

CLIMATE CHANGE AS A SOCIO-ECONOMIC CHALLENGE FOR THE TOURISM SECTOR: AN ECONOMETRIC ANALYSIS OF COUNTRIES WITH THE HIGHEST ECONOMIC LOSSES

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Abstract. The issue of climate change, and in particular the economic losses caused by natural disasters, is a significant problem for the tourism sector and its development. The research conducted aims to address the following research question: Does climate change, quantified by the economic losses attributed to extreme weather events, influence the development of the tourism sector, as measured by tourism's contribution to GDP? Furthermore, the study explores the role of insurance as a financial instrument for mitigating the effects of climate change on tourism. An important part of the research is an in-depth regional analysis of climate change losses. It was carried out both on a continental level and for the countries studied. Statistical and econometric techniques were employed to investigate the research question. The analysis focused on a selection of countries identified by the Swiss Re Institute as having experienced the highest economic losses due to climate change. Thirteen countries were surveyed, ensuring representation for each continent. The research period spans the years 2014–2023, and the data analysis was conducted using Statistica 13 and Gretl software. The findings indicate that economic losses resulting from natural disasters show an increasing trend, both in absolute terms and as a percentage of national GDP. These losses represent a significant constraint on economic growth, particularly limiting the development of tourism. Furthermore, the survey shows that the negative effects of climate change are more challenging for less economically developed countries. These countries are in addition to being more exposed to climate-related damages because of their natural conditions, but also struggle with underdeveloped insurance sectors. Reduced access to insurance compounds the disruptive impact of climate change on tourism. An analysis of the relationship between the weather damage load on a country's economy and the insurance gap identifies three countries – the USA and China – as being especially at risk. Investigating the impact of the effects of natural disasters on the development of the tourism sector in countries with the greatest economic losses from climate change fills a research gap in this area and contributes to the development of knowledge on the effects of climate change on the competitiveness and sustainability of tourism. The research should be considered original in its subject coverage. No studies of this scope have been found in the literature. Investigating the impact of insurance on climate change mitigation for the tourism sector should also be considered innovative. The results of the research can be used to shape tourism policy in the countries studied, as well as globally.

Keywords: tourism, climate, natural disasters, sustainable development, insurance.

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1. Introduction

The effects of climate change on various areas of economic life are currently the subject of much discussion among scientists from different disciplines and economic practitioners. This matter holds significant relevance for the tourism industry, where climate serves as a crucial factor, shaping its growth and sustainability. The climate shapes the conditions of the environment where tourism services are provided, and climate zones define global tourism zones that differ both in terms of forms of tourism, types and scope of services, and the economic effects of tourism activities. Issues of climate impacts on tourism are both the subject of scientific research and subject to cyclical assessments, presented in the form of reports. An example of such a study can be found in the findings and conclusions of the Davos Conference (Davos Declaration, 2007), which concluded that climate change could threaten areas with major tourist attractions and, at the same time, acknowledged that global tourism was one of the causes of global warming – tourism was assumed to contribute about 5% of global CO₂ emissions. It was further acknowledged that achieving sustainability in the tourism industry requires a flexible approach to climate change, which includes cutting and mitigating greenhouse gas emissions, adapting tourism operations and regions to evolving climate patterns, and leveraging innovative technologies to enhance energy efficiency. It is worth noting that climate change is increasingly causing adverse economic impacts, including extreme weather events. The economic damages associated with climate change are both financial losses and restrictions on tourism activities, resulting in reduced income for society and reduced economic growth. This poses a significant problem for tourism development. Studies on the impact of climate risks on tourism development have been conducted by: Scott et al. (2019), Badulescu et al. (2021), Mateos et al. (2023), Atstāja and Cakrani (2024) and Dube (2024). These included an analysis of the impact of selected elements of climate change on tourism in selected countries or regions of the world. It should be noted that climate change research is conducted both globally and individually for countries or regions of the world. This is related to both the size of losses caused by natural disasters and the impact of climate change effects. They affect both globally and regionally. Changes in a particular region often have a global impact, and global trends affect the development of tourism in particular regions. It is also worth noting that this is a topic that requires constant updating, due to the continuity and dynamics of climate change and the lack of sufficient knowledge in this area.

