

EVALUATING CLIMATE CHANGE ADAPTATION STRATEGIES FOR SUSTAINING MOUNTAIN TOURISM IN THE AUSTRIAN ALPS

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Abstract

The paper, "Evaluating Climate Change Adaptation Strategies for Sustaining Mountain Tourism in the Austrian Alps," provides a comprehensive examination of how climate change impacts the Alpine tourism industry in Austria. Focusing on the iconic Austrian Alps, this research paper assesses the effectiveness of adaptation strategies employed to mitigate the consequences of climate change and ensure the long-term sustainability of mountain tourism. The study combines data analysis, case studies, and stakeholder interviews to evaluate a variety of adaptation measures, including innovative snowmaking technologies, diversification of tourism offerings, and enhanced environmental conservation efforts. The findings offer valuable insights into the resilience and sustainability of mountain tourism in the context of climate change, providing essential guidance for other alpine regions facing similar challenges.

Keywords: *climate changes, mountain tourism, sustainable tourism*

JEL Classification: L83, Q01, Q26, Q54

1. Introduction

The mountainous regions of the world, including popular destinations like the Austrian Alps, have long been cherished for their scenic beauty, outdoor recreation opportunities, and cultural richness. However, these regions are particularly vulnerable to the impacts of climate change (Ulrike Pröbstl-Haider, 2021), which have the potential to disrupt both natural landscapes and tourism-based economies. Particularly, the Austrian tourism sector is prone to changing climate (Olefs et al., 2021).

The economic consequences of climate change on mountain tourism are profound. Many mountain destinations heavily rely on winter tourism, such as skiing and snowboarding, for their revenue. Rising temperatures and changing precipitation patterns pose significant challenges to snow reliability, leading to shorter snow seasons and increased snowmaking costs (Scott & McBoyle, 2007). The ski industry faces a critical need for adaptation strategies, such as investment in snowmaking technologies and the diversification of tourism offerings (Scott et al., 2019).

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Climate change also exerts ecological pressure on mountain regions, threatening their unique ecosystems and biodiversity. Careful use and protection of the important natural resources is an important aspect of sustainable tourism (Paunović, I.; Jovanović, V., 2017).

Warming temperatures lead to shifts in vegetation zones, endangering alpine flora and fauna (Dolezal et al., 2016). Melting glaciers and permafrost contribute to landscape transformations and the erosion of natural beauty. Extreme weather events, such as flash floods and landslides, become more frequent, impacting infrastructure and safety (Piazolo & Kane, 2016).

Social dimensions of mountain tourism are not immune to the effects of climate change. Communities that rely on tourism often experience economic fluctuations, as well as increased vulnerability to natural hazards and changing livelihoods for local residents (Blöschl et al., 2007). Unveiling changes in climate comfort for tourism can also contribute to more informed adaptation decisions within the tourism sector (Yu et al., 2023).

Moreover, cultural elements tied to mountain regions, such as traditional practices, indigenous knowledge, and historical sites, face threats due to changing environmental conditions (Jost, 2013).

2. Climate Change Impacts on Austrian Alps Tourism

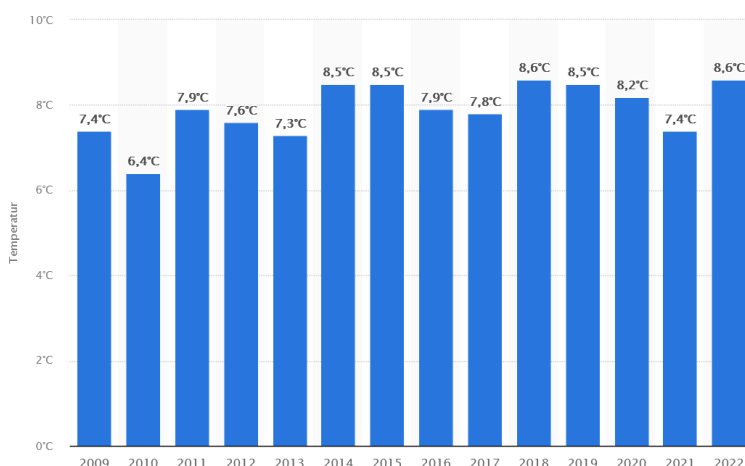
The Austrian Alps, a majestic mountain range stretching through much of Austria, are a UNESCO World Heritage Site and a global icon of natural beauty. These towering peaks, pristine lakes, and lush valleys have long captivated the imaginations of travelers and adventurers from around the world. Today, the Austrian Alps are not only a natural treasure but also a major economic driver, attracting millions of tourists each year. Tourism plays a crucial role in the Austrian economy, generating billions of euros in revenue annually. The industry directly employs over 300,000 people and indirectly supports countless more in related businesses such as hospitality, transportation, and retail. Tourism also contributes significantly to Austria's cultural and social life, fostering cross-cultural exchange and promoting local traditions.

