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Application of the Affinities Theory to the environmental sustainability of tourist destinations: The case of Ljubljana

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ABSTRACT

Sustainability has become a critical concern for many destinations seeking to revitalize their tourism industry while also dealing with issues stemming from climate change. To address these challenges, practical strategies to manage the harmful effects of the environmental crisis are necessary. Despite the critical role of sustainability, there still needs to be more practical solutions for implementing it in practice. The article aims to (i) broaden the discussion on sustainable tourism and solutions to reduce the impacts of climate change, and (ii) to understand the relationships of affinities between pro-environmental initiatives and the characteristics of the destination based on the perceptions of tourists who visit the city of Ljubljana. This study analyses tourist perception in an urban destination focusing on reducing carbon footprint and promoting sustainable development. Through a case study and the application of Affinities Theory, a specific algorithm to recognise affinity connections, a database with 372 international tourists who visited Ljubljana is utilised. This study has an explanatory goal and uses a comprehensive method (quantitative-qualitative). The findings confirmed that the characteristics of the destination most relevant to the tourist are Sustainable, Environmentally Friendly, and Safe. The research acknowledged practical approaches to improve the competitiveness and sustainability of tourism. The results could assist managers and policymakers in formulating sustainability-based strategies and reducing decision-making uncertainty. Also, it deepens the theoretical understanding of sustainable tourism and climate change mitigation strategies using a modelling and simulation method that other researchers can replicate in different contexts. This innovative research employs the Affinities Theory to assess Ljubljana's urban sustainability, examining how environmental practices can help reduce climate change's impact and how tourists perceive these practices.

1. Introduction

The World Tourism Organization (WTO) predicts that international tourists will reach 1.8 billion by 2030, increasing CO_2 emissions by 45% in the tourism sector until 2030 (World Tourism Organization and International Transport Forum, 2019). This growth creates development opportunities but also challenges the sector's efforts to meet the goals of the Paris Agreement (Diallo et al., 2022). The Sustainable Development Goals (SDGs) 2024 Report reveals that the climate crisis is worsening, with rising temperatures and Greenhouse Gas (GHG) emissions leading to more frequent and severe disasters worldwide (United Nations, 2024). Industries heavily relying on natural resources, such as tourism, are particularly vulnerable to climate change, affecting tourist arrivals (Diallo et al., 2022; Ghosh et al., 2024). Thus, businesses are urged to reduce waste and pollution and adopt pro-environmental practices (Loureiro et al., 2022). Governments and destinations are called to provide supportive frameworks for sustainable tourism (Schönherr and Pikkemaat, 2024).

Along with that, tourists are increasingly seeking sustainable travel options (Nieto-García et al., 2024; Schönherr and Pikkemaat, 2024; STATISTA Research Department, 2024a). So, environmental initiatives have become viable solutions to tackle environmental concerns, imbalances in resource utilisation, changes in consumer behaviour, and the long-term viability of businesses (Tavitiyaman et al., 2024). Also, comprehending tourist behaviours and encouraging sustainable behaviour become critical (Ait Taleb et al., 2021; Haba et al., 2023). However,

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little research has been done on how destinations' environmental performance produces tourists' responses (Wong et al., 2021). Furthermore, there is a demand for more sustainable practices to address adverse environmental and social effects (Diallo et al., 2022; Ghosh et al., 2024).

Regardless of a growing trend in sustainability and environmental behaviour due to the visible effects of climate change (Haba et al., 2023), further research is needed to address existing gaps. Firstly, studying tourist behaviour is crucial for aligning policies and industry practices with changing consumer trends to promote sustainable tourism, including investigating tourist perception (Ghosh et al., 2024). Secondly, many organizations have set guidelines to promote eco-friendly tourism and resilience in the industry (European Commission, 2022; WTTC, 2021). However, progress toward these goals must be improved (Matei et al., 2023; Scott et al., 2023), along with sustainable tourism governance, which is vital to success (Song and Kang, 2023). Then, it is decisive to understand the connection between tourism sustainability, nature affinity, and social engagement behaviour to achieve it (Diallo et al., 2022). Thirdly, sustainability in tourism is still challenging due to its lack of a practical approach (Mihalic et al., 2021) and exploring how new technologies, such as sustainable transportation, can contribute to practical applications and reduce the tourism industry's carbon footprint (Agarwal et al., 2024; Ghosh et al., 2024). Fourthly, insufficient literature exists on the connection between climate change mitigation and tourism (Ghosh et al., 2024; Scott et al., 2023; Scott and Gössling, 2022), including tourism essential tools (Peeters et al., 2024). A cleaner growth could reduce climate uncertainty and stabilise socio-economic outcomes (Ghosh et al., 2024). Fifthly, there are opportunities for studying pro-environmental behaviour using different methods, such as case studies, mixed methods, and experiments to study behavioural changes (Loureiro et al., 2022). The current methodologies, scope, and traditions of tourism research hinder the effective investigation into climate change (Peeters et al., 2024). Sixthly, it is essential to deepen the scientific study findings on tourists' perceptions ofLjubljana as an environmentally friendly destination (Bilynets et al., 2023), understanding effective policies that support consumers' pro-sustainability beliefs helping tourists overcome barriers to sustainable action (Haba et al., 2023). Seventh, little research has been done on the growth of urban tourism about sustainable tourism and regional development (Tyagi, 2024). Also, there is a lack of clarity in understanding the problem and limited interaction between stakeholders, indicating a need to adopt tangible measures and government guidance adapting the urban tourism sector to climate change needs (Lopes et al., 2022).

To bridge these gaps this study aims to expand the discussion on sustainability in tourist destinations, responding to current requests to examine the discrepancy between intentions and actions from a conceptual perspective. The objectives are to (i) broaden the discussion on sustainable tourism and solutions to reduce the impacts of climate change, (ii) to understand the relationships of affinities between pro-environmental initiatives and the characteristics of the destination based on the perceptions of tourists who visit the city of Ljubljana. The authors adopted the applied research method, using a mixed approach (qualitative-quantitative) through modelling, simulation, and case study (Will et al., 2002). Fig. 1 presents the classification of this research.

Ljubljana is the object of this study, a European city that is compromised in adopting environmental practices and is named among the world's 100 most sustainable destinations. An algorithm is proposed to address tourism and climate change. The Affinities Theory is used to recognise affinity connection and understand this intricate relationship. The data analysis uses a sample of 372 international tourists who visited Ljubljana. As a result of the study and based on the application of the algorithm to the case of Ljubljana, this paper aims to answer the following research questions: RQ1: How can sustainable tourism reduce the impacts of climate change? RQ2: How are pro-environmental initiatives and destination characteristics related to tourist perception?

For a tourist destination to improve sustainability and competitiveness, decision-makers must provide a supportive framework to help stakeholders effectively apply sustainable tourism practices. However, managers and policymakers lack data to formulate strategies based on sustainability (Pulido-Fernández et al., 2024) and, at the same time, be able to reduce uncertainty in decision-making (Mensah et al., 2021). This study suggests two methods for closing the gap between sustainable tourism principles and real-world implementation: i) to analyse tourist perceptions of the destination's environmental practices and minimise uncertainty in decision-making. ii) Provide examples of practical approaches to reducing carbon emissions and helping mitigate climate change to stimulate managers to improve environmentally sustainable practices. The results can be a guideline for climate change mitigation measures and could be used in other contexts, adapting to the unique characteristics of each destination (Ghosh et al., 2024). Fig. 2 graphically illustrates how the identified gaps will be addressed according to the scope of this research. The content comprises eight sections: introduction, theoretical background, case study, Fuzzy Logic and Affinities Theory, algorithm implementation and findings, discussion, research conclusions, limitations, and future research.

2. Theoretical background

This section presents the theoretical background to broaden the discussion on sustainable tourism and solutions to reduce the impacts of climate change.

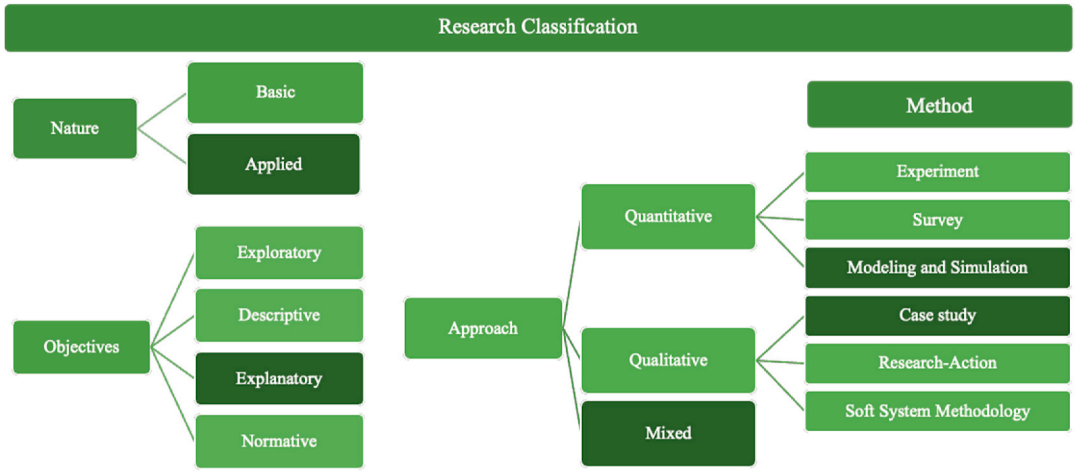

Fig. 1. Research classification.
Source: (Will et al., 2002).

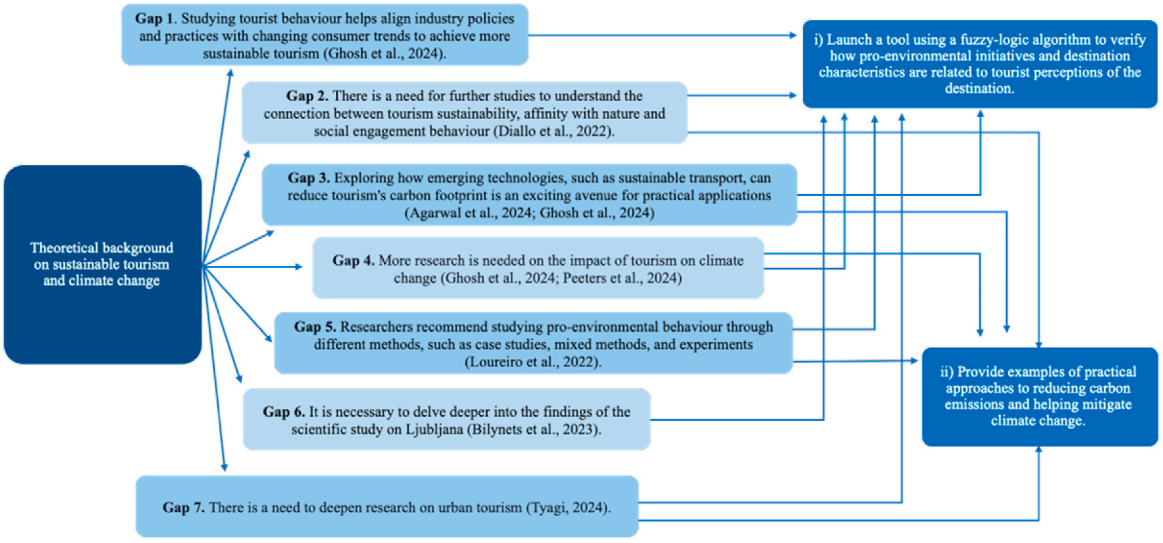

Fig. 2. Methods to bridge the gaps between sustainable tourism principles and real-world implementation.
Source: Own elaboration (2024).