The relationship between climate change and tourism can be bi-directional, i.e., both climate change impacts on tourism and tourism impacts on climate change. The first direction of influence, i.e., the analysis of the impact of climate change on the tourism sector, can be conducted as a disruptor of tourism activities or as a stimulant for the development of sustainable tourism. Climate change as a disruptor of tourism providers can cause direct or indirect impacts. Direct impacts cause direct damage, threatening the operation and development of tourism activities. This is confirmed by the results of studies conducted by Atstāja and Cakrani (2024) and Susanto et al. (2020), among others. Indirect impacts are related to changes in prices for tourism services, as well as changes in demand for services with negative climate

impacts. They contribute to behavioural change both in terms of consumer decisions and in terms of tourism business development. Indirect impacts are therefore due more to changes in business models and legal regulations. This is confirmed by the results of studies by Mateos et al. (2023) and Gössling et al. (2010), among others. Research on the impact of climate change on the stimulating tourism sector is part of the concept of sustainable development. The importance of sustainable development for tourism is indicated in their studies by, among others, Tyagi (2024), Carr et al. (2016) and Tran et al. (2022). The second impact direction, i.e., the analysis of the impact of tourism on climate change, is conducted in terms of environmental degradation by tourism operators. This is supported by the results of studies carried out by Navarro-Drazich et al. (2023), Mateos et al. (2023), Baloch et al. (2023), Shi et al. (2023), Sharif et al. (2020) and Scott et al. (2019), among others. This research area recommends mitigating the negative impacts of tourism on climate.

Our research is part of the first group of studies – the impact of climate change on the direct tourism sector.

The aim of the research undertaken is to analyse the impact of the financial consequences of natural disasters and the economic losses they generate on the development of the tourism sector, and in particular to answer the following research question:

Does climate change, as measured by the economic losses generated from extreme events, affect the development of the tourism sector, as reflected in its contribution to GDP?

Additionally, the study seeks to assess the role of insurance as a mechanism to mitigate the effects of climate change. Insurance plays a critical role in alleviating the economic and social impacts of natural disasters by providing financial compensation. Therefore, an important element of the research is to determine the role of insurance in covering economic losses caused by climate change in the studied countries by identifying the insurance gap.

To address the research question, statistical and econometric methods were employed. The analysis was conducted for a selection of countries with the highest economic losses attributed to climate change, as identified by the Swiss Re Institute (2021, 2024, 2025). The research covers the period from 2014 to 2023, with data analysis performed using Statistica 13 and Gretl software.

Investigating the impact of the effects of natural disasters on the development of the tourism sector in countries with the greatest economic losses from climate change, fills a research gap in this area and contributes to the development of knowledge on the effects of climate change on the competitiveness and sustainability of tourism. The research should be considered original in its subject coverage. No studies of this scope have been found in the literature. Investigating the impact of insurance on climate change mitigation for the tourism sector should also be considered innovative. In addition, the results of the research can be used to shape tourism policy in the countries studied, as well as globally.

The article consists of four sections. The Section 2 provides a literature review on the determinants of tourism development. The Section 3 describes the research methodology used. The Section 4 presents the results of the empirical research conducted and the Section 5 discusses the results of the research conducted in relation to previous research in the field.

