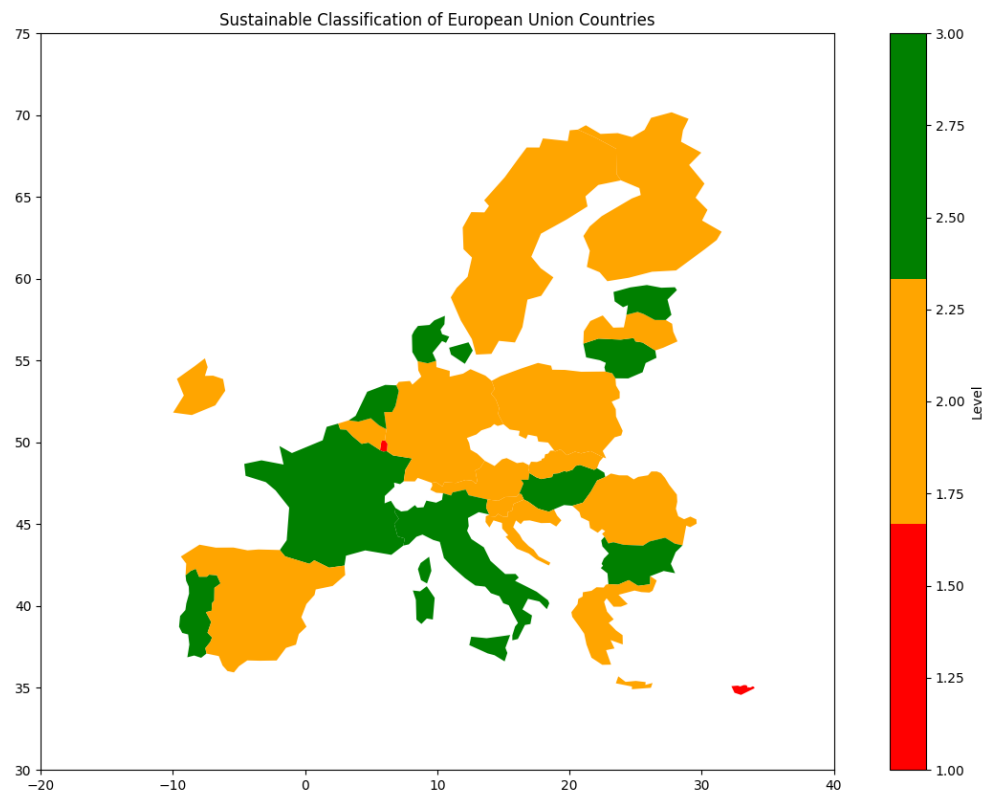


Figure 3. Level of sustainability in European Union countries.

As can be seen, countries like Luxembourg, Cyprus, and Malta belong to Cluster 1 and have the worst sustainability level, confirming that they belong to Cluster 1. These demonstrate that tourists from these countries have lower sustainability readiness than others. Conversely, countries like Belgium, Estonia, and Denmark belong to Cluster 3 and achieve higher sustainability, indicating stronger efforts in sustainable development initiatives. In six countries, there is no visible convergence between the grouping and the level of sustainability. While Romania, Greece, and Sweden belonged to Cluster 1 and were rated with the second level of sustainability, France, Netherlands, and Hungary were grouped in Cluster 2 and were attributed the highest level of sustainability. This non-conformity may be because, as Figure 2 shows, some countries overlap.

4.4. Tourism Destination Recommendations

The recommendation or allocation process relies on the similarity between countries' profiles and individual respondents' profiles. The profiles contemplate the answers to the 15 sustainability-based items in both questions of the Flash Eurobarometer 499, as represented in Figure 4. The main purpose is to allocate each individual, according to their sustainability profile, to one of five countries with a sustainability rating opposite their own. Suppose that an individual has a low level of sustainability. In that case, he/she will be directed as a tourist to travel to one of five countries with a higher sustainability rating in the hope that he/she will gain more sustainable habits. In the same way, an individual with a high level of sustainability will be allocated to a tourism destination with the worst sustainability results in the hope that, with his/her sustainable habits, he/she can make national citizens imitate him/her.

As an example and based on the results presented in Table 4, we recommended that a Luxembourg citizen travel to one of the seven countries belonging to Cluster 3 or any other belonging to Cluster 2. Similarly, citizens from Denmark should be directed to one of the first cluster countries. Therefore, it is possible to exchange sustainable habits among European member states, provoking a behavioural contagion effect.