2.1. Sustainable tourism and sustainable development goals (SDGs)

The concept of "sustainable tourism" is linked to sustainable development and emphasizes meeting the needs of present and future travellers (Tyagi, 2024). Tourism's sustainable development offers numerous benefits, including enhancing the competitiveness of various travel destinations (Mihalic, 2016; Pitakaso et al., 2024), mitigating the unfavourable effects of tourism (Baniya et al., 2019), and improving brand value, reputation, and relational benefits (Wong et al., 2021). The preference to visit and return to a tourist destination is positively influenced by reputation and trust. In this same direction, studies indicate that tourists tend to choose trips to places perceived as more reliable and trustworthy, which impacts the preference to return to the destinations they know (S. B. Hassan and Soliman, 2021). The triple-bottom-line is a commonly recognized framework that encompasses three key components of sustainability: environmental, social, and economic (Elkington, 1994). However, the environmental dimension is gaining more importance, considering the environmental

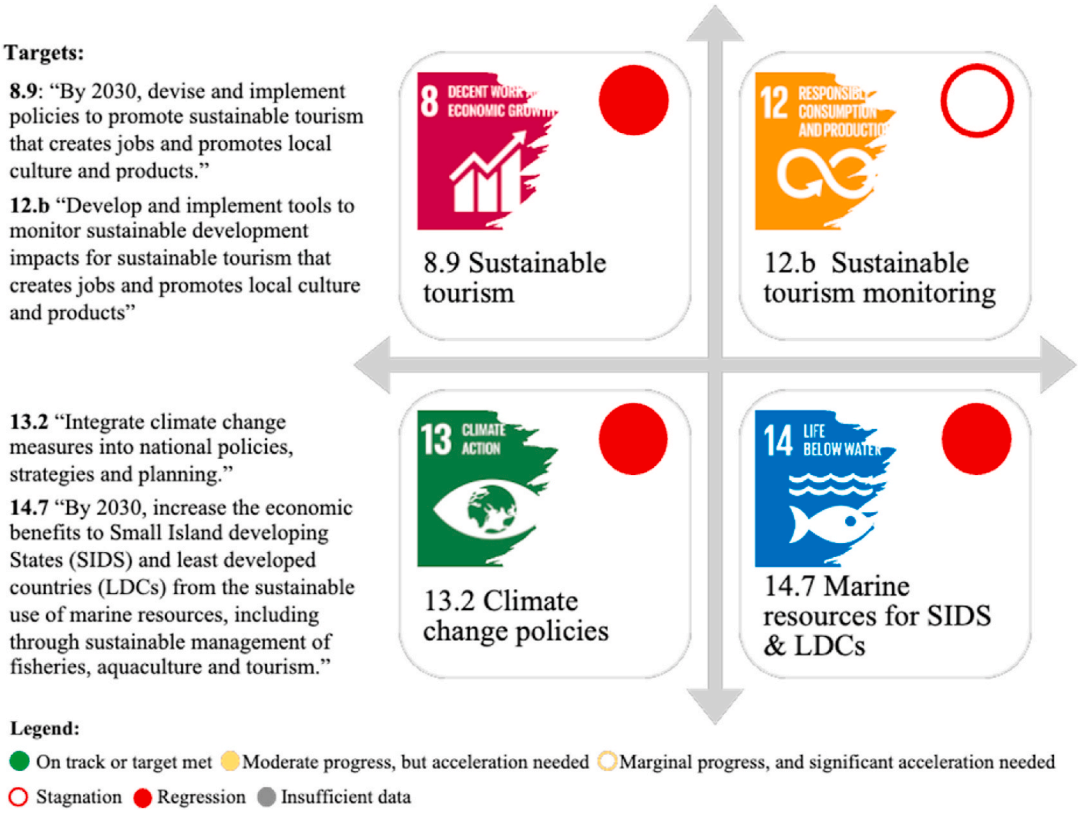

Fig. 3. Four targets and their status towards the SDGs.
Own design founded on (United Nations, 2024).

thresholds should stay below critical levels to avoid global ecosystem destruction, mainly due to the climate change that is threatening the tourism industry (Scott and Gössling, 2022) which is causing significant risks to specific destinations (WTTC, 2021). For example, deforestation worsens global warming and harms tourism, highlighting the need for sustainable forest management and ecotourism practices (Gu, 2023). Another study reveals that the impact of climate change on global tourism affects demand, competitiveness, and future tourist movement, forcing destinations to adapt to manage risks and take advantage of opportunities (Kayal, 2024). Along these lines, other researchers claim that climate change projections impact how tourists perceive the attractiveness of visiting ecotourism destinations, highlighting the importance of community-driven ecotourism businesses preparing for these effects (Deason et al., 2023).

The SDGs Report raises concerns about the critical goals related to sustainable tourism (United Nations, 2024). The tourism industry directly or indirectly impacts all SDGs, especially those related to inclusive and sustainable economic growth (SDG8, target 8.9), sustainable consumption and production (SDG12, target 12.b), and sustainable use of oceans and marine resources (SDG14, target 14.7) (World Tourism Organization, 2023). Nevertheless, the United Nations emphasizes the urgency of taking action in crucial areas that hinder SDG progress, such as climate change (United Nations, 2024). Therefore, climate action (SDG13, target 13.2) is also pertinent to sustainable tourism. Fig. 3 illustrates these four targets and their status towards the SDGs. The findings show that targets 8.9, 13.2, and 14.7 are at the regression level, and target 12.b is at the stagnation level. According to the United Nations, less than 50% of countries in most regions could report data on tourism sustainability indicators (United Nations, 2024). Monitoring tools for assessing the sustainable development effects of tourism, referred explicitly in Target 12.b, such as those for energy, water, waste, biodiversity, and job creation, will lead to improved economic, social, and environmental results (United Nations, 2024).

The global community must speed up low-carbon transformations to avoid escalating economic and social costs. The upcoming 2025 nationally determined contributions (NDC) cycle allows ambitious climate action plans to drive economic and social progress with increased ambition, more comprehensive coverage, and alignment with the 1.5 °C temperature rise limit (United Nations, 2024). On top of that, other researchers identified the need to investigate the impact of government rules, laws, and regulations on sustainable tourism, including measures such as banning single-use plastics and determining carrying capacity (Agarwal et al., 2024). These approaches can help reduce the use of resources and fossil fuels, drive innovation, conserve energy, and mitigate emissions. Progress depends on strong regulations, financial incentives, and public awareness campaigns (Agarwal et al., 2024). The global community must accelerate low-carbon transformations to avoid increasing economic and social costs. In addition, more research is needed on using technology to predict environmental impact and natural disasters. More research focuses on sustainable policies from regional and local perspectives (Agarwal et al., 2024). Promoting sustainable tourism can have a considerable impact in the fight against climate change, as it promotes low-carbon practices (Wu et al., 2023), expands the adoption of renewable energy (Kuldasheva et al., 2023), practices sustainable management (Gu, 2023), promotes public transport (Kim et al., 2024) and implements impact behavioural interventions (Bergquist et al., 2023). In this line, tourism companies and governments must collaborate to support these initiatives and achieve sustainable growth in the tourism sector (Tang and Zhang, 2023).

2.2. Consumer trend and sustainable tourism

Tourists are becoming more conscious of their travels' societal and environmental impacts and are often seeking sustainable options for products and services (Nieto-García et al., 2024). For example, Generation Z primarily focuses on green travel, waste reduction, and economic and social sustainability (Schönherr and Pikkemaat, 2024). That is line with most travellers worldwide, 81%, who believe sustainable travel is essential (STATISTA Research Department, 2024a). Previous research confirms that awareness and understanding of the environment positively influence tourist attitudes and behaviour impacting purchase intentions and destination engagement (Martínez García de Leaniz et al., 2024; Tavitiyaman et al., 2024). As a result, companies and tourist destinations are increasingly addressing the environmental and economic challenges (El Archi et al., 2023). This change has sparked significant interest among academics and tourism managers (Loureiro et al., 2022). As more people become aware of environmental concerns, it is essential to comprehend people's attitudes, behaviours, and intentions towards eco-friendly products and services for the overall sustainability of individuals and society (Tavitiyaman et al., 2024). Also, tourists are crucial in improving environmental sustainability through responsible behaviour (Schönherr and Pikkemaat, 2024). On the other hand, there is an increasingly demand that businesses reduce waste, pollute less, and adopt sustainable and pro-environmental practices (Loureiro et al., 2022). Researchers claim that climate change projections impact how tourists perceive the attractiveness of visiting ecotourism destinations, highlighting the importance of community-driven ecotourism businesses preparing for these effects (Deason et al., 2023). In this direction, studying tourists' behaviour helps align industry policies and practices with changing consumer trends to achieve more sustainable tourism (Ghosh et al., 2024). Thus, the first research gap identified.

2.3. Sustainable tourism and social engagement

Many organizations have established guidelines to facilitate a shift towards more eco-friendly tourism and promote resilience within the sector (European Commission, 2022; WTTC, 2021). These initiatives aim to design the industry for the net-zero emission targets and possible climate changes projected to occur by 2050, as stated in the Paris Agreement and Glasgow Declaration. However, progress toward these objectives is currently limited (Matei et al., 2023; Scott et al., 2023; Scott and Gössling, 2022). In this regard, sustainable tourism governance is vital to success, and it is essential to coordinate efforts between different stakeholders (Bramwell, 2011; Song and Kang, 2023). A complex management destination approach becomes necessary (Oklevik et al., 2019) to promote environmentally friendly practices, decrease carbon emissions, and mitigate the impact of climate change (Gössling and Higham, 2021). Stakeholders play an essential role in implementing it, and their performance affects the destination environment and influences pro-environmentally responsible behaviour (Lee et al., 2021; Su et al., 2018). Their engagement direct impact on climate change mitigation, which involves decreasing carbon emissions (Fakfare and Wattanacharoensil, 2023; Song, 2022), preserving wilderness (Hovelsrud et al., 2021) and proposing a holistic approach with a strategic plan for managing the impacts on a destination (Grydehøj and Kelman, 2017) to enhance carbon absorption, restore biodiversity, and improve livelihoods (Ashok et al., 2022). Likewise, sustainable forest management and ecotourism promotion can help alleviate the adverse effects of deforestation on the tourism sector (Gu, 2023). Balancing economic prosperity with environmental impact is a critical challenge for governments and industry, with profound implications for people and communities (Agarwal et al., 2024). The authors argue that there is a need to investigate how people's beliefs and value systems can be leveraged to promote sustainable tourism (Agarwal et al., 2024). Therefore, it is crucial to understand the connection between tourism sustainability, nature affinity and social engagement behaviour, directly and indirectly (Diallo et al., 2022), the second research gap identified.

2.4. Sustainable practices on carbon footprint

Sustainability in tourism is still challenging due to its lack of a

Table 1
Analytical summary of the leading publications.