2. Theoretical background

The development of the tourism sector depends on many factors. According But et al. (2025) “the tourism industry is constantly evolving and requires the introduction of the latest technologies and development tools, such as smart specialization, which contributes to the economic development of countries, the welfare of the population, and an increase in foreign Exchange earnings”. According to Payne and Mervar (2010), the development of tourism in a given country is influenced by economic policy, management system and investments in physical and human capital. According to But (2024, pp. 60–65), an important current factor affecting tourism development is the armed aggression in Ukraine. Firstly, because it hinders post-pandemic tourism recovery across the macroregion, and secondly it forces tourists to seek alternative destinations. In addition, armed conflicts always destroy the environment due to fires, water pollution and dangerous gases. This threatens the development of sports and recreational tourism, which are connected to natural resources. Nadirashvili and Jangulashvili (2016) divide the factors of tourism development in a region into internal (e.g., physical and technical resources, communication, skilled human resources) and external (e.g., natural and climatic, cultural-historical, economic-financial, demographic conditions). Undoubtedly, in the case of tourism, the natural and climatic conditions are an important factor in its development. Therefore, the issues of climate change and studying its impact on the tourism sector are currently important research problems. The analysis of the impact of climate change on the tourism sector can be conducted as a disruptor of tourism activities or as a stimulant for the development of sustainable tourism. Disruption of tourism activities due to climate change is caused by the effects of weather events and causes direct damage, threatening the continuation of the activity. According to Horbach and Rammer (2025), the effects of climate change can be direct or indirect. Direct impacts refer to disruptions in production, transport and communication, while indirect impacts can be related to changes in input prices and changes in demand for products with less negative climate impacts. According to the authors, however, it is not climate change that contributes to changes in the behaviour of economic entities, but changes in costs, business opportunities and other areas of compliance. This is also supported by research by European Commission (2022), which indicates that climate change can affect economic entities through new regulations, changes in demand, higher production costs and disruptions caused by extreme weather events.

Research on the impact of climate change on the stimulus tourism sector is part of the concept of sustainable development. The importance of sustainability for tourism is pointed out in his research by, among others, Tyagi (2024). Author presented the state of research on sustainable tourism and regional development. The research covered the period 2013–2023 and consisted of an analysis of Web of Science and Scopus databases. It confirms the important links between sustainability and tourism. Carr et al. (2016) and Tran et al. (2022) respectively suggest a sustainable tourism aims to balance economic growth, environmental protection and social responsibility. Considering that climate is a key resource for tourism, studying the implications of climate change on the sector’s development are both important and a matter of considerable urgency. Selected studies from this area are shown in Table 1.

Table 1. Climate change and tourism – literature review (source: the author's own compilation)

Year	Authors	Scope of research	Results of research
2024	Atstāja and Cakrani (2024)	Authors investigated the impact of climate change on tourism development in the Baltic Sea region. The study covered the years 2005–2022. Econometric modeling was used. Climate change was assessed using temperature and precipitation data.	The results showed a negative impact of climate change on tourism in the studied countries.
2024	But (2024)	The author examined the impact of the war in Ukraine on the development of the tourism sector, among other environmental impacts.	The results show that the war in Ukraine has a devastating impact on the environment, through fires, gas emissions and water pollution.
2024	Dube (2024)	Using bibliometric analysis, the author examined the impact of climate change on tourism. She identified knowledge gaps in some geographical regions due to unavailability of data. This situation is evident in Africa, which the author highlights as particularly vulnerable to climate change due to its high susceptibility to its impacts.	The results showed that most research on tourism and climate change is conducted in the USA.
2023	Mateos et al. (2023)	Authors analysed extreme climate events occurring in the Atlantic and Mediterranean in South-Western Europe from 1 January 2009 to 28 February 2020 and assessed their impacts.	The results show that the Mediterranean coast is more vulnerable to extreme climate events compared to the Atlantic coast, mainly due to higher levels of tourism development and urban and infrastructural expansion in the Mediterranean.
2023	Navarro-Drazich et al. (2023)	Authors reviewed the existing research on climate change and tourism. The study focused on South and Central America. Authors examined regional climate risks and greenhouse gas emissions.	The findings revealed a lack of comprehensive national and regional public policies on tourism.
2023	Shi et al. (2023)	Authors investigated local environmental change in Changhai County, Dalian, China. Authors used land use data.	The results showed that tourism development led to land use changes.
2023	Baloch et al. (2023)	Authors investigated the relationship between tourism development and environmental needs. The research was conducted in a survey format. It was conducted among tourists, government officials, hoteliers and tour operators.	The survey results indicated that tourism contributes to meeting environmental needs through job creation, new business opportunities and infrastructure improvements. However, there was also evidence of deteriorating natural and environmental conditions. The study proposed a model framework for the sustainable development of ecotourism, advocating for government policies that protect the environment and natural resources while maintaining the economic viability and social well-being of local communities.

