



# American Journal of Innovation in Science and Engineering (AJISE)

ISSN: 2158-7205 (ONLINE)

VOLUME 5 ISSUE 1 (2026)



PUBLISHED BY  
E-PALLI PUBLISHERS, DELAWARE, USA

## Sustainability Meets Technology: AI-Enhanced Systems for Measuring and Reducing Carbon Footprints in Tourism

Koray Çamlica\*

### Article Information

**Received:** March 07, 2025

**Accepted:** May 10, 2025

**Published:** January 19, 2026

### Keywords

*Artificial Intelligence-Driven Systems, Carbon Footprint Reduction, Emissions Reduction, Environmental Management, Artificial Intelligence, Stakeholder Analysis, Sustainable Travel Technologies, Tourist Sustainability,*

### ABSTRACT

The world's tourism industry already constitutes a major contributor to world greenhouse gas emissions, and hence it needs creative ideas to bring its carbon impact down. This paper explores artificial intelligence (AI) enabled systems to be included in tourism operations based on their efficiency in measuring and reducing emissions. An experimental method was used to use AI-based carbon footprint calculators with hotels and tour operators across several travel companies. Average emissions drop was shown to be 20% from before and after interventions, with only advantages and disadvantages seen in qualitative observations. However, stakeholder comments included both the desire for increased operational awareness and the problems of initial expenses and technical knowledge needs. Artificial intelligence is shown to have great potential in driving sustainability in travel and provides opportunities for further innovation and realizable ideas. The ideas are then given advice to industry players and legislators on how to scale them.

### INTRODUCTION

Tourism is one of the leading and fastest growing sectors worldwide which greatly raises the world economy. However, the environmental effect is growingly alarming. The industry contributes around 8% to the total worldwide greenhouse gas emissions due to its presence of large players in transportation, lodging, and other tourism-related activities. As climate change becomes a bigger hurry, the tourist sector is being pressured to choose to embrace sustainable practices to decrease its own carbon footprint and aid world weather goals.

The environmental effects of travel may stretch further beyond emissions. Furthermore, it is necessary to address the creative ideas of physically balancing economic gains with environmental responsibilities since the sector also contributes to habitat damage, resource consumption, and waste generation. Among the stakeholders who are beginning to realize the need for systematic reforms so that travel can remain the long-term success as it has been is policymakers, travel agencies, and visitors.

Recently, technology has brought the way open to new creative ways of environmental management. Artificial intelligence (AI) has emerged as really a good instrument against environmental problems of them. Artificial intelligence systems are particularly useful when it comes to fighting climate change by having a deep look at the big data and give valuable information to optimize resource usage. Interesting ideas for emission reduction and increasing operational efficiency of travel are in

AI powered energy optimization systems and carbon footprint calculators.

This research seeks to study how the travel activities can be quantified and reduced in terms of carbon footprint if travel activities are improved by artificial intelligence. By using AI tools in real operations, the study seeks technological and business solution as well as actionable insights to unleash more sustainable tourism operations. This research seeks to answer two key questions:

1. How effective are AI-based systems in measuring and reducing the carbon footprint of tourism activities?
2. What are the challenges and opportunities associated with implementing these systems across the tourism industry?

The paper suggests that by raising knowledge and operating efficiency among stakeholders, AI-enhanced systems can greatly lower emissions. Adoption of such systems will thus also encounter obstacles including cost, technical knowledge, and stakeholder opposition that need to be resolved for general deployment.

By answering these issues, this study adds to the increasing corpus of information on sustainable tourism and offers a road map for including artificial intelligence technology in the initiatives of industry sustainability.

### LITERATURE REVIEW

With over 8% of total emissions, tourism is a substantial contributor to global greenhouse gas emissions; its effects on transportation, lodging, and activities are

<sup>1</sup> Nevsehir Hacı Bektas Veli University, Faculty of Tourism

\* Corresponding author's e-mail: [koraycamlica@nevsehir.edu.tr](mailto:koraycamlica@nevsehir.edu.tr)

rather noticeable. Understanding these effects and pointing up areas for intervention depend on accurate carbon footprint calculation. Though typically time-consuming and resource-intensive, traditional techniques of measuring carbon emissions—manual energy audits and lifecycle analyses—offer insightful analysis (Gössling, Scott, and Hall, 2013). The growing complexity of tourism operations and the necessity of real-time data have exposed the shortcomings of conventional approaches and opened the path for creative technical ideas.