The Austrian Alps face a number of challenges as they strive to balance tourism with sustainability and environmental protection. The growing popularity of the region is putting pressure on the natural environment, leading to concerns about resource depletion, pollution, and habitat loss. Additionally, the industry's reliance on winter tourism makes it vulnerable to climate change, as rising temperatures and shorter winters threaten to reduce skiable terrain and visitor numbers.

Climate change is already having a significant impact on the Austrian Alps, and this is expected to continue in the future.

Temperature Rise: One of the most pronounced and well-documented effects of climate change in the Austrian Alps is the rise in temperatures. Over the past century, the region has experienced a significant increase in average temperatures. Winters are becoming milder, and the duration of snow cover in the lower elevations is decreasing. The average annual temperature was about 8.7 °C in the years after 1951 and about 10.7 °C in the last years before 2022. So, in less than 72 years, it has increased by about 2.0 °C.

Figure 1. Evolution of medium temperature in Austria between 2009-2022



Source: Eurostat, 2023

Reduced Snowfall: The Austrian Alps are famous for their pristine ski slopes and winter wonderland landscapes. However, climate change is leading to reduced snowfall, especially at lower elevations. This trend has a significant impact on the winter tourism industry, as well as on the mountain ecosystems that rely on consistent snow cover for their health and stability.

Researchers and scientists in Austria have been closely monitoring snowpack changes through the use of remote sensing technologies and field measurements. This data is crucial for understanding the trends, predicting avalanche risks, and informing climate policy.

The environmental impact of reduced snowfall is equally significant. Alpine ecosystems, flora, and fauna that rely on consistent snow cover for insulation and hydration are under stress. Furthermore, the decrease in snowpack has led to water resource challenges. Many rivers in Austria depend on the gradual melting of snow for a consistent flow, and altered snow patterns can affect water availability for agriculture, energy production, and daily consumption.

Also, reduced snowfall and diminished snowpack in the Austrian Alps pose significant challenges for the region's ski tourism industry. As climate change alters

weather patterns, the traditional snowy landscapes that attract winter sports enthusiasts are becoming less reliable. Insufficient snow coverage limits the ski season's duration and quality, impacting the overall appeal of the region for tourists. Ski resorts, vital to the local economy, face economic uncertainties due to shorter seasons and increased reliance on artificial snow. The interplay between climate conditions, snowpack levels, and ski tourism underscores the need for sustainable practices and climate change mitigation in the Austrian Alps. Some examples are: Saalbach Hinterglemm, a popular ski resort in Salzburgerland that was forced to close its lifts in early January 2023 due to a lack of snow (the resort relies heavily on artificial snowmaking, but even this was not enough to keep the slopes open), in January 2023, Sölden resort only had about 70% of its slopes open due to a lack of snow; Zell am See Kaprun, in January 2023, only had about 50% of its slopes open due to a lack of snow.

Glacier Retreat: The Austrian Alps are home to several glaciers, and these icy giants are shrinking rapidly due to rising temperatures. Glacier retreat is not only a visual representation of climate change but also affects the availability of freshwater resources, as many rivers in the region depend on glacial meltwater to sustain their flow during dry periods. According to a study made by Austrian Alpine Club, on average, 89 Austrian glaciers observed by the organization have become 28.7 meters (94.2 feet) shorter, compared to 11 meters in 2021.

Glacier retreat in the Austrian Alps and ski tourism are inextricably linked. Glaciers serve as natural snow reservoirs, providing a reliable source of snow for ski resorts during the winter months. However, due to climate change, glaciers in the Austrian Alps have been retreating at an alarming rate. This poses a significant challenge to the ski industry, as it threatens to reduce the availability of snow and shorten the ski season.

Changes in Precipitation Patterns: Climate change has also led to shifts in precipitation patterns in the Austrian Alps. While some areas may experience increased precipitation, others face a higher risk of drought. These changes can have significant implications for agriculture, water supply, and forest ecosystems.

Increased Frequency of Extreme Weather Events: The Austrian Alps have witnessed an increase in the frequency and intensity of extreme weather events, such as heavy rainfall, storms, and avalanches. These events can lead to flash floods, landslides, and other natural disasters, affecting infrastructure and safety in the region.