End of Table 1

Year	Authors	Scope of research	Results of research
2021	Badulescu et al. (2021)	Authors studied the impact of tourism development on economic growth, CO ₂ emissions and energy consumption. The research was conducted for European Union countries. Authors examined the impact in the long and short term.	The research results showed that economic growth and energy consumption significantly affect tourism development in both the short and long term. CO ₂ emissions affect tourism development only in the long term.
2020	Susanto et al. (2020)	Authors investigated the impact of weather events on the number of international tourists in Indonesia.	The study found that temperature and relative humidity have a significant impact on the demand for international tourism in the country.
2020	Sharif et al. (2020)	Authors investigated the impact of globalization or tourism in relation to the environmental decay, using China as a case study.	The findings indicated that while economic growth exacerbates environmental degradation, tourism generates positive environmental externalities and globalization has an adverse impact on the environment. Building on these insights, Authors proposed a comprehensive policy framework to help China achieve the Sustainable Development Goals (SDGs).
2019	Scott et al. (2019)	Authors proposed the Climate Change Vulnerability Index for Tourism (CVIT), which includes 27 indicators to measure climate change and its impact on tourism. The study covered 181 countries.	According to Authors findings, countries where tourism constitutes a significant share of GDP show the greatest vulnerability to climate change, while OECD countries at higher latitudes show the least vulnerability.
2012	Scott et al. (2012)	Authors analyzed how the tourism industry and destinations around the world are affected by climate change and climate policy.	Authors identified how climate change is affecting tourism and showed the global contribution of the sector to climate change, as well as highlighting the importance of mitigation and adaptation measures in response to these changes.
2010	Gössling et al. (2010)	The authors examined how different tourism sub-sectors contribute to greenhouse gas (GHG) emissions, identifying both technical and managerial strategies to reduce them. They also explored what systemic barriers need to be addressed for tourism to adapt to global climate change mitigation targets.	The authors identified both technical and management strategies to reduce greenhouse gas (GHG) emissions. They also identified the needs to adapt tourism development policies to climate change.

Analysis of the literature review shows that research on the tourism sector in relation to climate change can be divided into three main groups:

1. Climate has a direct impact on the tourism sector, affecting the ability to operate and develop tourism activities. This is confirmed by the results of research conducted by Atstāja and Cakrani (2024) and Susanto et al. (2020), among others.
2. Climate has an indirect impact on the tourism sector. Changes are a result of the need to adapt to systemic changes. This is confirmed by the results of research by Mateos et al. (2023) and Gössling et al. (2010), among others.
3. Tourism contributes to environmental degradation and thus affects climate change. Mitigation of negative impacts is recommended. This is confirmed by the results of research by Navarro-Drazich et al. (2023), Mateos et al. (2023), Baloch et al. (2023), Shi et al. (2023), Sharif et al. (2020) and Scott et al. (2019), among others.