Author(s)	Main contributions	Methods/Approaches	Gaps/Suggestions for future research
Haba et al. (2023)	The study provides a comprehensive overview of research conducted on the topic of 'green consumer' in marketing management. It identifies key themes, including consumer purchasing behaviour, sustainable development, eco-friendly products, human behaviour, and green marketing. It also notes emerging themes such as renewable energy and environmental policy.	Bibliometric analysis.	Green services, a critical aspect of sustainable consumption, require more attention in research. While existing studies primarily focus on eco-friendly products and, to some extent, on green consumer behaviour, there needs to be more evaluation of green services.
Schönherr and Pikkemaat (2024)	Generation Z's environmental attitudes towards travel prioritize climate-friendly options, waste reduction, and economic and social sustainability. The research highlights their sense of responsibility on both the supply and demand sides, emphasizing the need for supportive frameworks from governments and destinations.	Focus group discussions.	Further studies focusing on a quantitative analysis of other Generation Z individuals are recommended.
Loureiro et al. (2022)	The paper can guide destination and hotel managers by highlighting key issues affecting pro-environmental behaviour, such as the influence of tourists' values, beliefs, emotions, and social norms. It emphasizes the need for managers to raise awareness and promote pro-environmental behaviours among tourists, guests, employees, and residents.	Review literature. Text mining approach based on a hierarchical Bayesian model.	The results indicate opportunities for studying pro-environmental behaviour using different methods, such as case studies, mixed methods, and experiments. Specific behavioural changes are relevant to tourism and hospitality and can be explored further in future research.
Lengyel et al. (2019)	The article aimed to explain the concept of genuineness in sustainability education by combining mindfulness, human and environmental ethics, and a firm rejection of economic growth and neoliberal principles.	Directed content analysis and non-parametric quantitative methods.	Undergraduate students need more mindfulness, sustainability knowledge, universal values regarding nature and fellow humans, and the ability to think systematically.
Diallo et al. (2022)	The research evaluates how sustainable tourism and nature affinity directly impact social engagement. It also explores the mediating role of nature conservation attitude and personal tourism experience in these relationships.	Survey. Structural Equation Modelling (SEM)	It is crucial to comprehend the connection between tourism sustainability, nature affinity, and social engagement behaviour, both directly and indirectly.
Ghosh et al. (2024)	Researchers highlight the complex relationship between environmental, economic, and social factors in tourism, climate change, and development. This underscores the importance of tailoring policies, promoting sustainable tourism practices, and fostering international collaboration to address the challenges of climate change. Policymakers and businesses should consider these insights when planning for a more sustainable future.	Comparative analysis. Regression analysis	Studying tourist behaviour helps align policies and industry practices with evolving consumer trends for more sustainable tourism. Exploring how emerging technologies like sustainable transportation and eco-friendly accommodations can reduce tourism's carbon footprint is an exciting avenue for practical applications. More literature is needed on the link between tourism and climate change.
Tyagi (2024)	The paper comprehensively reviews the linkages between tourism sustainability and regional development. It outlines different themes, methods, and outcomes from earlier literature. New perspectives include eco-tourism, gastro-tourism, rural and agritourism, and high mountain and Arctic tourism.	Systematic literature review	The growth of urban tourism is an unexplored area of regional development related to sustainable tourism. Future research should address the impact of island tourism on the ecosystem, tourism economic viability, and community-driven tourism development.
Nieto-García et al. (2024)	The gap between tourists' intentions and actions threatens efforts to promote sustainable choices. Consumers' hypocritical behaviour and researchers' methodological shortcomings exacerbate this divide. The paper provides recommendations to address consumer hypocrite and offers methodological advice for researchers to minimise biases.	Literature review	Research should examine how tourists prioritize and reconcile sustainability actions. Studies should also aim to identify and reduce social desirability bias in tourists reporting their intentions and behaviours.
Pitakaso et al. (2024)	This study presents a new approach to sustainable tourist trip planning that combines tourists' preferences with crucial sustainability factors. The authors propose a model that optimizes travel itineraries across dimensions such as CO2 emissions, environmental impacts, and socio-economic benefits.	Artificial Multiple Intelligence System	Integrating real-time data and adaptive learning algorithms is necessary to enhance itinerary recommendations dynamically. Longitudinal studies are essential to evaluating the model's long-term impact on destination sustainability and tourist satisfaction.
Peeters et al. (2024)	This paper uses a critical review approach to assess the level of research on mitigating climate change in sustainable tourism. The current methodologies, scope, and traditions of tourism research hinder effective investigation into climate change. Rigidity in system boundaries, lack of standardised definitions, and incomplete data within tourism studies impede assessing ways to mitigate tourism's impact on climate change.	Literature review. Critical content analysis	Lack of attention to climate change mitigation in sustainability tourism research. The neglect of transportation, the main contributor to tourism emissions, and weak sustainability definitions are prevalent. More research is needed into the impact of tourism on climate change.
Peng et al. (2024)	This study introduces a new research framework based on legitimacy and signalling theories to understand how destination social responsibility influences residents' environmentally responsible behaviour. The findings reveal a positive link between destination social responsibility and residents' environmentally responsible behaviour, mediated by residents' perception of destination legitimacy and amplified by community concern. This research extends the applicability of legitimacy theory to tourist destinations.	Survey. Structural Equation Modelling (SEM)	Future research should gather data from residents' sources and explore additional experiments or a longitudinal design to better understand the causal relationship between destination social responsibility, destination legitimacy, and residents' environmentally friendly behaviour.
Bilynets et al. (2023)	This study demonstrates that eco-friendly initiatives at a destination can influence tourists' perception of the destination's environmental image. Tourists' perceptions	Survey. Independent-samples t-tests.	There is a need to deepen the findings of the scientific study on Ljubljana. Future studies could explore how tourists' perception of eco-friendly projects at the location affects

(*continued on next page*)

Table 1 (*continued*)

Author(s)	Main contributions	Methods/Approaches	Gaps/Suggestions for future research
	change after visiting, and they can recall and name the eco-friendly initiatives they observed, supporting the study's hypotheses. Experiencing these initiatives influences the destination's organic image, providing empirical evidence that destinations can proactively shape their environmental image.		their behaviour. It would also be valuable to include various destinations with different eco-friendly projects and examine the interaction of organic and induced images.
Agarwal et al. (2024)	The article contributes to knowledge on sustainable tourism by synthesising the literature to identify important research topics for the academic community, practitioners, and regulatory bodies. The authors used a robust structural topic modelling technique to analyse textual data from 3289 research articles published between 1978 and 2022. The identified topics were categorised into macro, meso, and micro levels, and they compared research themes across three periods.	Literature review. Structural topic modelling (STM)	Focusing on sustainable transportation is a critical initiative in the efforts to enhance tourism's sustainability. It is essential to research the impact of government rules, laws, and regulations on sustainable tourism. More research is needed on utilizing technology to forecast environmental impact and natural disasters. More research needs to be done that focuses on sustainable policies from regional and local perspectives.
El Archi et al. (2023)	The rise of smart tourism destinations (STDs) has led to a need to investigate their impact on sustainable development. This review analysed 20 papers to identify current research on STDs and their implications for sustainable development. The review found that STDs have been used to examine their impact on sustainable development's economic, social, and environmental aspects. Additionally, there is a growing interest in smart cities to reduce tourism's ecological footprint and promote sustainable tourism development.	Systematic Literature Review	Emerging research areas in the literature include achieving sustainable development goals, adopting green information technology (IT), and implementing smart energy and waste management.
Tang and Zhang (2023)	The text discusses the impact of climate change on the tourism industry and efforts to reduce energy consumption and emissions. It introduces an evolutionary game approach to analyse interactions between tourism enterprises and the government. The research emphasizes adjusting penalty measures for environmental pollution and reducing the cost of controlling low-carbon tourism. It highlights the need for tourism enterprises to lower energy-saving costs and for the government to adjust carbon emission rewards dynamically. Ultimately, the text emphasizes the importance of joint efforts between tourism enterprises and the government to achieve energy conservation, environmental protection, and SDGs.	Evolutionary Game Theory and Theoretical analysis.	In future research, the tourism industry is expected to subdivide, construct a low-carbon implementation path, and explore specific paths to develop carbon tourism.

practical approach (Mihalic et al., 2021). Implementing it requires a pragmatic method shaped by the realistic operational constraints and existing systems used in the tourism industry (McCombes et al., 2015). The literature indicates there is a lack of action among stakeholders to mitigate climate change tourism (Peeters et al., 2024; Scott et al., 2011). However, tourism enterprises and the government should collaborate to promote energy efficiency, protect the environment and encourage sustainable development by adjusting penalties for environmental pollution and reducing the cost of controlling low-carbon tourism (Tang and Zhang, 2023). The effects of climate change and tourism have been identified with issues like environmental pollution, overexploitation, and ecological imbalance (Kong et al., 2024). The environmental impact of tourism has a worldwide reach but is experienced on a local level, and CO_2 emissions from tourism significantly impact the environment (Gössling, 2002). Tourism induces pollution through various services, hampering sustainability goals (Ghosh et al., 2024). After an extensive literature review on sustainable tourism between 1978 and 2022, the authors identified sustainable transport as a key initiative in improving tourism sustainability (Agarwal et al., 2024). Tourism-related transport was responsible for 5% of the CO_2 emissions worldwide in 2016, and the forecast for 2030 is to achieve 5.3% (STATISTA Research Department, 2024b). Despite the failure of policies, it is essential to maintain the aim of achieving sustainable tourism (UNWTO, 2023). ~~R~~researchers identified that in countries focusing on tourism, a 1% increase in renewable energy use results in a 1% reduction in CO_2 emissions (Kuldasheva et al., 2023). Therefore, the global community must accelerate low-carbon transformations to avoid increasing economic and social costs (United Nations, 2024). Thus, promote sustainable transport is critical to improving tourism sustainability (Agarwal et al., 2024). Exploring how emerging technologies, such as sustainable transport, can reduce the carbon footprint of tourism is an exciting avenue for practical applications (Agarwal et al., 2024; Ghosh et al., 2024), this being the third research gap identified. Table 1 presents an analytical summary of the leading publications, indicating the contributions, methods and approaches used, gaps and suggestions for future research.

2.5. Tourism and climate change research

Over several decades, climate change has significantly altered typical weather patterns, such as increasing warmth, precipitation, or aridity (WTTC, 2021). The impact of climate change on global tourism affects demand, competitiveness, and future tourist movement, forcing destinations to adapt to manage risks and take advantage of opportunities (Kayal, 2024). Their effects are seen through extreme weather events worldwide, like droughts, floods, and wildfires (Scott and Gössling, 2022). The extent of climate change impacts depends on reducing GHGs, such as solid reduction that could limit the global annual average increase to 2 °C (IPCC, 2021). Supra national institutions are emphasizing the implications of climate change for humanity and calling for measures to mitigate the climate crisis (IPCC, 2023; United Nations, 2021). In this context, a cleaner growth could reduce climate uncertainty and stabilise socio-economic outcomes (Ghosh et al., 2024).

The literature review on tourism and climate change indicated two main gaps 1. the lack of practical approach and convergence to make destinations more sustainable, and 2. Need for further investigation on the topic. A critical review on tourism and climate change in the last 20 years in the Australasia region, identified a lack of alignment between climate change and tourism policy, and stated that the climate responses for tourism are typically restricted to descriptive and normative methods (Higham et al., 2022). The authors concluded that significant gaps persist in converting climate science into tourism policies, which are necessary for adapting tourism systems to the challenges of climate

change. Other studies highlight the need to incorporate environmental practices and improve management in different regions of the globe. For instance, to face climate change effects like drought in Africa (Dube et al., 2022) or tourism water use in the Mediterranean region (Ricart et al., 2024). Managing tourism and climate change is challenging due to the complex relationship between environmental, economic, and social factors in tourism, climate change, and development (Ghosh et al., 2024). After a critical review approach to assess the level of research on climate change mitigation in sustainable tourism authors pointed to several shortcomings that must be address in future research (Peeters et al., 2024). Such as, rigid system boundaries, lack of standardized definitions, and incomplete data in tourism studies impede assessing ways to mitigate tourism's impact on climate change. They draw especial attention to the neglect of transport research, the main contributor to tourism emissions. The conclusion is a lack of attention to climate change mitigation in sustainability tourism research. Therefore, more research is needed on the impact of tourism on climate change (Ghosh et al., 2024; Peeters et al., 2024) revealing the fourth identified research gap.

Including applying different methods, such as case studies, mixed methods, and experiments to study behavioural changes (Loureiro et al., 2022). Since current methodologies, scope, and traditions of tourism research impede effective climate change research (Peeters et al., 2024). Most studies to assess tourism behaviour use the method of structural equation model (Singh et al., 2022). This being the fifth research gap identified. To address this gap, this research will use a mixed approach, using an algorithm based on the Affinities Theory and the Ljubljana case study.

2.6. Green urban destination

Recent research has underlined the significance of consumer awareness when making decisions about eco-friendly services (Tavitiyaman et al., 2024) and destinations (Garanti et al., 2024). A sustainable destination, especially environmentally, is perceived as more attractive and relevant when choosing a destination (Bilynets et al., 2023; Lee and Xue, 2020). It was verified that tourists select ecological destinations to match their ecological concerns and discomforts (Nieto-García et al., 2024). This is because they depend on the compliance of environmental actions by organizations such as efficiency in energy use, renewable energy sources, waste management, and carbon emissions reduction (Nieto-García et al., 2024). Despite the destination's sustainability being identified as a significant driver in stimulating tourists' internal and external responses (Bilynets et al., 2023), little knowledge is available on how destinations' environmental performance produces tourists' responses (Wong et al., 2021). And how consumers react to environmental challenges and how to encourage sustainable behaviour (Haba et al., 2023). On the other hand, although organizations are increasingly focused on sustainability, they are not addressing it (Córcoles Muñoz et al., 2023). That means it lacks action to implement sustainability (Peeters et al., 2024). To face this challenge, researchers recommend adequately exploring the effectiveness of adaptation strategies at the destination level (Scott et al., 2023; Scott and Gössling, 2022).