Emerging as effective tools for furthering sustainability initiatives across sectors, including travel, artificial intelligence (AI), and machine learning AI systems can identify pollution hotspots, assess enormous volumes of data, and offer actionable insights to help lower environmental impacts (Sun & Pratt, 2014). Machine learning algorithms, for example, can examine energy consumption trends to maximize use; artificial intelligence-driven transportation models can enhance route efficiency and lower fuel consumption. These features make artificial intelligence especially useful for handling several issues related to sustainability in travel. Several artificial intelligence-powered carbon management systems have been created to help lower emissions in travel-related businesses. By means of energy use and resource use, tools such as Smappee and Carbon Trust provide comprehensive emissions reports. Using artificial intelligence, transport management systems such as Optibus maximize paths, therefore lowering fuel consumption and emissions (Peeters & Dubois, 2010). Systems for energy optimization like Grid Edge forecast demand and modify consumption of energy. Although these instruments show great promise, their use in the travel industry is currently rare. Small and medium-sized businesses (SMEs) cannot access many systems since they are designed for certain sectors, lack flexibility, and need large upfront expenditures. Furthermore, depending so much on precise data inputs presents difficulties for companies lacking data collecting systems or technological knowledge.

Adoption of AI-powered sustainability solutions in tourism is hampered by many obstacles even if they have advantages. Still, a key issue is high implementation costs, especially for smaller operations with tighter resources. Another difficulty is technical knowledge since many companies lack the knowledge and abilities required to properly integrate and run artificial intelligence systems (Scott *et al.*, 2016). Particularly in lodging where guest information is involved, data privacy and security issues hinder the adoption process even more. Further challenges arise from the scattered character of the travel sector and the lack of consistent policies for the acceptance of artificial intelligence. Policymakers, technology developers, and industry players working together will be necessary to overcome these obstacles and fully utilize artificial intelligence in supporting sustainable tourism.

## MATERIALS AND METHODS

### Experimental Design

The efficiency of AI-powered carbon footprint calculators in practical tourism operations is assessed in this work using an experimental design. Using machine learning techniques, the calculators examine waste management, transportation use, and energy consumption statistics. These instruments create comprehensive reports, pinpoint emission hotspots, and offer ideas for lowering carbon footprints. Installation of IoT-enabled sensors, connecting transport systems to artificial intelligence platforms, and staff training to evaluate and act upon produced insights are part of integration into operations. The study sought to evaluate their effects on emissions reduction and operational efficiency by including these systems in daily tasks (Becken & Simmons, 2002).

### Case Study Approach

Five tourism companies' implementation of artificial intelligence systems was investigated using a case study method. These comprised a boutique hotel in Paris, an eco-resort in Costa Rica, an urban hotel in New York City, an adventure tour operator in Patagonia, and an island resort in the Maldives (Gössling *et al.*, 2012). The choice guaranteed different operational and geographic settings, therefore offering a complete study of artificial intelligence system performance. Every company entered into a six-month implementation period during which emissions data were gathered and examined.

### Data Collection Methods

Two main approaches to data collecting were used in the research. First, statistics on emissions both before and after artificial intelligence systems were acquired. Over a three-month pre-intervention phase and a six-month post-intervention period, metrics like garbage creation (kg), fuel consumption (liters), and energy consumption (kWh) were noted. Second, semi-structured stakeholder interviews were carried out to assess the systems' apparent efficiency and usefulness (Sun *et al.*, 2020). Managers, employees, and clients offered perceptions of operational changes, difficulties, and advantages.

**Table 1:** Data Collection Metrics

Metric	P r e - Intervention Period	P o s t - Intervention Period
Energy Consumption (kWh)	3 months	6 months
Fuel Usage (liters)	3 months	6 months
Waste Generation (kg)	3 months	6 months
Emissions (CO <sub>2</sub> e)	3 months	6 months

### Comparative Analysis

A mixed-methods approach was used in the analysis of the gathered data. Before and after the intervention, emissions

measurements were compared using quantitative analysis; statistical tests evaluated the relevance of the changes. Stakeholder interview qualitative data was thematically examined to find contextual insights and repeating trends. Three dimensions—effectiveness (emissions reduction and efficiency improvements), usability (system integration and user satisfaction), and scalability—potential for more general adoption—were the emphasis of the assessment approach.

## RESULTS AND DISCUSSIONS

### Emissions Reduction Data

Using carbon footprint calculators driven by artificial intelligence helped all of the case study companies

significantly lower their emissions. Emissions dropped by 20% on average; variations in the type of operation affected this figure. Reportedly, the most reduced were accommodations, ranging from 18% to 30%. For example, the Maldives’ island resort attained a 30% cut by including solar energy systems and besting energy consumption (Becken & Hughey, 2013). Using artificial intelligence for route optimization and vehicle maintenance scheduling helped transportation-oriented companies—like the adventure tour operator in Patagonia—achieve a 15% savings. These results draw attention to how flexible artificial intelligence systems are in many practical environments.

