

# Climate Change and Artificial Intelligence.

## A text analysis on academic and grey literature

Marco Antonioli<sup>1</sup>, Maddalena Penna<sup>1</sup>, Federica Nobile<sup>1</sup>, Rodolfo Baggio<sup>2</sup>

<sup>1</sup> Studio Giaccardi & Associati, Ravenna, Italy

<sup>2</sup> Dondena Centre for Research on Social Dynamics and Public Policy- Bocconi University, Milan, Italy

Paper presented at the ENTER25  
eTourism conference, Wrocław, Poland, 17-21 February

**Abstract.** This study investigates the intersection of Artificial Intelligence (AI), climate change, and tourism through a comprehensive text analysis of academic and grey literature in English and Italian. Using the Scopus database and Google searches, we collected 58 multi-type sources and analyzed them with AntConc, a corpus analysis toolkit. Our findings reveal a predominant focus on AI and machine learning technologies for climate change mitigation rather than adaptation. Data emerges as a central theme across all literature types, underscoring the data-driven nature of both AI applications and climate research. Machine learning, deep learning, and neural networks are prominent in academic literature, while grey literature emphasizes greenhouse gas emissions and environmental impacts. The Italian grey literature uniquely highlights risks and sustainability. This research identifies the potential of AI in addressing climate change challenges in tourism while also highlights the need for more studies on adaptation strategies and consideration of AI's own environmental impact.

**Keywords:** Tourism, Climate change, Artificial Intelligence, Mitigation, Adaptation.

## 1 Introduction

Two factors are shaping, and will influence strongly in the future, the tourism phenomenon and its components: artificial intelligence and climate change. Even in apparently belonging to different realms, the connection between them is well established [1].

As artificial intelligence (AI) becomes increasingly embedded into our daily lives, much attention is focused on the potential ethical issues that concern privacy, security. Beyond these important issues, however, AI holds a remarkable potential to optimize various activities, boost efficiency, and significantly improve the accuracy and effectiveness of systems that rely heavily on predictions and probabilities. Most promising applications, in fact, lie in areas that address complex technical challenges that exceed human capacity. One such challenge is climate change, a multifaceted

problem that demands significant transformations across key sectors, including transportation, agriculture, construction, and energy [1].

AI has the potential to play a critical role in tackling climate change, with the energy sector providing a prime example of its promise and limitations. Through AI, we can optimize energy usage, predict consumption patterns, and integrate renewable sources more effectively into power grids. However, this technological shift also introduces important policy trade-offs. To truly benefit from AI's potential in combating climate change, we must approach its use thoughtfully, balancing its strengths with its risks and ensuring it is applied in ways that minimize drawbacks while maximizing its ability to reduce greenhouse gas emissions.

Some tourism destinations – especially in Northern Europe – are already using adaptive policies often based on AI technologies. It is clear that Artificial Intelligence may be an innovative instrument to prevent and manage climate change in tourism, but might also cause an increase in energy consumption which may affect the state of the planet [2]. An example of a Northern European destination which is using an Artificial Intelligence tool to implement climate adaptive policies is given by Visit Norway – the Norwegian DMO – who on their website published a CO<sub>2</sub> calculator [2].

This is one of the possible examples on how AI tools can help in facing climate change in the tourism industry. Another increasingly important role of AI in the contrast of climate change is the use of data to forecast the emergence of climate extremes (e.g.: increase in heat days, droughts and floods, sea level rise, etc.) which can have a wide impact on all the tourism products. Forecasting gives to destinations the opportunity to implement adaptive policies in advance, instead that following the emergencies.

As part of a larger ongoing project on the attitudes of Italian tourism destinations towards the issues of climate change, we performed an investigation on how these topics are discussed in three types of literature: academic literature in English language, grey literature in English, and grey literature in Italian. Here we report a preliminary analysis of this exploration as the results might be relevant for those interested in these issues and pose some questions that concern the similarities and the differences between these three different sources.