Another obstacle to achieving sustainability in tourism is the intention-behaviour gap. It is observed that the actual behaviour of tourists only sometimes coincides with their intentions and attitudes towards sustainability (Nieto-García et al., 2024). Since tourism focuses on pleasure and self-indulgence, it can lead to disregard for ethical standards, even by conscientious tourists (Dolnicar, 2020). Research results suggest that it is essential to encourage travellers to embrace sustainable behaviours (Dolnicar, 2020; Olya et al., 2023; Trabandt et al., 2024). In fact, destination social responsibility (DSR) and perceptions of climate change were found to significantly influence visitors' willingness to make sacrifices, adopt green behaviours, and prioritize localism (Olya et al., 2023). Other researchers identified that promoting climate change mitigation behaviours increased pro-environmental behaviours by 2% and 12% (Bergquist et al., 2023). Encouraging visitors to use less energy-intensive public transportation is a crucial strategy to reduce carbon emissions from tourism and help mitigate climate change (Kim et al., 2024). This aligns with the results of studies that suggest a positive connection between residents' environmentally responsible actions and the destination's social responsibility (Peng et al., 2024). Therefore, understanding how a destination's environmental performance activates tourists' responses is essential for organizations to develop strategies that align with tourists' perceptions of the destination. In this direction, other researchers demonstrated that green initiatives in a destination can influence tourists' perception of the destination's environmental image (Bilynets et al., 2023). Tourists' perceptions change after the visit, and they can recall and name the green initiatives they observed (Bilynets et al., 2023). Experiencing these initiatives influences the destination's organic image, providing empirical evidence that destinations can proactively shape their environmental image (Bilynets et al., 2023). Therefore, this manuscript seeks to broaden the discussion on sustainability in tourist destinations, responding to current requests to examine the discrepancy between intentions and actions from a conceptual perspective. Proposing effective policies to support consumer convictions in favour of sustainability helps overcome barriers to sustainable action (Haba et al., 2023). Despite the contributions, the researchers point out that it is necessary to explore further the findings of the scientific study on Ljubljana, as this is the sixth research gap identified.

Climate change affects the risk factor for urban areas, which could impact the appeal of specific destinations (Lopes et al., 2022). To overcome that, adaptation and mitigation in urban destinations should address the challenges of climate change by managing systems and providing support mechanisms. That includes implementing best practices for planning and tourism activities, which should be integrated into territorial planning (Lopes et al., 2022). Other researchers address the importance of planning and indicate environmental policy as an emerging theme in green management and marketing areas (Haba et al., 2023). And call attention for the lack of clarity in understanding the problem and limited interaction between stakeholders, indicating a need to adopt tangible measures and government guidance adapting the urban tourism sector to climate change needs (Lopes et al., 2022). After a systematic literature review analysing the link between climate change and regional development, the authors indicated the need for further research on urban tourism (Tyagi, 2024). To help address this gap, this study provides further analysis in the case of Ljubljana, an urban sustainable tourism destination focused on reducing the effects of climate change. That will provide practical examples of reducing carbon emissions and mitigating climate change. The sustainable practices analysed can be a scalable solution for cities with similar characteristics in Europe or globally. That is in line with other study findings that underline the importance of adapting policies, promoting sustainable tourism practices and fostering international collaboration to address the challenges of climate change (Ghosh et al., 2024). This is the seventh research gap identified.

The following section addresses the case study of Ljubljana, which will serve as a basis for applying the Affinities Theory.

3. The Ljubljana case study

This section presents the case study on Ljubljana's urban sustainability. It includes scientific research that analyses the impacts of this environmental performance implemented in the city and how it changes tourist perception.

3.1. Destination characterization

Ljubljana is Slovenia's capital, a European Union country near Italy. The city has an approximate population of 300,000 and received 1.02

million tourists in 2019 (Ljubljana Tourism, 2023). Fig. 4 shows its geographical location. Today, Ljubljana is an established tourist destination.

The number of visitors and the number of nights spent both increased by twofold from 2014 to 2019 (Slovenia Tourism Board, 2020). It is a city with a strategic vision of becoming a destination known for its commitment to sustainable living practices (Mestna občina Ljubljana, 2020). Ljubljana started this journey in the late 2000s and, with this, has been able to reap many awards, which are illustrated in Fig. 5. For example, it has been designated European Green Capital in 2016. It has also received the award for the best destination in Europe (Best European Destination) in 2022. It stands out among the one hundred most sustainable cities worldwide (Destinations Top 100 Sustainability Stories) in 2021 for the seventh consecutive year. In addition, it has won an award from The Green Destinations – an international institution that certifies destinations and regions in terms of sustainability, in which it has obtained the highest award (Slovenia Green Destination Platinum) (Oficina de Turismo de Slovenia, 2023a).

From 2016 to 2020, the city implemented over 700 initiatives focused on environmental conservation to enhance the sustainable way of life for its inhabitants and enrich the visitors' experiences (Mestna občina Ljubljana, 2020). The focus has been primarily on its inhabitants, positively impacting the tourists' experience. Among the measures is the increase in the city's pedestrian area, which now covers more than 10 ha in the city centre. The city centre is closed to traffic and can only be reached on foot or by electric (green) vehicles, including an ecological train that drops off tourists at the main tourist spots. Athletes can also arrive on surfboards since the river runs through the city's centre. In addition, 300 km of bike lanes and 600 shared-use bicycles have been implemented. Ljubljana is considered one of the greenest in Europe, with 542 m^2 per inhabitant, which has increased in the last ten years. Fig. 6 illustrates some green parts of the city.

The incentive for greener public transport began in 2013. Currently, green buses and electric cars are shared throughout the city, including at the airport (Slovenia Convention Bureau, 2016). It also has a parking system connected to public transport routes to facilitate travel and a parking area connected to ecological buses. 390 km of public transport lines and 280 buses run on methane (Ljubljana Tourism, 2023). Another success story concerns waste management. The Slovenian capital adopted a "Zero Waste" program in 2014 (Golob, 2019), and the city currently has a recycling plant that is considered one of the most efficient in the world. The city has been visited by managers from several countries in search of good practices. There, 98% of everything that enters the plant from Ljubljana and 58 cities around the capital is recycled. The plant serves half of Slovenia's population (Euronews, 2018). At the country level, 58.5% waste separation was achieved in 2021 (Statista, 2023) compared to the European average of 49% in the same year (Eurostat, 2023). With these waste management actions, Slovenia is in second place in the EU, after Germany, with 46.3%.

It should be noted that waste management in the city is practically all underground, except for the trash cans. The city has 69 collection stations and 9500 litter bins (City of Ljubljana, 2023). This strategy was implemented in 2012, and a pay-per-use system was adopted. Disposal of plastic, glass or paper can be done indiscriminately. However, compost or unusable waste is deposited in underground containers, which residents access using a magnetic card. An advanced management system tracks each resident's waste disposal through their cards and calculates the charges to be levied at the end of the month (European Bank for Reconstruction and Development, 2022), encouraging recycling and responsible consumption.

Regarding initiatives to encourage sustainability in tourism, the Slovenian Tourism Green Scheme (Slovenia Green) is being developed. The program provides resources to destinations and service providers, enabling them to assess and enhance their sustainability initiatives. It also offers tools to evaluate and improve these efforts, which the Slovenia Green brand promotes. It has more than 280 members, including sustainable destinations, accommodation providers, natural parks, tourism agencies and attractions. This initiative has been awarded several times, and these green practices and their conserved nature have allowed the destination Slovenia to project itself as one of the leading sustainable destinations (Oficina de Turismo de Slovenia, 2023a). Ljubljana is a founding signatory of a network of cities committed to circularity called the Circular Cities Declaration (ICLEI Europe, 2023). This group was founded in May 2020 with 28 cities, and now there are 73 cities committed to supporting and acting in the shift to a circular economy. This network has just launched a report on the good practices carried out in the last two years by the signatory cities.

3.2. Environmental performance and tourist perception

We analyse Ljubljana's environmental performance from a scientific perspective through a recently launched study (Bilynets et al., 2023). The contributions are enriching for two reasons. First, because it is a study carried out on an urban environment, the environmental impact is usually measured, especially in nature destinations, but in this case, it is a city. Second, the tourist's perception of adopting these practices is measured to verify if pro-environmental initiatives influence a destination's image and whether they can be effectively implemented. The authors specify that environmentally friendly initiatives embraced by a destination encompass activities, procedures, and visible actions that enable it to minimise its adverse environmental impact. These activities entail the sustainable management of water and waste, eco-friendly transportation (such as cycling and electric vehicles), using renewable energy sources, introducing recycling systems, and reducing disposable plastic (Bilynets et al., 2023).

The methodology used is a survey of international tourists divided into two groups when they arrive and leave the country. Data was collected through questionnaires, with a sample of 372 respondents (233 before the visit and 139 after), carried out in August 2019. Data were collected on the airport bus, during the wait, and at the bus station in Ljubljana. The study participants were foreign tourists who had never been to Ljubljana and could answer the questionnaire in English. The university's human research ethics committee approved this data collection process (Bilynets et al., 2023). The objective of the first group, before the visit, was to verify their expectations regarding the sustainability of the destination. Then, with tourists who have already visited the country, verify that some initiatives favouring the environment have been observed.

The results indicate that tourists expected to find a sustainable and responsible city from the beginning. After the visit, this possibility is not only confirmed but it is overcome. Fig. 7 shows the percentage of tourists based on the criteria asked.

It can be seen that sustainability was expected for 62.6% of tourists, and 75% of tourists confirmed it after the visit. "The same goes for the perception of the destination as environmentally friendly" (Bilynets et al., 2023). 76.1% of tourists expected to find an ecologically friendly city; however, the number has risen to 86.7% after the visit. That is, the general image of the Ljubljana destination is positive, at both times, as a sustainable and environmentally friendly city.

The study also reveals that almost all tourists, 92%, perceived some pro-environmental initiative. The survey used open and closed questions. Participants were asked whether they had observed any environmentally friendly initiatives and, if so, what they had noticed. The spontaneous responses indicated that 23% of tourists had noticed waste recycling. Moreover, 19% of people use public transportation. When answering the questionnaire with closed questions, 84% referred to bicycle lanes, 82% to litter bins, 76% to local food, and 73% to drinking water – because there are several drinking water sources around the city with the attempt to reduce single-use plastic. Moreover, 56% of the respondents noticed electric transportation.