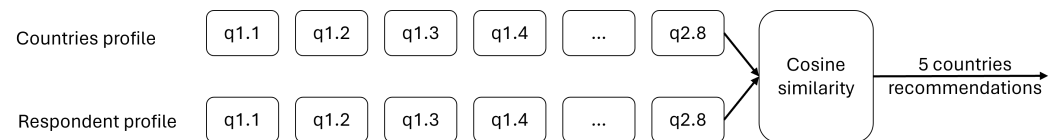


Figure 4. Recommendations based on respondents' and countries' profiles.

By identifying countries with divergent sustainability outcomes, the objective is to foster the exchange of sustainable habits among EU Member States. This approach aims to trigger a behavioural contagion effect whereby nations can learn from each other's successes and challenges in sustainability initiatives. By recommending five countries with distinct sustainability performances, the initiative seeks to facilitate cross-border collaboration and inspire collective action towards a more sustainable future within the EU member states.

5. Discussion

It is undeniable that traveller behaviours are essential for the development of more sustainable tourism. It also seems certain that citizens' attitudes, values, and ideas vary from country to country. These cultural differences may be shaped by tradition, history, or the economic and social conditions of the country. Through a combination of tourists' propensity to change travel and tourism habits to become more sustainable and accessibility of reliable information about destination sustainability practices, we found that the 27 EU member states can be segmented into three clusters. Our findings denote that tourist respondents from Estonia, Denmark, Bulgaria, Lithuania, Italy, and Portugal exhibited a high commitment to sustainable tourism, forming cluster 3. These findings are particularly interesting for countries like Portugal and Italy. Both of these Mediterranean countries have a strong economic dependence on tourism and, as such, it makes sense that Portuguese and Italian tourists were more committed sustainable tourists. This pattern of behaviour is confirmed by evidence pointing that Portuguese and Italian citizens were among the Europeans who revealed less scepticism concerning climate change, as well as those who recognised most of the negative impact of climate change and thus exhibited more concerns about climate change [Poortinga et al. \(2019\)](#).

On the other hand, tourist respondents from Luxembourg, Cyprus, Malta, Romania, Greece, and Sweden were uncommitted to tourism sustainability, forming Cluster 1. The EU member states where respondents were moderately committed to achieving tourism sustainability were Austria, Croatia, Latvia, Poland, Germany, France, Spain, Finland, Czechia, Slovenia, Slovakia, Ireland, Netherlands, Hungary, and Belgium, joining Cluster 2. The lack of commitment from the Greek respondents and the moderate commitment of Spaniards is an unexpected result given the previous explanation for the other two Mediterranean countries—Portugal and Italy. The economic importance of the tourism sector in these countries would suggest that their citizens, as tourists, would be more aware of sustainability.

Since we used a different methodology than what is available in the literature, we cannot directly compare our results with international empirical evidence. Even so, and with the appropriate methodological differences, we see that our findings contradict empirical evidence, indicating that tourists from Romania and Sweden are greener, belonging to Class 1 (in order from 1 to 7), considered the most committed to change their habits while travelling and on holidays, followed by Spain, Greece, Czechia, and Slovakia, members of Class 2 [Bassi and Martín \(2024\)](#). Furthermore, the authors classified into Class 6 the countries with the lowest percentage of 'green tourists', i.e., those from Bulgaria, Portugal, Italy, Belgium, Ireland, Malta, and Lithuania [Bassi and Martín \(2024\)](#). However, we find partial support in evidence published elsewhere [Bassi \(2023\)](#). By exploring European consumption attitudes, the authors conclude that consumers in Romania, Slovakia, and Czechia showed a very mild attitude toward sustainable practices and the conservation of natural resources [Bassi \(2023\)](#).

The difference between our results and those of [Bassi and Martín \(2024\)](#) can be explained by methodological differences and the fact that we used information about sustainable practices in the destination as the second explanatory variable. In this regard, our findings indicate an almost general feeling among the participants that, when planning trips, there was a lack of information about local sourcing of the food served in restaurants and eco-friendly activities available at the destination. This lack of information probably had a negative impact on the segmentation of countries. This plausible explanation finds support in empirical evidence that shows that, when tourists receive information about the sustainability of their destination, they are more likely to develop travel and tourism habits that support sustainable tourism [Holmes et al. \(2021\)](#); [Tang et al. \(2022\)](#).