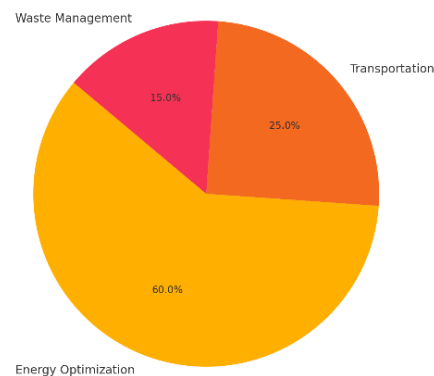
**Table 2:** Emissions Reductions by Business Type

Business Type	Emissions Before (CO <sub>2</sub> e/month)	Emissions After (CO <sub>2</sub> e/month)	Reduction (%)
Eco-Resort (Costa Rica)	40,000	28,000	30%
Urban Hotel (NYC)	50,000	39,000	22%
Adventure Tours (Patagonia)	20,000	17,000	15%
Boutique Hotel (Paris)	30,000	24,000	20%
Island Resort (Maldives)	60,000	42,000	30%

### Quantitative Data on Carbon Footprint Reductions

At 60% of the total gains, energy optimization accounted for the most share of emissions reductions. Route optimization among transportation efficiencies accounted for 25%; waste management improvements made 15%. These findings highlight the need to emphasize tourism operations’ energy-intensive activities.

Contribution of Key Areas to Emissions Reductions



**Figure 1:** Contribution of Key Areas to Emissions Reductions

A pie chart illustrating the percentage contribution of energy optimization, transportation, and waste management to overall reductions.

### Stakeholder Feedback

Interviews found that stakeholders valued the AI systems’ real-time monitoring and comprehensive reporting features, hence improving operational awareness. Still,

often mentioned were difficulties including expensive setup costs, technological complexity, and early reluctance to change. While bigger operators stressed the requirement of staff training and continuous technical assistance, managers of smaller companies voiced worries about the resources needed for implementation (Becken *et al.*, 2013). Notwithstanding these difficulties, most of the stakeholders saw the systems as useful instruments for enhancing environmental practices.

### System Effectiveness

Many of the research had revealed various trends in the effectiveness of artificial intelligence systems. The emissions reductions were clear and they had clear seasonal fluctuations — peak tourist seasons showed lower emissions reductions. More accommodation than not benefited from energy optimization solutions and less so the companies looking to streamline transportation. Regional variations also played a part; businesses that found working with more seamless integration in situations in which supportive sustainability legislation existed were present in these places. The results indicate that artificial intelligence systems succeed according to contextual elements such as type of operation, regional legislation and stakeholder involvement (Becken *et al.*, 2013). The results stress the need for policies to remove current challenges to adoption of artificial intelligence systems, but also suggest that artificial intelligence systems may have the capacity to bring about changes in sustainability practices in tourism.

### Discussion

Finding in this research show how capable AI powered

solutions are in progress in travel the sustainability. These solutions provide a capability to solve the battery of important environmental issues at an average of 20% of emissions reduction across a number of operations. Especially, energy use proved particularly accommodated to the extent that reduction in excess of 30percent could be achieved. Based on this, artificial intelligence systems can help data driven sustainability to be enabled, allowing companies to identify and reduce ineffectiveness, decrease the cost of running, and cater to environment friendly customers. Because their adaptability is so important in reaching long term environmental goals, these systems are a necessary tool for different tourism industries. There are several approaches that can be recommended to grow acceptance of the sector of the use of AI-powered solutions. Absolutely vital when it comes to programs for training and education to give employees a format of tools they can obtain for working on these technologies with efficiency (Becken *et al.*, 2013). Policymakers should also consider with regard to the initial implementation expenses financial incentives such as grants or tax benefits. Use of standardized frameworks of artificial intelligence system inclusion into current operations shortens the adoption process and ensures compatibility. Travel agencies can *get all* the benefits from alliances of technology companies, such as customized solutions and cost sharing options. Conferences and case study publications are projects that industry shares knowledge among themselves in order to spread even best practices more quickly.