The conclusions of this study suggest that environmental sustainability generates an image that positively influences the perception of

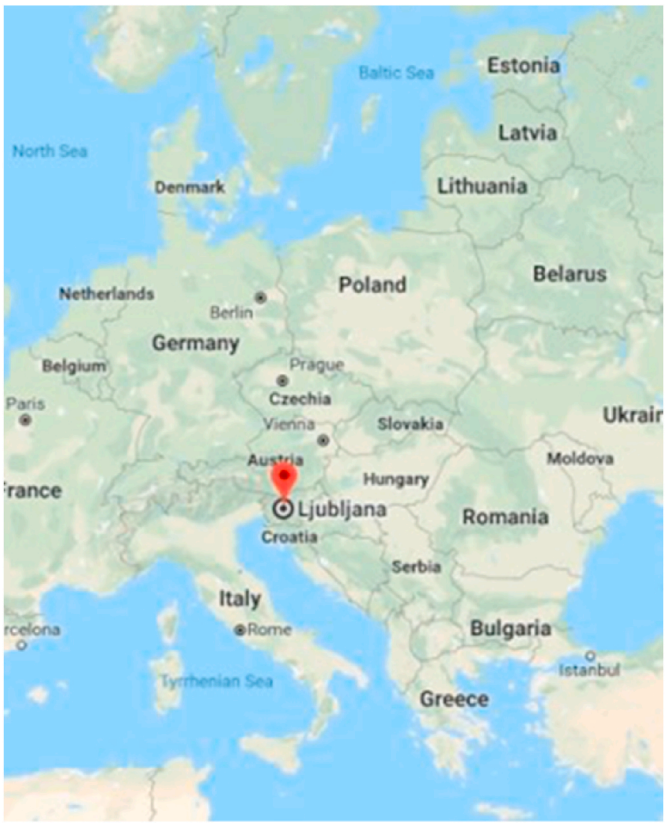

Fig. 4. Geographical location of Ljubljana.
Source: (Google, 2023)

tourists. Furthermore, the authors indicate that this image perceived by tourists, called organic, formed by previous information compiled during their stay, is more relevant for decision-making than marketing actions. Hence, it is determined that the location can actively maintain the natural perception of being an eco-friendly and sustainable destination. Although you cannot change what the tourist thinks, this study shows that making visible the environmental measures adopted by the destination can impact the tourist's perception. Additionally, this is crucial as it impacts how the destination is perceived regarding its environmental performance (i.e., carbon emissions, recycling, etc.) is crucial for the choice of the tourist destination (Bilynets et al., 2023). Everyone wants to go to healthy, environmentally responsible, clean, safe, and better-managed destinations. Recent research points to 81% of tourists want to vacation in sustainable places (STATISTA Research Department, 2024a). The following section will introduce Fuzzy Logic and Affinities Theory.

4. Fuzzy Logic and Affinities Theory

This section is divided into two parts. The first part presents Fuzzy Logic and introduces the Affinities Theory. The second part presents the foundations of the Affinities Theory and its methodological procedure.

4.1. Fuzzy Logic and Affinities Theory

Fuzzy Logic (FL), a mathematical theory within multivalent logic is more than just a theory; it is a groundbreaking tool (Zadeh, 1965). It initiates the start of a mathematical theory rapidly expanding across various scientific disciplines, providing a methodical approach to addressing subjectivity and uncertainty. In 1965, Lofti Zadeh introduced FL by suggesting that multivalent sets can be fuzzy, with their elements belonging to them to varying degrees. FL emerged as a way to reduce uncertainty and improve decision-making. At first, FL was used in the exact sciences. Nevertheless, numerous researchers have released multiple articles and studies showcasing its wide-ranging applications over the last fifty years. Notably, the first book dedicated to applying FL to economic and management dilemmas was released in 1986 (Kaufmann and Gil Aluja, 1986). This significant work encompassed various studies, such as investments, equipment renewal, inventory management, and product distribution, emphasizing the practical significance and influence of FL in decision-making processes.

Simultaneously, it has started to explore non-quantitative mathematics—more in the practical application area than in the foundational one. It represents three levels: quantitative mathematics, numerical and non-numerical tools, and economic applications and management (Barcellos de Paula and Gil Lafuente, 2018). Zadeh presented a new method known as "Soft Computing" in 1991. This method combines various approaches, such as FL, neural networks, evolutionary algorithms, and probabilistic reasoning (Barcellos de Paula and Marins, 2018). This novel approach merges the advantages of these methodologies to tackle intricate problems, offering real-world applications spanning from consumption to innovative products (Nădăban, 2022). Furthermore, it meets the requirements of emerging social demands, including sustainable growth (Tseng et al., 2022), climate change (Wilberforce et al., 2017), reverse logistic (Mishra and Rani, 2021), and

Fig. 5. Awards received.
Source: (Oficina de Turismo de Slovenia, 2023a).

Fig. 6. Green facts.
Source: (Oficina de Turismo de Slovenia, 2023b).

Covid-19 (Melin et al., 2020), showcasing its pertinence and potential across various domains. FL is valuable for decision-makers in uncertain situations because it enables them to assess available information using fuzzy sets and systems (Blanco-Mesa et al., 2017). FL can be a helpful approach in dealing with uncertain areas as it becomes increasingly possible to integrate sensory perceptions and quantitative judgments into formal systems over time (Barcellos de Paula and Gil Lafuente, 2018). FL represents a major advancement seeking to bridge the gap between traditional mathematics's precision and the tangible world's inherent imprecision.

Using a Fuzzy Logic algorithm is beneficial in mitigating risks within intricate scenarios (Rubín, 2018). It simplifies decision-making by effectively accounting for uncertainty through mathematical calculations, considering the overlap of goals and limitations across multiple stages where human subjectivity plays a role (Barcellos de Paula and Marins, 2018). Additionally, the fuzzy approach enables the representation of imprecision, uncertainty, or the absence of information (Tariq et al., 2021). For these compelling explanations, this study employs the Affinities Theory (Kaufmann and Gil-Aluja, 1991) to determine the relationships between pro-environmental initiatives and the characteristics of the destination based on the tourist's perception. This approach provides a valuable mechanism for the clustering process, aiding in establishing relationships among different concepts concerning the satisfaction levels of the variables under analysis and identifying similar affinities. The Affinities Theory facilitates not only the formation of homogeneous groupings but also structures comprised of groups that

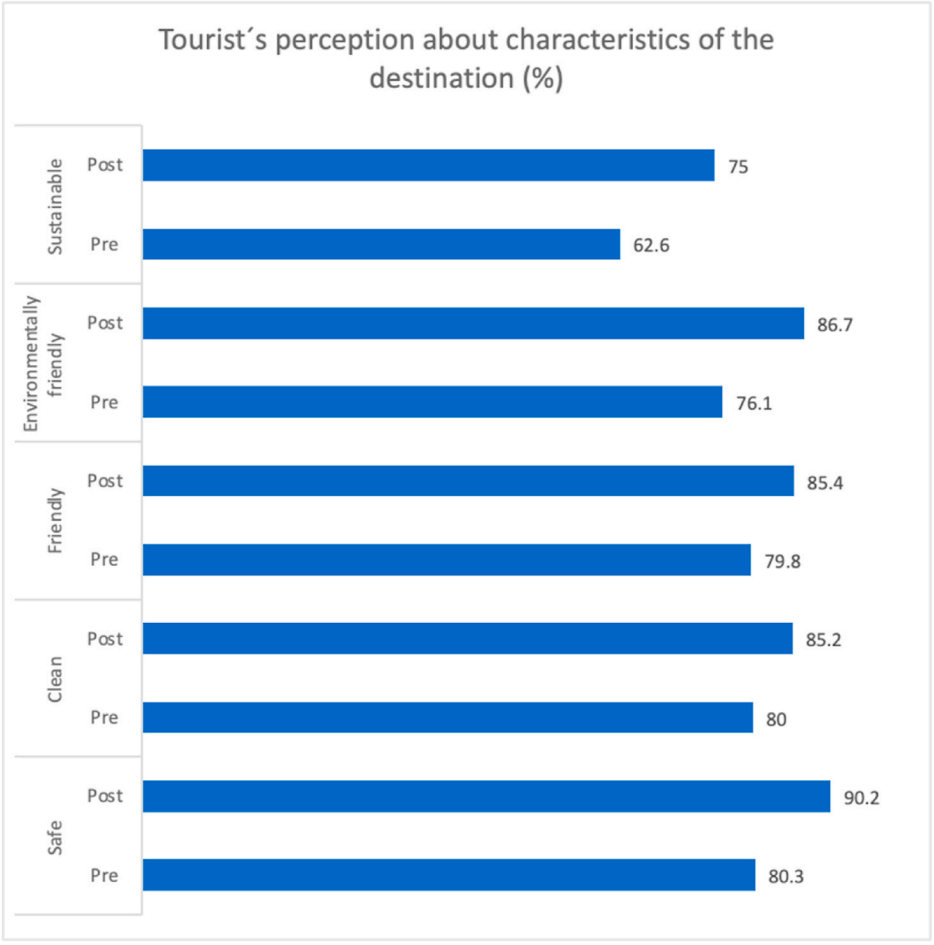

Fig. 7. Results of the survey.
Source: Own design founded on (Bilynets et al., 2023).

maintain a specific yet persuasive order (Kaufmann and Gil-Aluja, 1991). The effectiveness of this algorithm relies on the accuracy of the information it receives. The authors utilised data from a field study performed by researchers, validated and published in a scientific article, to perform the calculations. In addition, using this data fulfils a demand in the literature related to sustainable tourism in which researchers need to examine the actual actions of tourists (Nieto-García et al., 2024), including studying interventions, particularly those targeting the environment, in real-world situations (Kallbekken and Sælen, 2013).

The Affinities Theory is a powerful tool for this research compared to other correlational analyses like Pearson's or Spearman's coefficients (Barcellos-Paula et al., 2023). While correlation measures variable associations, it does not establish causality and is unsuitable for concordance analysis. In contrast, the Affinities Theory examines connections, associations, and cause-and-effect based on the concept of incidence, which can be strengthened or weakened by changing the intensity of the relationship (Barcellos-Paula et al., 2023). The membership function represents strength and variability, clarified through max-min composition, making it a flexible approach to decision-making. Furthermore, the method accommodates the integration of uncertainty management models such as Moore's Families and Galois lattices with traditional quantitative analysis to enhance the accuracy of data processing. This allows for forming clusters and a comprehensive display based on current relationships to facilitate well-informed decision-making (Barcellos-Paula et al., 2023). In summary, the Affinities Theory provides a hopeful method for establishing causation based on similarities instead of solely measuring statistical correlations, making it a valuable resource for making data-informed decisions. Fig. 8 illustrates the Algorithm's functionality.

Real-world case studies also demonstrate the model's relevance and potential in different research and professional contexts (Barcellos-Paula et al., 2023). For instance, researchers sought to identify similarities between Colombian regions by analysing economic activities and location to improve competitiveness (Blanco-Mesa and Gil-Lafuente, 2017). In other study, the affinity theory provided an extensive overview of the economic situation of the Russian Federation and Ukraine regions, offering essential decision-making guidelines (Gil-Lafuente and Klimova, 2014). Also, researchers used the affinity theory to analyse the factors impacting the competitiveness of Brazil and Peru (Barcellos-Paula et al., 2023). It has also been employed to assess suppliers' sustainable practices (Barcellos de Paula and Gil-Lafuente, 2020). Moreover, this approach has found application in diverse areas such as employee management (Gil Aluja, 1987), financial analysis (Gil-Lafuente, 2001).

4.2. Methodological foundations of Affinities Theory

The Affinities Theory was created in 1991 by doctors Arnold Kaufman and Jaime Gil-Aluja. They consider affinities as organised, uniform groupings at particular levels that link items from two sets of distinct natures (Kaufmann and Gil-Aluja, 1991). The idea is founded on three main elements: The initial aspect pertains to the uniformity of each group associated with the selected level. The next highlights the necessity for distinct guidelines to connect elements, while the final element calls for an essential framework for making decisions. The purpose of the grouping and the relationship between the elements determine all possible groupings (Kaufmann, A.; Gil Aluja, 1987). The Moore family model will be utilised to form affinity relationships (Kaufmann and Gil-Aluja, 1992). It is essential to note the wealth of knowledge stemming from Moore's family concept, which enables the creation of suitable groupings (Barcellos-Paula et al., 2023). The representation of these groupings through reticular structures emphasizes the affinities. The approach used to derive affinities enables us to outline the methodological procedure presented in Fig. 9.