## **2 Materials and methods**

### **2.1 Data collection**

The academic literature paper were collected by using the Scopus database. First of all we searched for papers which had in the title and in the abstract the keywords “artificial intelligence”, “climate change” and “tourism”. The result of these first research is a spreadsheet of 4.076 titles and abstracts. Then by reading this first output we selected a list of 90 papers with a clear focus on artificial intelligence, climate change and tourism. At a later stage to reduce our field of research from this list of 90 papers we selected 15 papers which discuss about Artificial Intelligence, climate change and tourism together. We also selected the most recent (2020-2024) and most cited publications for providing a relevant and updated view.

For what concerns the grey literature data have been collected by running a set of 30 keywords both in English and Italian on Google.com and by selecting articles related to our three topics from online newspapers, magazines, institutional websites (i.e. NASA, European Parliament, World Economic Forum, etc.), private companies (i.e. Boston Consulting Group, McKinsey, etc.), research institutes (i.e. Climate Change AI, Centre for AI and Climate, etc.). Thanks to this process we managed to get 32 contributions in English and 11 in Italian.

In the end, adding up all the different paper and articles, we scrutinized 58 multi-type sources.

## 2.2 Data treatment and analysis

All the texts from pdf and website pages have been copied into three different notepads: one for academic literature, one for English grey literature and another one for Italian grey literature.

Then all the notepads have been run separately with AntConc [4], a freeware corpus analysis toolkit for text analysis based on Python, being careful of using proper stopwords in Italian and English to reduce possible biases.

With AntConc we were able to analyze word frequencies and N-grams frequencies (bi-grams), obtaining in this way six tables (three words tables and three N-grams tables) which give us the point of view of our three main sources on which are the main concepts connected to Artificial Intelligence, climate change and tourism and show us which are the main similarities and differences between the academic literature, the grey literature in English and in Italian.

## 3 Results

In tables 1, 2 and 3 it is visible how the main topics discussed in all the three literatures considered are connected to how Artificial Intelligence and machine learning technologies can prevent climate change effects [5]. In general we can say that the main focus is on mitigation solutions and not on adaptation.

As stated by the European Environment Agency (EEA) “mitigation” means making the impacts of climate change less severe by preventing or decreasing the emission of greenhouse gases (GHGs) into the atmosphere. Mitigation is achieved by reducing the sources of these gases or by enhancing their storage. In short, mitigation is a human intervention that reduces the sources of greenhouse gas emissions and/or strengthens sinks. In contrast, the term "adaptation" denotes the anticipation of the harmful consequences of climate change and the implementation of suitable strategies to prevent or mitigate the potential damage, while simultaneously exploiting the potential opportunities that may emerge. In essence, adaptation can be understood as the process of adjusting to the current and future effects of climate change [6].

**Table 1.** Top 5 N-grams in English academic literature

Rank	N-gram	Frequency
------	--------	-----------

1	Machine learning	557
2	Deep learning	202
3	Neural networks	184
4	Data driven	117
5	GHG emissions	97

**Table 2.** Top 5 N-grams in English gray literature

Rank	N-gram	Frequency
1	Machine learning	62
2	Greenhouse gas	8
3	Satellite imagery	8

**Table 3.** Top 5 N-grams in Italian gray literature

Rank	N-gram	Frequency
1	Gas serra (GHGs)	16
2	Impatto ambientale (Environmental impact)	12
3	Riscaldamento globale (Global warming)	11
4	Consumo energetico (Energy consumption)	9

The fact that the main focus is on mitigation and possible uses of technology to prevent or reduce climate gas emissions is also visible in the top 5 words in every literature (table 4, 5 and 6). Another evidence based on the word analysis is the centrality of data in both fields of Climate Change and Artificial Intelligence [7].

**Table 4.** Top 5 words in English academic literature

Rank	Word	Frequency
1	Data	1.708
2	Learning	1.007
3	Energy	952
4	Models	844
5	Machine	636

**Table 5.** Top 5 words in English gray literature

Rank	Word	Frequency
1	Data	84
2	Learning	66
3	Machine	64
4	Energy	52

5 Carbon 40

**Table 6.** Top 5 N-grams in Italian gray literature

Rank	Word	Frequency
1	Rischi (risks)	49
2	Dati (data)	48
3	Impatto (impact)	44
4	Sostenibilità (sustainability)	44
5	Emissioni (emissions)	38

## Conclusions

This study analyzed the intersection of Artificial Intelligence (AI), climate change, and tourism across academic and grey literature in both English and Italian. Our analysis reveals several key findings:

1. There is a strong focus on how AI and machine learning technologies can mitigate climate change effects, rather than on adaptation strategies [8,9].
2. The importance of having a good set of data is evident across all literature types, highlighting the data-driven nature of both AI applications and climate change research.
3. Machine learning, deep learning, and neural networks emerge as dominant topics in the academic literature, indicating their significance in climate change-related research [10].
4. Both English and Italian grey literature emphasize GHGs emissions and environmental impacts, suggesting a consistent concern across different cultural contexts [11,12].