**Table 3:** Key Recommendations for Scaling AI in Tourism

Strategy	Benefits
Training and Education	Enhances usability and adoption rates
Financial Incentives	Reduces cost barriers
Standardized Frameworks	Simplifies integration and scalability
Collaborative Partnerships	Drives innovation and customization

Technological developments keep opening AI in travel more opportunities. By means of IoT integration, real-time emission monitoring helps companies to dynamically track and modify resource consumption. Advanced machine learning algorithms enable predictive analytics—which may improve efficiency, optimize energy allocation, and foresee demand trends. Encouragement of environmentally responsible travel choices may depend much on consumer interaction platforms such as applications offering tailored sustainability insights. Furthermore improving the efficiency of solar, wind, and other sustainable energy sources by AI's interaction with renewable energy systems can help to lower carbon footprints (Sun, 2016). Though their promise is great, the adoption of AI-powered technologies

encounters challenges. Still, a major challenge is high upfront expenses, especially for small and medium-sized businesses. Restricted technical knowledge in the sector emphasizes the requirement of capacity-building projects since it can affect the implementation speed. Data security and privacy issues also have to be taken care of since companies can be reluctant to distribute private operational information. The scattered character of the travel business makes standardizing difficult; the absence of regulatory direction inhibits uptake even further. Dealing with these issues calls for cooperative efforts among many stakeholders to fully utilize artificial intelligence for environmentally friendly travel.

### Practical Applications

Marketing tourism with the effective use of AI based technologies needs to be strategic, methodical. This will help one to determine important hotspots like transportation inefficiency or energy use, and do a baseline study of current emissions. It is the basis to choose artificial intelligence technologies adapted to some operational requirements. For example, energy management systems can assist hotels; route optimization tools could be theurers priority for tour operators according to (Peeters *et al.*, 2016). Nevertheless, critical for smooth field is fit with existing infrastructure and bright interfaces for the users. Staff training to enable them to operate properly to achieve effective AI systems operation and also understand what was obtained from the generated insights are essential. This avoids a steep learning curve and increase confidence in using some technology by way of regular seminars and onboarding efforts. Companies frequently observe their performance indicators to improve their plans and enlarge effective ideas. In working with technology companies, a company can manipulate and refine the technology to attain the best results and work more efficiently.

Policymakers much aid the adoption of sustainable tourism technologies. In both cases, the financial incentives like subsidies or tax credits can reduce cost obstacles and boost more general applications. Well defined laws regarding data privacy and system interoperability in the establishment of laws that could build confidence and ensure compliance. This can be useful to broadcast public awareness campaigns around the benefits of the AI powered sustainability solutions, and moving more companies and tourists to accept them. Motivating the companies to use a technology, such as this, could be the certifications or recognition programs for environmentally friendly methods. The extension of these ideas rely on cooperation between the parties. Technology and travel agency companies working in cooperation can inspire, cost effectively, solutions tailored specifically according to the destination. The sharing through means of industry networks and forums provide chances for group development, and best practices, to promote (Gössling *et al.*, 2016). Firstly, the AI driven AI platforms to monitor and report the carbon footprints of

customers and engage them in environmentally friendly behaviour and in addition to that, customer satisfaction is also raised. These cooperative efforts will help in integration of the artificial intelligence technology into regular tourism operations.

## CONCLUSION

This paper emphasizes the great possibilities of AI based solutions to increase sustainability of the travel sector. These technologies are a viable option to address the travel environmental issues by reducing emissions, minimizing the utilization of resources, and generating actionable insights. The potential to dramatically reduce carbon footprints for lodging and tour companies is shown by the findings that, while they are able to please their clients' desire for environmental travel while also satisfying the rising demand for operational efficiency, these companies have the ability to significantly reduce their carbon footprints. Future studies should aim to scale up artificial intelligence systems, understand how they will impact the long term, and also devise engagement platforms that create consumer incentives in order to further power them. Spreading pilot projects across a number of areas and operational settings enables one to guarantee inclusion and flexibility. However, policymakers and business leaders have to build encouraging structures and become motivator for the adoption of sustainable technologies. These include provision of financial incentives, handling data privacy issues and provision of training and education programs. One should act right immediately. Legislators and technology companies should agree on overcoming adoption barriers, and for tourism companies, this is a question of banking on AI powered systems as part of their sustainability plan. Artificial intelligence can help travel sector to cut out its environmental footprint, increase resilience and essentially play a massive role in the world's sustainability goals. A more conscientious travel future is guaranteed as long as it has the shared dedication.