The procedure starts by utilizing fuzzy subsets (FS) that describe an object $O_j.j = 1,2,\ldots m$, obtained through elements $E_i, i = 1,2,\ldots n$, in the context of similarity relationships. The sets include $S_1 = \{O_j \,/\, \mathrm{j} = 1,2,\ldots \mathrm{m}\}$ and $S_2 = \{E_i \,/\, \mathrm{i} = 1,2,\ldots \mathrm{n}\}$, together with the relevant FS:

$$\widetilde{O}_j \begin{array}{cccccc} E_1 & E_2 & E_3 & & & E_n \\ \mu_1^{(j)} & \mu_2^{(j)} & \mu_3^{(j)} & \cdots & & \mu_n^{(j)} \end{array} \tag{1}$$

$0 \le \mu_i^{(j)} \le 1, i = 1,2,\ldots n.$

$j = 1,2,\ldots m.$

FS collections can come together to form a fuzzy reference $[\widetilde{F}]$, for example:

$$[\widetilde{F}] = \begin{array}{c|ccccc} & E_1 & E_2 & E_3 & & E_n \\ O_1 & \mu_1^{(1)} & \mu_2^{(1)} & \mu_3^{(1)} & \cdots & \mu_n^{(1)} \\ O_2 & \mu_1^{(2)} & \mu_2^{(2)} & \mu_3^{(2)} & \cdots & \mu_n^{(2)} \\ & \cdots & \cdots & \cdots & & \cdots \\ O_m & \mu_1^{(m)} & \mu_2^{(m)} & \mu_3^{(m)} & \cdots & \mu_n^{(m)} \end{array} \tag{2}$$

Where, as we have indicated, the value of $0 \le \mu_i^{(j)} \le 1$. The existence of homogeneity for each element $E_i, i = 1,2,\ldots n$, in set S_2 is determined by establishing the minimum degree, for which a threshold θ_i is set. A new matrix [G] is created, where values of $\mu_i^{(j)}, i = 1,2,\ldots n; j = 1,2,\ldots m$, that meet the condition $\mu_i^{(j)} \ge \theta_i$ are assigned $\beta_i^{(j)} = 1$, while for $\mu_i^{(j)} < \theta_i$, $\beta_i^{(j)} = 0$. These thresholds $\theta_i, i = 1,2,\ldots,n$ specify the uniformity that is preferred for every item within the group S_2. A similar approach could be taken with set S_1 if the problem being addressed requires it. The initial generalising factor is commonly seen in systems that involve the computation of distances. The produced Boolean matrix $[G]$ contains different values from the characteristic membership function at various levels $\mu_i^{(j)}$, for each $E_i, i = 1,2,\ldots n$. To sum up, it can be stated:

$$[G] = \begin{array}{c|ccccc} & E_1 & E_2 & E_3 & & E_n \\ O_1 & \beta_1^{(1)} & \beta_2^{(1)} & \beta_3^{(1)} & \cdots & \beta_n^{(1)} \\ O_2 & \beta_1^{(2)} & \beta_2^{(2)} & \beta_3^{(2)} & \cdots & \beta_n^{(2)} \\ & \cdots & \cdots & \cdots & & \cdots \\ O_m & \beta_1^{(m)} & \beta_2^{(m)} & \beta_3^{(m)} & \cdots & \beta_n^{(m)} \end{array} \tag{3}$$

It is crucial to acknowledge that the figures of $\beta_i^{(j)} = \{0, 1\}$. The matrix $[G]$ serves as the initial step in identifying the connections between the selected levels θ_i. The following is a discussion of the notion of a power set. It concerns a finite set S_1, its power set, denoted as $\Pi(S_1)$. It includes every conceivable arrangement of its components taken one at a time, two at a time, …, up to m at a time, if m is its cardinality. For example, if we have the set $S_1 = \{a,b,c\}$, its power set is the set of all its parts.

$\Pi(S_1) = \{\varnothing, a, b, c, ab, ac, bc, E_1\}$

We will now proceed to establish the definition of a Moore family (Kaufmann, A.; Gil-Aluja, 1991). Let us consider a family of $\Pi(S_1), F(S_1)$, means that $F(S_1) \subset \Pi(S_1)$. If $F(S_1)$ satisfies:

1) $S_1 \subset \mathrm{F}(S_1)$.
2) The point where the quantity of components intersects of $\Pi(S_1)$ that belong to $\mathrm{F}(S_1)$, also fits to $\mathrm{F}(S_1)$. This is expressed as: $(\mathrm{A} \in \mathrm{F}(S_1), \mathrm{B} \in \mathrm{F}(S_1)) \Rightarrow (\mathrm{A} \cap \mathrm{B} \in \mathrm{F}(S_1))$, then $\mathrm{F}(S_1)$ is a "Moore family". If the relation $(S_1), \varnothing$ is also included, the Galois Lattice can be created formally.

The following section will employ this algorithm to assess Ljubljana's urban sustainability.

5. Application of the Affinities Theory to the urban sustainability of Ljubljana

This section is dedicated to configuring and applying the Affinities Theory and presenting the results.

First, the authors define the model variables based on research data on Ljubljana (Bilynets et al., 2023), which reveals the main pro-environmental initiatives and characteristics of the destination. The model includes seven key indicators of pro-environmental initiatives. These variables determine the set $E_1 = \{a,b,c,d,e,f,g\}$. Table 2 specifies these variables and indicators.

Next, the model includes the five indicators of the destination characteristics. These variables determine the set $E_2 = \{A,B,C,D,E\}$. Table 3 displays these variables and indicators. The authors have constructed a matrix representing the fuzzy connection between the two sets of variables. The matrix was created using responses from international visitors surveyed in Ljubljana in August 2019. The sample was 139 respondents who visited the tourist destination to identify whether pro-environmental measures were perceived during their stay.

The percentage values obtained were transformed into an 11-point scale (ranging from 0 to 1). The assigned value lies within the range of 0–1. Higher values indicate the strength of the relationship, while lower values indicate a weaker causal link between the elements. The fuzzy relationship between the variables is calculated using an average of the ratings of tourists who visited Ljubljana (Bilynets et al., 2023). In this case, the results reveal the relationship between pro-environmental initiatives (E_1) and the characteristics of the destination (E_2). Fig. 10 presents the fuzzy relationship.

After finishing the model configuration stage, the algorithm is put into action. Initially, the fuzzy association is transformed into a boolean matrix. The thresholds are based on the expectations of the tourists. Therefore, the matrix is based on surveys of 233 respondents before visiting the tourist destination (Bilynets et al., 2023). As a result, the authors establish the thresholds: $\theta_A \geq 0,626, \theta_B \geq 0,761, \theta_C \geq 0,803, \theta_D \geq 0,800, \theta_E \geq 0,798$ and the Boolean matrix is found. Fig. 11 displays the Boolean matrix.

The next step involves acquiring a group of subsets.

$$A_A = \{c,d,e,f,g\},\ A_B = \{c,d,e,f\}, A_C = \{c,d,e,f\},\ A_D = \{c,d,e\}, A_E = \{c,d,e\}$$

Presented below is the F group:

$$F = \{\{c,d,e,f,g\},\{c,d,e,f\},\{c,d,e,f\},\{c,d,e\},\{c,d,e\}\}$$

Following this, the group becomes the clan.

$$A_A = \{c,d,e,f,g\},\ A_B = \{c,d,e,f\}, A_C = \{c,d,e,f\},\ A_D = \{c,d,e\}, A_E = \{c,d,e\}$$

$$\overline{A}_A = \{a,b\}, \overline{A}_B = \{a,b,g\}, \overline{A}_C = \{a,b,g\}, \overline{A}_D = \{a,b,f,g\}, \overline{A}_E = \{a,b,f,g\}$$

Step three involves identifying the atoms.

$$A_A \cap A_B \cap A_C \cap A_D \cap A_E = \{c,d,e\} \quad A_A \cap A_B \cap \overline{A}_C \cap \overline{A}_D \cap \overline{A}_E = \varnothing$$

$$A_A \cap A_B \cap A_C \cap A_D \cap \overline{A}_E = \varnothing \quad A_A \cap \overline{A}_B \cap A_C \cap \overline{A}_D \cap \overline{A}_E = \varnothing$$

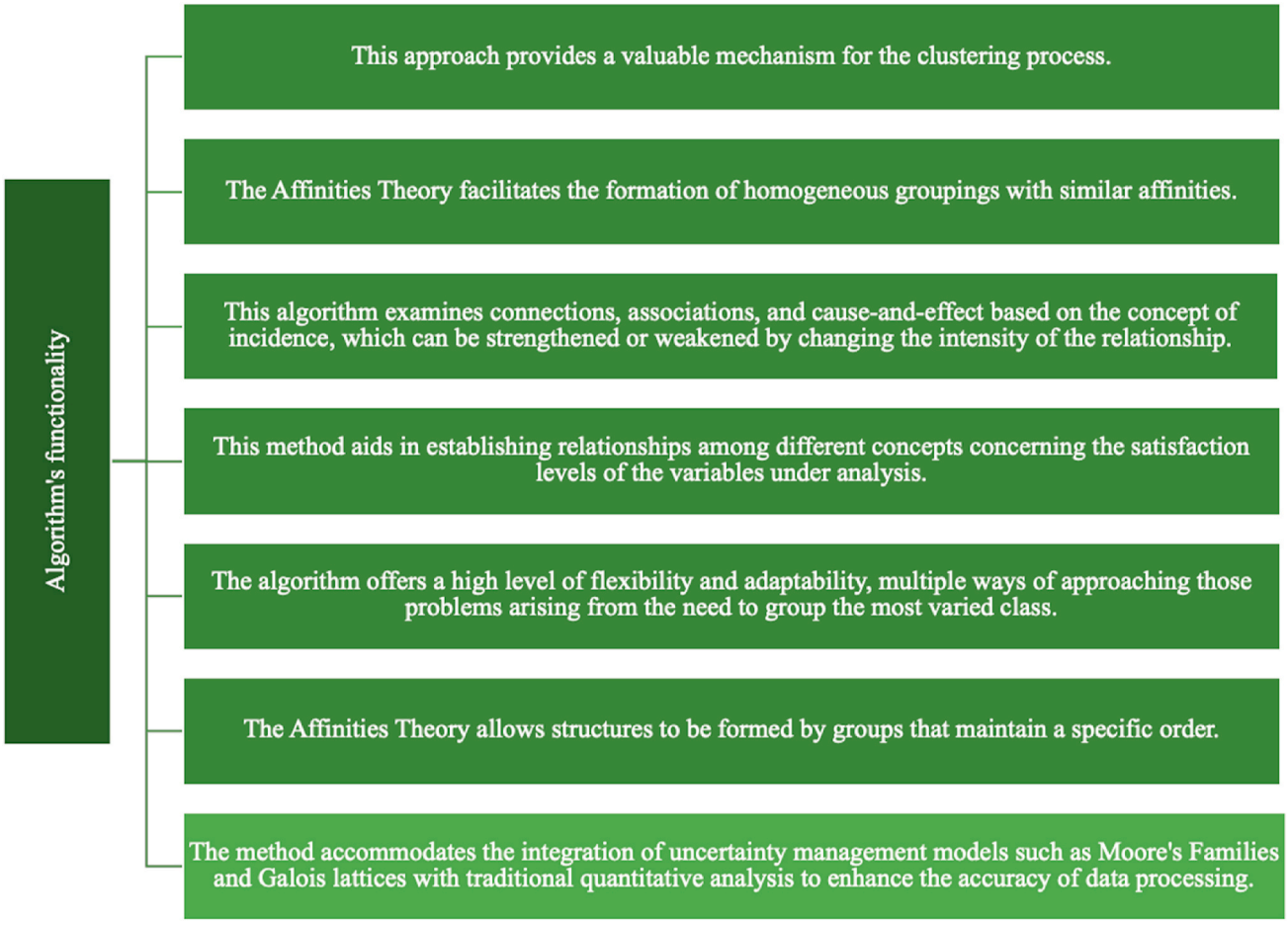

Fig. 8. Algorithm's functionality.
Source: Own design founded on (Kaufmann, A.; Gil-Aluja, 1991).