Our research is part of the first group of studies – the impact of climate change on the direct tourism sector. Climate change research, and in particular natural disasters, is an important research problem. Climate change and its financial effects affect the development of tourism both globally, regionally and nationally. The need to analyse climate change results from ensuring business continuity in the tourism sector. It should be noted that this sector is very closely linked to climate. Climate and geographical conditions are an important factor in the development of tourism. In addition, climate change and its financial effects are an area of research that requires constant updating, due to the dynamics of climate change and the lack of sufficient knowledge in this area. Previous studies have concerned different groups of entities or geographical regions. The scope of studied climatic events was also diverse, and the results of the studies showed different impacts and effects depending on the region. For example, in some regions there was a decrease in the number of tourists due to the increase in temperature (e.g., Falk & Lin, 2018; Pintassilgo et al., 2016), but in other regions the increase in temperature caused an increase in the number of tourists (e.g., Giannakopoulos et al., 2011). Research to date therefore does not provide clear results. Assuming, therefore, that research on the impact of climate change caused by weather events is a current research topic that needs to be continuously updated, and that no research conducted on a selected research group – the countries with the greatest economic losses due to climate change – has been found in previous studies, we identify research gaps in this area.

For the purposes of the study, a research hypothesis was formulated: climate change induced weather events affect the development of the tourism sector in countries with the greatest economic losses due to climate change.

Undertaking research on the impact of natural disasters on the development of the tourism sector in countries with the greatest economic losses caused by climate change contributes to the development of the discipline of economics and finance, and in particular to problems related to the sustainable development of tourism.

3. Research methodology

The research was conducted for selected countries of the world. The selection was purposive – countries with the greatest economic losses due to climate change were chosen,

according to the Swiss Re Institute (2025), ensuring representation for each continent. The tourism markets of 13 countries were surveyed. These are:

- Europe – France, Germany, Italy, the UK and Switzerland,
- Asia – India, China and Japan,
- America – Mexico, USA and Canada,
- Africa – South Africa,
- Australia – Australia.

The research aims to analyse how the financial repercussions of natural disasters and the resulting economic losses affect the growth of the tourism sector.

Statistical and econometric methods were used to realise the research aim. A panel model was constructed and estimated using the Weighted Least Squares (WLS) a method. This estimation method was selected to address and eliminate issues of autocorrelation and heteroskedasticity. The results were compiled using Statistica 13 and Gretl software.

The explanatory variable in the model was assumed to be the share of tourism's sector in GDP, which measures the development of a country's tourism sector. This is supported by research conducted by, among others: Kumar and Melkani (2023), Rasool et al. (2021), Ardeleanu (2021), Perles-Ribes et al. (2017), Maráková et al. (2016), Antonakakis et al. (2015), Payne and Mervar (2010).

The determinants of the development of the country's tourism sector were described using dependent variables. They were determined by analysing existing research results and own observations. Numerous authors emphasize that cultural, economic, infrastructural, political and regulatory factors are essential for the sustainable growth of tourism. This is indicated by studies conducted by e.g: Nguyen et al. (2024), Cárdenas-García and Alcalá-Ordoñez (2023), Wardana et al. (2021), Amerta et al. (2018) and Wszendybył-Skulska et al. (2016). Kumar and Melkani (2023) identified five main factors that affect the growth prospects of the tourism industry. These are: employment, income, infrastructure development, quality of life, social development.

The significance of a changing climate for the development of tourism is indicated in their studies by, among others: Scott et al. (2019), Badulescu et al. (2021), Mateos et al. (2023), Atstāja and Cakrani (2024) and Dube (2024).

Taking into account previous research findings, it has been assumed that tourism development in a country is influenced by:

- level of socio-economic development of the country measured by GDP per capita ($GDP_{i,t}$), high-technology exports ($HT_{i,t}$), life expectancy ($LE_{i,t}$),
- resources of the tourism sector, as measured by employment in tourism ($E_{i,t}$), number of bed-places ($BP_{i,t}$),
- effects of tourism activities measured by number of tourists ($A_{i,t}$), income from tourism ($R_{i,t}$),
- climate change measured by economic losses caused by climate changes ($EL_{i,t}$).