We proposed a recommendation system to reach more homogeneity among EU member states based on our findings. This system recommends that tourists more (less) committed to sustainable tourism practices travel to destinations where citizens show less (more) commitment to these practices. Although we do not have any results to show for this, we believe that it will have a good outcome, as there is empirical evidence that has found that tourist environmental behaviours are influenced by exposure to other tourists [Su et al. \(2022\)](#) and to residents' sustainable behaviours [Liu et al. \(2024\)](#).

6. Conclusions and Implications

Sustainable tourism includes practices to minimise environmental impact and benefit local communities. Within the EU member states, the promotion of sustainable tourism has become a key priority, given the region's rich cultural diversity, natural landscapes, significant contribution to global tourism flows, and commitment inscribed in the 2030 Agenda for Sustainable Development.

The present paper aims to help the European tourism sector face the challenges ahead. It requires understanding the relationship between tourism and the environment in order to boost the sector's competitiveness and promote the development of quality, diversified, and sustainable tourism in a responsible manner. In response to this requirement, we explored, through ML and sustainable rating indicators, the level of involvement of the 27 EU member states with sustainable tourism, concluding that there is significant heterogeneity between them. The commitment to tourism sustainability was gathered through two questions retrieved from the Flash Eurobarometer 499, which assesses EU citizens' willingness to change their travel and tourism habits to assume a more sustainable behaviour and the accessibility of reliable information on destination sustainability for planning their travel.

We conclude that, while some member states were very involved in sustainable tourism, such as Portugal, Estonia, Denmark, Bulgaria, Italy, and Lithuania, others were uncommitted to sustainable tourism, such as Greece, Malta, Luxembourg, Cyprus, Sweden, and Romania. To overcome the heterogeneity among EU member states regarding tourism sustainability, we rely on the social contagion theory to propose a recommendation system for allocating tourists between the various countries to promote convergence between them and thus develop a sustainable tourism sector in Europe.

Overall, our findings offer a comprehensive overview of how countries are clustered and assessed regarding tourism sustainability, providing valuable insights for policymakers, researchers, and stakeholders interested in promoting sustainability and addressing environmental challenges at regional or global scales. In particular, tourism stakeholders and decision-makers should pay more attention to disseminating information regarding sustainable practices in destinations to help tourists plan their trips and promote sustainable behaviour. Furthermore, awareness-raising campaigns should be aimed at countries less committed to sustainable tourism in order to make them aware of the need to reconvert their tourism sector to a form more in line with economic, social, and environmental precepts, emphasising that failure to do so will jeopardise the EU's entire effort to achieve the 2030 sustainable development target.

7. Limitation and Future Research Direction

Like any study, this one is not without limitations. The results should be interpreted with caution. Despite the large sample, the sizes of the countries and the numbers of respondents in each country are very different, which may have biased the results. Additionally, tourism sustainability was evaluated only by ten items concerning travel and tourism habits and by five items evaluating the availability of information, which is certainly insufficient to assess sustainability. Furthermore, the countries are economically and culturally very different from each other, which undoubtedly impacts the results. Finally, our recommendation process needs to be confirmed and tested. It is our contention that these drawbacks are overcome by the contribution of this study.

In follow-up research, it would be useful to more specifically investigate and evaluate the relevance of applying a mobile device that traces the behavioural contagion effect left by the tourists in their tourism experience. It would also be interesting to introduce demographic data in the individual profiles to refine the results and provide better recommendations. We intend to follow this investigation shortly. Future studies concerning tourist sustainability convergence among EU member states should consider their cultural and economic differences. Finally, the data of the Flash Eurobarometer 499 were collected during 2021, when many Europeans were unable to travel or, if they did so, with many restrictions. Therefore, it will be necessary to repeat the interviews in order to compare the 2021 results with the current ones, focusing on a series of questions about the real habits of the consumer as a tourist.

Author Contributions: Conceptualisation, F.L. and M.P.; methodology, F.L. and M.P.; validation, F.L. and M.P.; formal analysis, F.L. and M.P.; investigation, F.L. and M.P.; resources, F.L. and M.P.; data curation, F.L. and M.P.; writing—original draft preparation, F.L. and M.P.; writing—review and editing, F.L. and M.P.; visualisation, F.L. and M.P.; supervision, F.L. and M.P.; project administration, F.L. and M.P.; funding acquisition, F.L. and M.P. All authors have read and agreed to the published version of the manuscript.

Funding: This work was funded by the Interreg Spain-Portugal (POCTEP) 2021-2027 programme, cofunded by the European Union, under the Twin NavAux project, 0070_TWAIN_NAV_AUX_1_E.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SDG	Sustainable Development Goal
EU	European Union
ML	Machine Learning

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