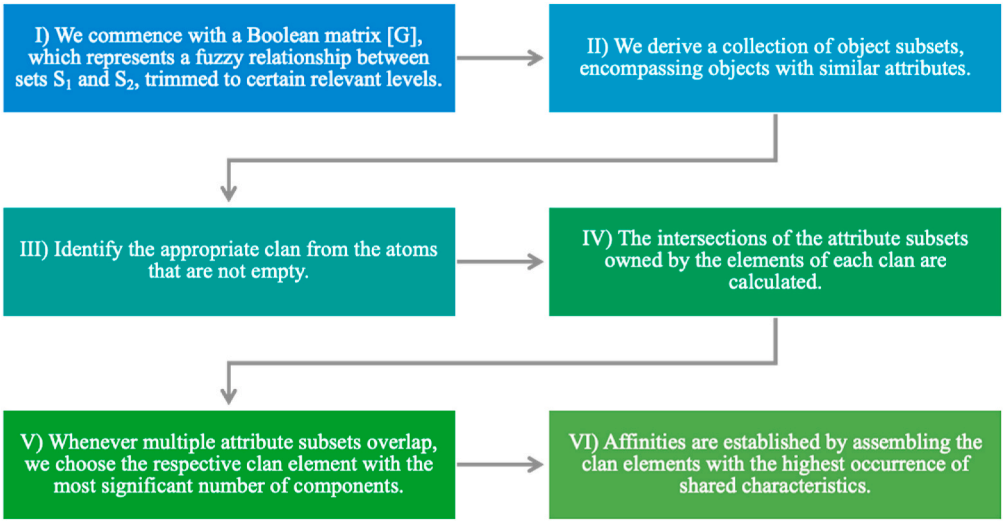

Fig. 9. Methodological procedure.
Source: Own design founded on (Kaufmann, A.; Gil-Aluja, 1991).

$A_A \cap A_B \cap A_C \cap \overline{A}_D \cap A_E = \varnothing \quad \overline{A}_A \cap A_B \cap A_C \cap \overline{A}_D \cap \overline{A}_E = \varnothing$

$A_A \cap A_B \cap \overline{A}_C \cap A_D \cap A_E = \varnothing \quad A_A \cap \overline{A}_B \cap \overline{A}_C \cap A_D \cap \overline{A}_E = \varnothing$

$A_A \cap \overline{A}_B \cap A_C \cap A_D \cap A_E = \varnothing \quad \overline{A}_A \cap A_B \cap \overline{A}_C \cap A_D \cap \overline{A}_E = \varnothing$

$\overline{A}_A \cap A_B \cap A_C \cap A_D \cap A_E = \varnothing \quad \overline{A}_A \cap \overline{A}_B \cap A_C \cap A_D \cap \overline{A}_E = \varnothing$

$A_A \cap A_B \cap A_C \cap \overline{A}_D \cap \overline{A}_E = \{f\} \quad A_A \cap \overline{A}_B \cap \overline{A}_C \cap \overline{A}_D \cap A_E = \varnothing$

$A_A \cap A_B \cap \overline{A}_C \cap A_D \cap \overline{A}_E = \varnothing \quad \overline{A}_A \cap A_B \cap \overline{A}_C \cap \overline{A}_D \cap A_E = \varnothing$

$A_A \cap \overline{A}_B \cap A_C \cap A_D \cap \overline{A}_E = \varnothing \quad \overline{A}_A \cap \overline{A}_B \cap A_C \cap \overline{A}_D \cap A_E = \varnothing$

$\overline{A}_A \cap A_B \cap A_C \cap A_D \cap \overline{A}_E = \varnothing \quad \overline{A}_A \cap \overline{A}_B \cap \overline{A}_C \cap A_D \cap A_E = \varnothing$

$A_A \cap A_B \cap \overline{A}_C \cap \overline{A}_D \cap A_E = \varnothing \quad A_A \cap \overline{A}_B \cap \overline{A}_C \cap \overline{A}_D \cap \overline{A}_E = \{g\}$

$A_A \cap \overline{A}_B \cap A_C \cap \overline{A}_D \cap A_E = \varnothing \quad \overline{A}_A \cap A_B \cap \overline{A}_C \cap \overline{A}_D \cap \overline{A}_E = \varnothing$

$\overline{A}_A \cap A_B \cap A_C \cap \overline{A}_D \cap A_E = \varnothing \quad \overline{A}_A \cap \overline{A}_B \cap A_C \cap \overline{A}_D \cap \overline{A}_E = \varnothing$

$A_A \cap \overline{A}_B \cap \overline{A}_C \cap A_D \cap A_E = \varnothing \quad \overline{A}_A \cap \overline{A}_B \cap \overline{A}_C \cap A_D \cap \overline{A}_E = \varnothing$

$\overline{A}_A \cap A_B \cap \overline{A}_C \cap A_D \cap A_E = \varnothing \quad \overline{A}_A \cap \overline{A}_B \cap \overline{A}_C \cap \overline{A}_D \cap A_E = \varnothing$

$\overline{A}_A \cap \overline{A}_B \cap A_C \cap A_D \cap A_E = 0 \quad \overline{A}_A \cap \overline{A}_B \cap \overline{A}_C \cap \overline{A}_D \cap \overline{A}_E = \{a,b\}$

The group below is currently present:

$$K = \{\varnothing, \{c,d,e\}, \{f\}, \{g\}, \{a,b\}, \{c,d,e,f\}, \{c,d,e,g\}, \{a,b,c,d,e\}, \{f,g\}, \{a,b,f\}, \{a,b,g\}, E_1\}$$

In step four, the authors compute the overlaps between the subsets:

$\varnothing \rightarrow \{A,B,C,D,E\}$

$\{c,d,e\} \rightarrow \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} = \{A,B,C,D,E\}$

$\{f\} \rightarrow \{A,B,C\}$

$\{g\} \rightarrow \{A\}$

$\{a,b\} \rightarrow \varnothing$

$\{c,d,e,f\} \rightarrow \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C\} = \{A,B,C\}$

$\{c,d,e,g\} \rightarrow \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A\} = \{A\}$

$\{a,b,c,d,e\} \rightarrow \varnothing \cap \varnothing \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} = \varnothing$

$\{f,g\} \rightarrow \{A,B,C\} \cap \{A\} = \{A\}$

$\{a,b,f\} \rightarrow \varnothing \cap \varnothing \cap \{A,B,C\} = \varnothing$

$\{a,b,g\} \rightarrow \varnothing \cap \varnothing \cap \{A\} = \varnothing$

$E_1 \rightarrow \varnothing \cap \varnothing \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C,D,E\} \cap \{A,B,C\} \cap \{A\} = \varnothing$

No subset shares the same characteristics. Lastly, the affinity connections are:

$E_2 \rightarrow \varnothing$

$\{A,B,C,D,E\} \rightarrow \{c,d,e\}$

$\{A,B,C\} \rightarrow \{c,d,e,f\}$

$\{A\} \rightarrow \{c,d,e,g\}$

$\{A\} \rightarrow \{f,g\}$

$\varnothing \rightarrow E_1$

First, the families of closed sets representing the isomorphic lattices

Table 2
Indicators of pro-environmental initiatives. Own source based on (Bilynets et al., 2023).

Variables	Indicators
a	Recycling waste
b	Public transport
c	Bike lanes
d	Litter bins
e	Local food
f	Drinking water
g	Electric transport

Table 3
Indicators of the destination characteristics Own source based on (Bilynets et al., 2023).

Variables	Indicators
A	Sustainable
B	Environmentally friendly
C	Safe
D	Clean
E	Friendly

are associated. In this way, it is possible to analyse, on the one hand, all the potential relationships of affinities between the destination characteristics indicators on the left and, on the other hand, all the relationships of affinities between the pro-environmental initiatives indicators on the right. Fig. 12 shows the Isomorphic lattices from the Lubjana Case.

The findings depicted in Fig. 13 visually illustrate the connections between pro-environmental initiatives and the destination characteristics. These findings are elaborated below.

The Galois Lattice identifies five destination characteristic indicators: Sustainable (A), Environmentally Friendly (B), Safe (C), Clean (D), and Friendly (E). Similarly, the results pinpoint the indicators of pro-environmental initiatives: Bike lanes (c), Trash cans (d), Local food (e), Drinking water (f), and Electric transportation (g). However, the results do not include Waste Recycling (a) and Public Transportation (b). Notably, tourists noticed the two pro-environmental initiatives (a and b) but received lower ratings than the other indicators. When the thresholds were applied based on the tourist's expectations, these variables were shown to have little relevance and did not seem in the Galois Lattice. One of the reasons for this finding for waste recycling (a) suggests that tourists are not the primary users of this service. However, residents value the bins more (d), and they also collaborate with recycling as they have compartments to separate garbage. On the other hand, the finding for public transport (b) can be explained by the small territorial extension of the city and the availability of other means to get around, on foot, for example, since the city centre is pedestrian, bikes or even surfboards.

6. Discussion

The literature review broadens the discussion on sustainable tourism and solutions to reduce the impacts of climate change, addressing research question RQ_1. With the application of the Affinities Theory, it was possible to understand the pro-environmental initiatives and tourist perception addressing research question RQ_2. The main findings of this study related to the literature gaps are as follows.

Firstly, the Galois Lattice method presents all the current connections between the variables of pro-environmental initiatives in a structured and systematic manner. It lists the indicators of the characteristics of the destination that each homogeneous group possesses and links them cohesively through a structure. The results allowed us to understand the affinity relationships between pro-environmental initiatives and destination characteristics based on the tourist's perception (Bilynets et al., 2023), which helps to reduce gap six by deepening the findings of the scientific study on Ljubljana.

$[\tilde{R}] =$

↗	A	B	C	D	E
a	0.490	0.549	0.566	0.541	0.542
b	0.470	0.529	0.546	0.521	0.522
c	0.795	0.854	0.871	0.846	0.847
d	0.785	0.844	0.861	0.836	0.837
e	0.755	0.814	0.831	0.806	0.807
f	0.740	0.799	0.816	0.791	0.792
g	0.655	0.714	0.731	0.706	0.707

Fig. 10. Fuzzy relationship.
Source: Own design founded on (Bilynets et al., 2023).

Secondly, the algorithm shows that pro-environmental initiatives (cde) have affinities related to the destination's characteristics (ABCDE). These findings coincide with another study (Olya et al., 2023) on visitors' willingness to adopt ecological behaviours and prioritize local products. As recommendations, restaurant managers could prioritize local food (e), and the public administration should invest in bike lanes (c) and litter bins (d). That corroborates with research findings indicating that residents' environmentally responsible behaviour positively correlates with destination social responsibility (Peng et al., 2024). It also supports other researchers' findings that promoting low-carbon attitudes, knowledge, environmental education, and policy incentives can drive sustainable behaviour among tourists (Wu et al., 2023). These findings help to bridge the gap seven when researching urban tourism (Tyagi, 2024).

Thirdly, pro-environmental initiatives (cdef) present a relationship of affinities with the characteristics of the destination (ABC). This result corroborates the research findings (Martínez García de Leaniz et al., 2018), indicating that destinations should strive to be innovative to improve the living environment for residents and tourists, being a sustainable city (A), environmentally friendly (B), and safe (C). That align with organizations' compliance with environmental actions such as waste management and carbon emission reduction (Nieto-García et al., 2024). And the conclusion of another study where residents' environmentally responsible behaviour positively correlates with destination social responsibility (Peng et al., 2024). Furthermore, this result reduces gap two, as it helps to understand the connection between tourism sustainability, affinity with nature and social engagement behaviour (Diallo et al., 2022).

Fourthly, pro-environmental initiatives (cdeg) have a relationship with the characteristics of the destination (A), and demonstrate the movement towards promoting visitors to embrace environmentally friendly behavioural attitudes (Dolnicar, 2020; Olya et al., 2023; Trabandt et al., 2024). In this case, decision-makers should introduce renewable energy initiatives such as electric transport for sustainable economic growth (Kuldasheva et al., 2023). These results converge with another study indicating that promoting climate change mitigation behaviours increases pro-environmental behaviours by 2% and 12% (Bergquist et al., 2023). Therefore, these findings help to narrow gap four by deepening research on the impact of tourism on climate change (Ghosh et al., 2024; Scott et al., 2023; Scott and Gössling, 2022).

$[B] =$

↗	A	B	C	D	E
a	0	0	0	0	0
b	0	0	0	0	0
c	1	1	1	1	1
d	1	1	1	1	1
e	1	1	1	1	1
f	1	1	1	0	0
g	1	0	0	0	0

Fig. 11. Boolean matrix.
Source: Own design founded on (Bilynets et al., 2023).