In the beginning stage of the research, 8 dependent variables were adopted. These are:

- $GDP_{i,t}$ – GDP per capita,
- $HT_{i,t}$ – high-technology exports (% of manufactured exports),
- $LE_{i,t}$ – life expectancy,
- $EL_{i,t}$ – economic losses caused by climate changes,

- $E_{i,t}$ – employment in tourism,
- $BP_{i,t}$ – number of bed-places,
- $A_{i,t}$ – number of tourists,
- $R_{i,t}$ – income from tourism.

Table 2 shows how the variables under study were calculated.

The study period covers 2014–2023. Annual financial data were obtained from the Swiss Re Institute (2025) and the UN Tourism (n.d.). Table 3 presents the statistics for the variables under study.

Table 2. Calculation methods of the studied variables (source: the author's own compilation)

Specification	Indication of the variable	Calculation method
Share of tourism's sector in GDP	$T_{i,t}$	Value of tourism services in a country [current international \$/Year] * 100/ Value of goods and services produced in the country [current international \$]/Year]
GDP per capita	$GDP_{i,t}$	GDP [current international \$/Year]/Population [Year]
High-technology exports (% of manufactured exports)	$HT_{i,t}$	High-technology exports [current international \$/Year] *100/ manufactured exports [current international \$/Year]
Life expectancy	$LE_{i,t}$	Life expectancy at birth, total [Years]
Economic losses caused by climate changes	$EL_{i,t}$	Economic losses caused by climate changes [USD bn/Year] Losses caused by climate changes – natural catastrophes such as hurricanes, earthquakes, floods and winter storms
Employment in tourism	$E_{i,t}$	Number of employees in tourism [Year]
Number of bed-places	$BP_{i,t}$	Number of bed-places [Year]
Number of tourists	$A_{i,t}$	Number of tourists [Year]
Income from tourism	$R_{i,t}$	Income from tourism [Year]

Table 3. Statistics of the studied variables for selected countries of the world in the years 2014–2023 (source: own based on UN Tourism, n.d.; Swiss Re Institute, 2025)

Specification	$T_{i,t}$	$GDP_{i,t}$	$HT_{i,t}$	$LE_{i,t}$	$EL_{i,t}$	$E_{i,t}$	$BP_{i,t}$	$A_{i,t}$	$R_{i,t}$
N importance	130	130	130	130	130	130	130	130	130
Average	3.5	41168.8	18.3	77.8	15.8	4929.7	2271029.6	35280.6	45748.0
Median	3.0	45795.0	18.8	81.3	3.3	2281.6	1690147.0	28767.5	32710.0
Maximum	8.92	90080.0	37.3	84.6	327.0	33078.8	10997532.0	108928.0	241999.0
Minimum	0.14	680.00	0.67	50.56	0.00	161.00	20674.00	245.80	2113.00
Variance	3.518E+00	5.092E+08	4.444E+01	6.639E+01	1.605E+03	6.284E+07	7.360E+12	9.485E+08	2.639E+09
Standard deviation	2	22567	7	8	40	7927	2713016	30798	51379
Coefficient of variation	54.268	54.815	36.385	10.467	252.897	160.806	119.461	87.295	112.307

Note: $T_{i,t}$ – share of tourism's sector in GDP; $GDP_{i,t}$ – GDP per capita; $HT_{i,t}$ – high-technology exports (% of manufactured exports); $LE_{i,t}$ – life expectancy; $EL_{i,t}$ – economic losses caused by climate changes; $E_{i,t}$ – employment in tourism; $BP_{i,t}$ – number of bed-places; $A_{i,t}$ – number of tourists; $R_{i,t}$ – income from tourism.

The analysis of the data on the development of basic statistics for the variables under study in selected countries, as presented in Table 3, indicates that these variables exhibit significant internal variation. This is shown by the analysis of basic statistics. The variance and standard deviation show dispersion around the mean. The minimum and maximum values of the studied variables also show great variability. This is largely due to differences in the socio-economic development of the analysed countries.