Alpine Ecosystem Changes: As temperatures rise and snow cover decreases, alpine ecosystems are undergoing significant transformations. Plant

and animal species that are adapted to cold and snowy conditions are facing challenges in adapting to the new climate. This affects biodiversity and the delicate balance of mountain ecosystems.

Water Resource Management: The changing climate is also impacting water resource management in the Austrian Alps. Snowmelt and glacial runoff are essential sources of freshwater for the region, and their variations can lead to water scarcity and conflicts over water allocation.

Austria has already a comprehensive strategy for the sustainable development of tourism. The strategy, known as "Plan T," was first launched in 2016 and aims to make tourism more sustainable and resilient in the face of climate change and other challenges.

Key objectives of the strategy include:

- **Protecting and enhancing the natural environment:** Austria is committed to preserving its alpine landscapes and ecosystems. The strategy includes measures to reduce pollution, promote renewable energy, and protect endangered species.
- **Promoting sustainable practices:** The strategy encourages tourism businesses to operate in a more environmentally friendly and socially responsible manner. This includes measures to reduce waste, conserve water, and minimize their carbon footprint.
- **Diversifying tourism offerings:** Austria is aiming to reduce its reliance on snow-based tourism and develop a more year-round appeal. This includes promoting summer activities, such as hiking, biking, and sightseeing, and investing in new tourism products and services.
- **Strengthening community engagement:** The strategy emphasizes the importance of involving local communities in the development and implementation of tourism initiatives. This helps to ensure that tourism benefits the local population and does not harm the environment or cultural heritage.

The Austrian government is investing heavily in the implementation of the "Plan T" strategy. A number of initiatives have been launched, including:

- **The Alpine Pearls program:** This program recognizes and promotes destinations that are committed to sustainable tourism.
- **The Green Accommodation label:** This label recognizes hotels and other accommodation providers that meet high standards of environmental sustainability.
- **The Climate Ticket:** This ticket offers visitors discounted access to public transport and other services, encouraging them to travel in a more sustainable way.

The Austrian government is also working with industry partners to develop and implement innovative solutions for sustainable tourism. For example, the government is supporting the development of new snowmaking technologies that are more environmentally friendly.

As a result of these efforts, Austria is making significant progress towards becoming a more sustainable tourism destination. The country is committed to protecting its natural environment, promoting sustainable practices, and diversifying its tourism offerings. These efforts are helping to create a more sustainable and resilient tourism industry that can benefit the Austrian economy and society for many years to come.

3. Research Methodology and results

The tourism industry worldwide is grappling with the multifaceted challenges posed by global climate change and global warming. Mountain regions, including the Austrian Alps, are particularly susceptible to the detrimental effects of climate change, a vulnerability exacerbated by their unique topography and reliance on snow-based activities. A primary driver of global warming is the excessive emission of greenhouse gases, particularly carbon dioxide (CO₂).

In order to see if there is a connection between the CO₂ emissions and the changes in the annual average temperature in Austria we used the latest data provided by the International Energy Agency (IEA) and Copernicus Climate Change Service (C3S). Our analysis is based on data collected between 1970 and 2022 and we used the Pearson correlation coefficient.

Based on the data collected, the following is calculated:

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i = \frac{564.4}{53} = 10.649056603774$$

$$\bar{Y} = \frac{1}{n} \sum_{i=1}^n Y_i = \frac{5462.7}{53} = 103.06981132075$$

$$SS_{XX} = \sum_{i=1}^n X_i^2 - \frac{1}{n} \left(\sum_{i=1}^n X_i \right)^2 = 6221.66 - 564.4^2/53 = 211.33245283019$$

$$SS_{YY} = \sum_{i=1}^n Y_i^2 - \frac{1}{n} \left(\sum_{i=1}^n Y_i \right)^2 = 622629.13 - 5462.7^2/53 = 59589.671698113$$

$$SS_{XY} = \sum_{i=1}^n X_i Y_i - \frac{1}{n} \left(\sum_{i=1}^n X_i \right) \left(\sum_{i=1}^n Y_i \right) = 61320.71 - 564.4 \times 5462.7/53 = 3148.108490566$$

Therefore, based on the above calculations, the correlation coefficient is obtained as follows:

$$\begin{aligned}
 r &= \frac{SS_{XY}}{\sqrt{SS_{XX} \cdot SS_{YY}}} \\
 &= \frac{3148.108}{\sqrt{211.332 \cdot 59589.672}} \\
 &= 0.887
 \end{aligned}$$

The complete results of the Pearson correlation coefficient

Parameter	Value
Pearson correlation coefficient (r)	0.8871
r ²	0.787
P-value	0
Covariance	60.5405
Sample size (n)	53
Statistic	13.7263

A Pearson correlation coefficient (r) of 0.8871 is a strong, positive correlation. This means that there is a strong positive relationship between the two variables being measured. In other words, as one variable increases, the other variable also tends to increase.