These findings underscore the potential of AI in addressing climate change challenges, particularly in the tourism sector. However, they also point to a need for more research on adaptation strategies and a broader consideration of AI's own environmental impacts. In fact, most of the literature examined deals with mitigation actions while adaptation strategies or policies are relatively overlooked.

We came to this conclusion because most of the top 5 words and bi-grams published in tables, both in English and Italian, and in academic and grey literature, are clearly focused on mitigation policies. Summarizing all the analyses, we can state that one cluster of words and bi-grams refers to methods and technologies (e.g.: machine learning, deep learning, data, etc.) that are already applied in the implementation of mitigation policies in most economic sectors. The other cluster consists of words and bi-grams directly related to mitigation policies (GHG emissions, greenhouse gas, gas serra, energy consumption, etc.). This is also in line with the definition of the differences between adaptation and mitigation given by the European Environment Agency: while the former means anticipating the adverse effects of climate change, the latter means making the effects of climate change less severe by preventing or reducing the emission of greenhouse gases (GHG) into the atmosphere.

Future work should aim at bridging the gap between academic research and practical applications, ensuring that AI technologies are leveraged effectively and responsibly in the fight against climate change and to support the definition of new adaptive strategies. By fostering collaboration between researchers, policymakers, and industry leaders, the power of AI can be used in more efficient and effective way to build a more sustainable and resilient future.

## Acknowledgments

This work is part of a project carried out by Studio Giaccardi & Associati ([www.giaccardiassociati.it](http://www.giaccardiassociati.it)) aimed at understanding the overall impact of AI technologies and the relationship between tourism activities and climate change in Italy.

## References

1. Stein, A. L. Artificial intelligence and climate change. *Yale Journal on Regulation*, 37(3), 890-939 (2020)
2. Grythe H., Lopez-Aparicio S. The who, why and where of Norway's emissions from tourist travel; *Environmental Advances*, Volume 5 (2021)
3. Visit Norway, <https://business.visitnorway.com/no/utslippskalkulator/>, last accessed 2024/11/15
4. Cowls et al. (2021): The AI gambit: leveraging artificial intelligence to combat climate change—opportunities, challenges, and recommendations; *AI & SOCIETY*, 38:283–307 (2021)
5. Anthony, L. AntConc (Version 4.3.1) [Computer Software]. Tokyo, Japan: Waseda University. Available from <https://www.laurenceanthony.net/software> (2024).
6. Rolnick et al.: Tackling Climate Change with Machine Learning; *ACM Computing Surveys*, Vol. 55, No. 2, Article 42 (2022)
7. European Environment Agency, <https://www.eea.europa.eu/en/about/contact-us/faqs/what-is-the-difference-between-adaptation-and-mitigation>, last accessed 2024/10/10
8. Schultz et al.: Can deep learning beat numerical weather prediction?; *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 379:20200097 (2021)
9. Loucks: Meeting Climate Change Challenges: Searching for More Adaptive and Innovative Decisions; *Water Resources Management*, 37:2235–2245 (2022)
10. Huntingford et al.: Machine learning and artificial intelligence to aid climate change research and preparedness; *Environmental Research Letters*, 14 124007 (2019)
11. Leal Filho et al.: Deploying artificial intelligence for climate change adaptation; *Technological Forecasting and Social Change*, 180 p. 121662 (2022)
12. World Economic Forum, <https://wtfc.org/news-article/ai-set-to-shape-the-future-of-travel-and-tourism-says-wtfc>, last accessed 2024/10/10
13. Namirial Focus, <https://focus.namirial.it/intelligenza-artificiale-crisi-climatica/>, last accessed 2024/10/10