The initial testing of the model, based on the analysis of the explanatory variables and their impact on the dependent variable, allows for the classification of these variables into the following groups:

- Stimulants – number of tourists ($A_{i,t}$), income from tourism ($R_{i,t}$),
- Destimulants – economic losses caused by climate changes ($EL_{i,t}$),
- Neutral – GDP per capita ($GDP_{i,t}$), high-technology exports ($HT_{i,t}$), life expectancy ($LE_{i,t}$), employment in tourism ($E_{i,t}$), number of bed-places ($BP_{i,t}$).

An important part of the research is an in-depth regional analysis of climate change losses. It was carried out both on a continental level and for the countries studied. Its aim was to examine the strength of the impact of climate change on the regions and countries studied. The scope of the analysis covers both the distribution and changes in the value of climate change losses, such as the value of insured damages, economic losses as a % of GDP, as well as the extent and types of damages caused by weather change and their share in GDP.

4. Results

We have developed the following panel data model to address the research question:

$$\ln T_{i,t} = a_1 + a_2 \ln EL_{i,t} + a_3 \ln A_{i,t} + a_3 \ln R_{i,t} + u_{i,t} \quad (1)$$

where: $T_{i,t}$ – share of tourism's sector in GDP, $EL_{i,t}$ – economic losses caused by climate changes, $A_{i,t}$ – number of tourists, $R_{i,t}$ – income from tourism, $\ln$ – natural logarithm, $u_{i,t}$ – joint random factor.

A stepwise regression method was used to construct the model. Backward elimination was also applied. To address heteroscedasticity and autocorrelation issues, the weighted least squares (WLS) method was used to estimate the model. The model was tested using the Schwarz and Akaike test. The results are shown in Table 4 – method and in Table 5 – tests.

Table 4. Results of model estimation – method
(source: own based on UN Tourism, n.d.; Swiss Re Institute, 2025)

Specification	Coefficient	Std. Error	t-ratio	p-value	Significance level
const	–12.1960	1.32075	–9.234	<0.0001	***
l_EL	–0.0652663	0.0176154	–3.705	0.0003	***
l_A	0.146101	0.0232146	6.293	<0.0001	***
l_R	0.209250	0.0448402	4.667	<0.0001	***

Note: The variable is significant at the significance level of : *** 0.01. *EL* – economic losses caused by climate changes, *A* – number of tourists, *R* – income from tourism.

Table 5. Results of model estimation – tests

(source: own based on UN Tourism, n.d.; Swiss Re Institute, 2025)

Specification	Value
Statistics based on the weighted data	
Sum squared residuals	116.3106
R-squared	0.519233
F (3, 126)	45.36049
Log-likelihood	-177.2294
Schwarz criterion	373.9290
S.E. of regression	0.960781
Adjusted R-squared	0.507787
P-value (F)	5.99e-20
Akaike criterion	362.4589
Hannan-Quinn	367.1196
Statistics based on the original data	
Mean dependent variable	-3.523242
Sum squared residuals	34.68654
S.D. dependent variable	0.621208
S.E. of regression	0.524681

The model estimation shows that there is statistical significance of all the variables studied. This is consistent with both the theoretical expectations and the proposed hypothesis. Moreover, an analysis of the model estimation results shows that the model explains 51.9% of the variation in the dependent variable. This is a good result for panel data models.

The analysis of the research results shows that the development of tourism in the countries studied is influenced in a stimulating way by the number of tourists and tourism revenues, and in a destimulating way by economic losses caused by climate change.

Climate change losses obviously have different scope and impact depending on the region. This is confirmed by the results of previous studies, including Alonso-Almeida et al. (2024). The authors identified six regional clusters in the EU-27, indicating the need for segmentation due to the heregonicity of the group of countries studied. Also, research by Barra and Falcone (2024) confirms differences in environmental performance between different countries. According to the authors, country differences are influenced by geographical and environmental factors, including climate. Hoque et al. (2024) examined seven stock markets related to climate change. Their findings confirm the differential impact of climate change by region. Climate change-related equity markets in Japan and the Asia-Pacific region consistently experience net shocks, while the United States, Europe, emerging markets (EM), North America and the European Economic and Monetary Union (EMU) show fluctuations depending on market conditions and timeframes. Thus, a regional analysis of climate change losses finds support in the literature. A regional view of climate change losses from 2014 to 2023 by continent is shown in Figure 1. Table 6 presents climate change losses more broadly by showing the number of events, the number of victims, as well as the value of damages, the value of insured damages and economic losses as a % of GDP.