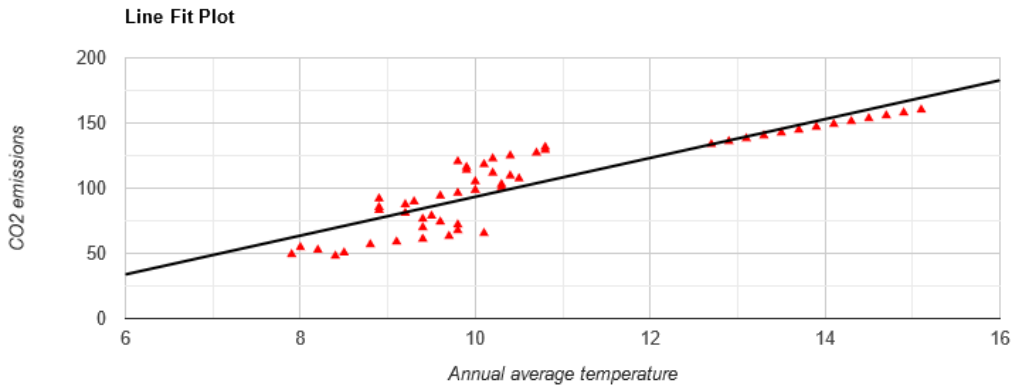
A correlation coefficient of 0.8871 is very close to 1, which is the highest possible correlation coefficient. This means that the relationship between the two variables is very strong and consistent.

The strength and direction of the correlation coefficient can be interpreted as follows:

- **0:** No correlation
- **0.1-0.3:** Weak correlation

- **0.3-0.5:** Moderate correlation
- **0.5-0.8:** Strong correlation
- **0.8-1:** Very strong correlation

In this case, the correlation coefficient of 0.8871 indicates a very strong positive correlation between CO₂ emissions in Austria and the average temperature in Austria. This means that as CO₂ emissions increase, the average temperature in Austria also tends to increase.



The relationship between CO₂ emissions and average temperature is well-established and is a major factor contributing to climate change. CO₂ emissions trap heat in the atmosphere, which leads to an increase in the average global temperature. This increase in temperature is causing a number of negative impacts, including rising sea levels, more extreme weather events, and changes in precipitation patterns.

The correlation coefficient of 0.8871 provides strong evidence of the link between CO₂ emissions and average temperature in Austria. This evidence can be used to support policies and measures aimed at reducing CO₂ emissions and mitigating the effects of climate change.

4. Conclusions

To mitigate the negative impacts of climate change and ensure the sustainability of mountain tourism in the Austrian Alps, various adaptation strategies can be implemented:

1. Investment in Snowmaking Technology: Snowmaking systems can artificially create snow cover, extending the ski season and providing a fallback option for when natural snowfall is insufficient.

2. Diversifying winter sports regions: Austria acknowledges that some winter sports regions are threatened by climate change, with reduced snowfall and shorter snow seasons. To address this challenge, the country is actively working on creating alternative offers not solely dependent on snow. This diversification aims to keep winter tourism thriving even in a changing climate.

3. Strengthening Alpine summer tourism and development of alternative tourism activities: Recognizing the potential of the summer season in the Alps, Austria is investing in strengthening Alpine summer tourism. This includes promoting outdoor activities like hiking, cycling, and cultural experiences to attract visitors during the warmer months.

4. Improved infrastructure for water management: Strengthening water infrastructure, including reservoirs and water treatment plants, can enhance the region's ability to manage water resources and ensure access for both tourism and local communities.

5. Community engagement and education: Raising awareness among tourists and residents about climate change and its impacts can foster a sense of responsibility and encourage sustainable practices.

In conclusion, Austria's approach to securing its position as an attractive and sustainable tourism destination is marked by a forward-thinking commitment to adapt to the challenges posed by climate change. By incorporating climate change into tourism strategies, developing climate-friendly adaptation measures, improving data-driven decision-making, diversifying winter sports regions, promoting summer tourism in the Alps, and expanding city tourism, Austria is poised to continue offering memorable and environmentally responsible travel experiences for visitors while preserving its natural beauty and cultural heritage.

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