## REFERENCES

- Becken, S. (2004). How tourists and tourism experts perceive climate change and carbon-offsetting schemes. *Journal of Sustainable Tourism*, 12(4), 332–345.
- Becken, S. (2005). Harmonising climate change adaptation and mitigation: The case of tourist resorts in Fiji. *Global Environmental Change*, 15(4), 381–393.
- Becken, S. (2013a). Developing a framework for assessing the resilience of tourism sub-systems to climatic factors. *Annals of Tourism Research*, 43, 506–528.
- Becken, S. (2013b). A review of tourism and climate change as an evolving knowledge domain. *Tourism Management Perspectives*, 6, 53–62.
- Becken, S., & Patterson, M. (2006). Measuring national carbon dioxide emissions from tourism as a key step towards achieving sustainable tourism. *Journal of Sustainable Tourism*, 14(4), 323–338.
- Becken, S., & Simmons, D. G. (2002). Understanding energy consumption patterns of tourist attractions and activities in New Zealand. *Tourism Management*, 23(4), 343–354.
- Becken, S., & Hughey, K. F. (2013). Linking tourism into emergency management structures to enhance disaster risk reduction. *Tourism Management*, 36, 77–85.
- Gössling, S., & Peeters, P. (2007). 'It does not harm the environment!' An analysis of industry discourses on tourism, air travel, and the environment. *Journal of Sustainable Tourism*, 15(4), 402–417.
- Gössling, S., Peeters, P., et al. (2016). Tourism and renewable energy: Stakeholder engagement and the sustainable transition in islands. *Journal of Sustainable Tourism*, 24(5), 766–785.
- Gössling, S., Scott, D., & Hall, C. M. (2013). Challenges of tourism in a low-carbon economy. *Wiley Interdisciplinary Reviews: Climate Change*, 4(6), 525–538.
- Gössling, S., et al. (2010). *Climate change and tourism: Impacts, adaptation, and mitigation*. Routledge.
- Gössling, S., et al. (2012). Tourism and water use: Supply, demand, and security. An international review. *Tourism Management*, 33(1), 1–15.
- Peeters, P., & Dubois, G. (2010). Tourism travel under climate change mitigation constraints. *Journal of Transport Geography*, 18(3), 447–457.
- Peeters, P., et al. (2007). Major environmental impacts of European tourist transport. *Journal of Transport Geography*, 15(2), 83–93.
- Peeters, P., Higham, J., Kutzner, D., Cohen, S., & Gössling, S. (2016). Are technology myths stalling aviation climate policy?. *Transportation Research Part D: Transport and Environment*, 44, 30–42
- Scott, D., et al. (2008). Consequences of climate policy for international tourist arrivals in developing countries. *Third World Quarterly*, 29(5), 873–901.
- Scott, D., et al. (2010). The future of tourism: Can tourism growth and climate policy be reconciled? A mitigation perspective. *Tourism Recreation Research*, 35(2), 119–130.
- Gössling, S., Hall, C. M., Peeters, P., & Scott, D. (2010). The future of tourism: Can tourism growth and climate policy be reconciled? A mitigation perspective. *Tourism Recreation Research*, 35(2), 119–130.
- Scott, D., McBoyle, G., Minogue, A., & Mills, B. (2006). Climate change and the sustainability of ski-based tourism in eastern North America: A reassessment. *Journal of Sustainable Tourism*, 14(4), 376–398.
- Scott, D., Gössling, S., Hall, C. M., & Peeters, P. (2016). Can tourism be part of the decarbonized global economy? The costs and risks of alternate carbon reduction policy pathways. *Journal of Sustainable Tourism*, 24(1), 52–72.
- Scott, D., Gössling, S., & Hall, C. M. (2012). International tourism and climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 3(3), 213–232.
- Sun, Y.-Y. (2014). A framework to account for the tourism carbon footprint at island destinations. *Tourism Management*, 45, 16–27.
- Sun, Y.-Y. (2016). Decomposition of tourism greenhouse

- gas emissions: Revealing the dynamics between tourism economic growth, technological efficiency, and carbon emissions. *Tourism Management*, 55, 326–336.
- Sun, Y.-Y., & Pratt, S. (2014). The economic, carbon emission, and water impacts of Chinese visitors to Taiwan: Eco-efficiency and impact evaluation. *Journal of Travel Research*, 53(6), 733–746.
- Sun, Y. Y., Cadarso, M. A., & Driml, S. (2020). Tourism carbon footprint inventories: A review of the environmentally extended input-output approach. *Annals of Tourism Research*, 82, 102928.
- Sun, Y. Y., & Higham, J. (2021). Overcoming information asymmetry in tourism carbon management: The application of a new reporting architecture to Aotearoa New Zealand. *Tourism Management*, 83, 104231.