Fifthly, the indicators (fg) present an affinity relationship with the indicator (A). This result coincides with other findings (Nieto-García et al., 2024) since tourists are predisposed towards ecological destinations to address their environmental concerns. Therefore, policymakers should provide drinking water (f) and electric transportation services (g), which would increase the social responsibility of the destination and tourists' perception of actions to mitigate climate change (Olya et al., 2023). Also, the authors demonstrated by focusing on sustainable transport to improve tourism sustainability (Agarwal et al., 2024). These approaches can help reduce the use of resources and fossil fuels, boost innovation, conserve energy and mitigate emissions (United Nations, 2024). Furthermore, the results help to reduce gap three by exploring sustainable transport as a practical application to reduce the carbon footprint of tourism (Agarwal et al., 2024; Ghosh et al., 2024).

These findings corroborate what was initially found in the Boolean matrix that revealed the relevance of pro-environmental initiatives (cde) in tourist perception of the variables (f and g), respectively. Therefore, Bike Lanes (c), Trash Cans (d), and Local Food (e) are transversal to all the characteristics of the destination (ABCDE). On the other hand, electric transportation (g) is only related to sustainable (A). Drinking water (f) has been perceived as an initiative related to characteristics of being sustainable (A), environmentally friendly (B) and safe (C). Consequently, these results agree that the destination's sustainability is essential in stimulating the internal and external responses of tourists (Bilynets et al., 2023; Wong et al., 2021). Mainly capable of generating the perception of a reliable (safe) place, inducing repetition of the destination (S. Hassan and Soliman, 2021). And tourist prioritize climate-friendly options, waste reduction, and economic and social sustainability (Schönherr and Pikkemaat, 2024). On the other hand, the research helps narrow the gap in understanding how the environmental performance of destinations produces tourist responses (Wong et al., 2021). Our research also significantly reduces gap one, as it provides valuable insights into tourist behaviour. This understanding can help align industry policies and practices with changing consumer trends, empowering the industry to achieve sustainable tourism (Ghosh et al., 2024).

In response to the lack of a practical approach (Mihalic et al., 2021) the lack of crucial resources for addressing climate change in the tourism sector (Peeters et al., 2024), the algorithm allowed the most relevant characteristics of the destination to be ordered for the tourist. In this case, first, Sustainable (A); second, Environmentally Friendly (B) and Safe (C); third, Clean (D) and Friendly (E). In this way, these results could help managers and policymakers formulate strategies based on sustainability (Pulido-Fernández et al., 2024), and reduce uncertainty in

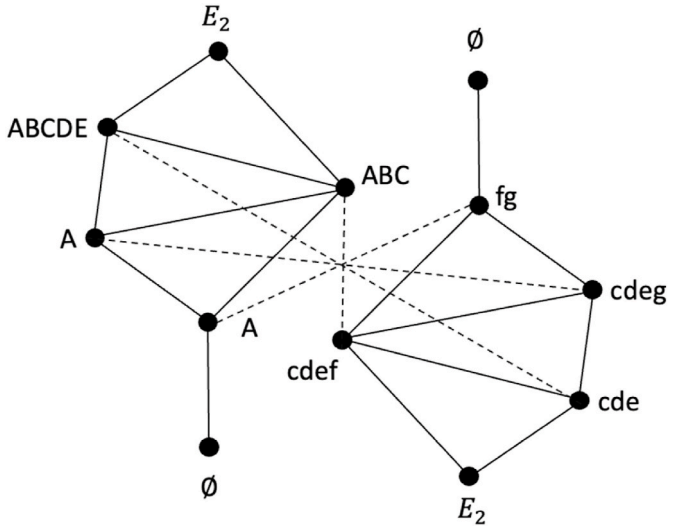

Fig. 12. Isomorphic lattices from the Lubjana Case.

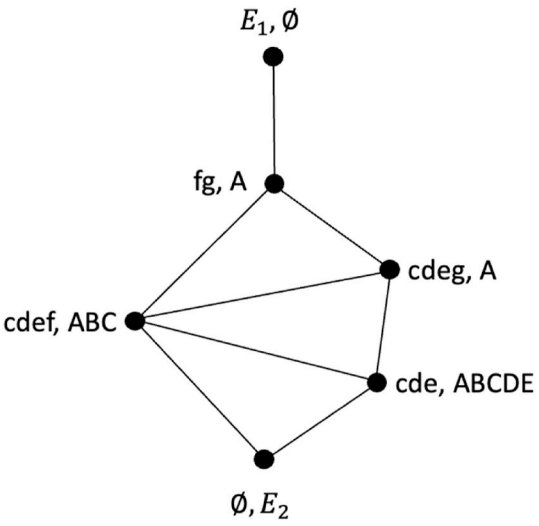

Fig. 13. Galois lattice from the Lubjana case.

decision-making (Mensah et al., 2021). It was also evident that sustainable tourism governance is crucial to achieving success, and it is essential to coordinate efforts between different stakeholders (Bramwell et al., 2017; J. Song and Kang, 2023). These findings help to reduce gap five by studying pro-environmental behaviour through different methods, such as case studies, mixed methods, and experiments (Loureiro et al., 2022).

Finally, choosing Ljubljana as a destination answers a call for investigating sustainable policies from regional and local perspectives (Agarwal et al., 2024). Due to the complexity of the tourism sector, climate change, and regional development, researchers advocate for customising policies and sustainable tourism practices, encouraging global cooperation to tackle climate change issues (Ghosh et al., 2024). Although the results are specific in this context, other cities can use inspiration from these practices to improve sustainable tourism and minimise climate change.

7. Conclusions

This research fills the gap in the existing literature by examining how environmental practices can help reduce climate change's impact and how tourists perceive these practices. The research acknowledged important features of destinations that are related to sustainability. Also, it indicates practical approaches to improve the competitiveness and sustainability of tourism.

As theoretical implications, this research brings several significant contributions to the literature. First, this study broadens the discussion on sustainable tourism and solutions to reduce the impacts of climate change, allowing the identification of specific knowledge gaps. Second, this research analyses the theoretical background of Fuzzy Logic and Affinities Theory and presents the application possibilities of this algorithm. Third, this study is novel in that it deepens the connections of preferences between environmentally friendly initiatives and destination characteristics from the perspective of tourists travelling to Ljubljana, allowing it to reduce a gap in the literature and validate other academic research. Fourth, using the specific algorithm to recognise affinity relationships contributes significantly to advancing knowledge on sustainable tourism, addressing specific gaps and improving our understanding of the topic. Fifth, this study confirms the theoretical value of Affinities Theory in decision-making processes, particularly in identifying the interconnections between pro-environmental efforts and destination characteristics perceived by tourists. Furthermore, the algorithm employed effectively organises variables according to their relevance, reducing uncertainty and facilitating decision-making.

Ultimately, this work is a valuable resource for guidance for scholars and students from various parts of the world researching sustainable tourism, climate change, decision-making, and Fuzzy Logic algorithms.

As practical implications, the research findings reveal significant contributions to management and policy. First, this research warns managers and policymakers about the risks and impacts of climate change on the tourism sector and recommends adopting climate change adaptation and mitigation measures. For example, cities can reduce GHG emissions through renewable energy initiatives, encourage visitors to use energy-efficient public transport, and promote circular economy models, sustainable production practices, and responsible consumption. These approaches can help reduce the use of resources and fossil fuels, drive innovation, conserve energy, and mitigate emissions. The study's findings also suggest practical implications to address climate change, such as improving planning and management, emphasizing the necessity of supportive regulations from governments and destinations. In addition, governments should adapt their policies to incorporate climate change measures, promote sustainable tourism practices, and foster international collaboration to address the challenges of climate change.

Secondly, this research highlights the importance of stakeholder engagement in achieving sustainable tourism and reducing the impacts of climate change. As practical implications, the tourism industry and government should cooperate to promote energy conservation, protect the environment, and ensure sustainable development. For example, promoting attitudes, knowledge, environmental education, and low-carbon policy incentives can encourage sustainable behaviour among tourists and residents. The research also suggests a joint effort to implement awareness programs to reduce food waste and losses, decrease waste generation, and manage data to monitor sustainable tourism indicators.

Third, based on the findings of the Ljubljana case study, managers and policymakers can strengthen the tourism sector by prioritising management and marketing strategies that consider the adoption of pro-environmental initiatives and their subsequent perception by tourists. That could be the implementation of bicycle lanes and electric transport systems, proper installing trash bins and awareness about the correct use of waste recycling, and efficient cleaning of parks, streets and sidewalks. Other strategies can be the valorisation of local food producers and efficient drinking water management. This would increase the attractiveness of the destination since pro-environmental measures are perceived as a positive and relevant attribute in decision-making. Consequently, it would increase its competitiveness and contribute to the sustainable development of tourism. These implications can be applied beyond the specific country studied, such as in other cities in Europe or another destination worldwide.

8. Limitations and future research

The research presents some limitations related to the case study that include an analysis of the sustainability of the tourist destination, focusing on the perceptions of tourists visiting Ljubljana and taking into account various pro-environmental initiatives and the characteristics of the destination.

Firstly, the study contemplates seven indicators of pro-environmental initiatives and five indicators representing the characteristics of the destination. Future research can expand the number of variables in these two categories, including, for example, eco-accommodation and price. Or include another category with indicators related to the SDGs. In this way, research on sustainable tourism can address other issues not contemplated in this study.

Secondly, possible biases in tourists' perceptions may occur when answering the questionnaires, such as fatigue from the trip, the type of environment in which the survey is conducted, the resource used to obtain the answers (paper and pen questionnaire), possible pressure to answer the questions on time, and knowledge of the English language. In this sense, future research should try to minimise the biases mentioned, such as, for example, offering a comfortable environment for the survey, providing computer equipment such as tablets to answer the questions, and questionnaires in other languages. These recommendations can improve the information collection process and reduce biases in the study.

Third, the research used a specific algorithm to identify the relationships between the variables. However, other nuances of sustainable tourism can be investigated and require other algorithms tailored to different problems. For instance, Fuzzy Logic algorithms, such as, the Ordered Weight Averaging (OWA) operator (Yager, 1988) and the Simple Additive Weighting (SAW) method (Rogers et al., 2000). Research has employed these techniques to assess the competitive nature of tourism spots in Sinaloa, Mexico (Huesca-Gastélum and León--Santiesteban, 2021). Another example is the Theory of Forgotten Effects (Kaufmann, A.; Gil-Aluja, 1988), which address cause-effect relationships and identify hidden effects. In Brazil, a study has uncovered the overlooked consequences of tourism that may affect sustainable development (de Paula et al., 2021). Fourth, the case study addressed an urban European tourist destination. Future research can replicate the same model in cities with similar characteristics. Also, this study focused on a single destination, and the findings could reflect the participants' cultural beliefs. Additional studies could explore various geographical locations to contrast how tourists perceive and interact with environmental initiatives. This approach can deepen research and expand findings on sustainable tourism.

Another area for improvement lies in the challenges of implementing the proposed strategies. Despite presenting sustainable practices for tourism and finding solutions that may be scalable for cities with similar characteristics in Europe or globally, environmental policies and tourism strategies may need to be adapted to the unique characteristics of each region. Future research can further study the challenges of implementing sustainable strategies in other tourist destinations and conduct comparative analyses. As indicated in the literature review, future research can investigate the impact of government rules, laws, and regulations on sustainable tourism, including measures such as banning single-use plastics and determining carrying capacity.

Finally, the research broadened the discussion on sustainable tourism and climate change, answered the two research questions, and addressed the seven identified knowledge gaps. However, the literature review revealed other knowledge gaps that needed to be addressed as they are outside the scope of the present research. Future research can address these literature gaps, such as conducting further assessments of eco-services, examining how tourists prioritize and reconcile sustainability actions, and conducting studies to identify and reduce social bias in tourists reporting their intentions and behaviours. Future research can also collect data from resident and explore additional experiments to understand better the causal relationship between destination social responsibility, and residents' eco-behaviour.

CRediT authorship contribution statement

Luciano Barcellos-Paula: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Aline Castro-Rezende:** Writing – original draft, Validation, Supervision, Investigation, Data curation. **Anna María Gil-Lafuente:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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