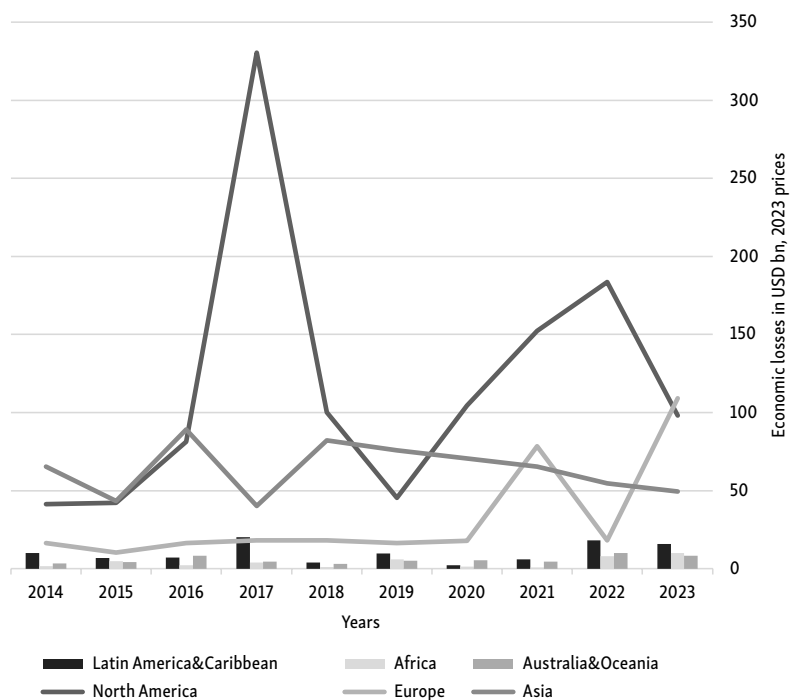


Figure 1. Climate change losses by region of the world in 2014–2023 (source: Swiss Re Institute, 2024)

Table 6. Characteristic climate change losses by regions of the world
(source: own based on Swiss Re Institute, 2021, 2024)

Region	Number of events		Number of victims		Economic losses in USD bn		Economic losses in %		Insured losses in USD bn		Insured losses in %		Economic losses in USD bn as a % of respective GDP	
	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023
North America	83	105	478	297	104.6	98.0	51.8	33.7	69.8	72.7	78.9	62.1	0.46	0.33
Latin America & Caribbean	10	27	633	576	2.2	15.9	1.1	5.5	0.4	5.1	0.5	4.3	0.05	0.21
Europe	39	53	336	62 980	17.9	109.2	8.9	37.5	6.0	26.9	6.8	22.9	0.08	0.41
Africa	38	54	1720	7589	1.4	10.0	0.7	3.4	0.6	0.0	0.0	0.5	0.06	0.35
Asia	96	85	4792	5098	70.5	49.6	34.9	17.0	8.6	7.8	9.8	6.6	0.22	0.11
Australia & Oceania	8	8	34	29	5.3	8.2	2.6	2.8	3.6	4.2	4.0	3.6	0.31	0.41
World	274	332	7993	76569	202.0	290.7	100.0	100.0	88.6	117.2	100.0	100.0	0.24	0.26

The regional analysis of climate change losses and their impacts shows an upward trend in both quantity and value, although it is important to note the cyclical and irregular nature of the events. The highest number of natural disasters occurred in North America. In value terms, they represented in 2020 – 51.8% of natural disasters worldwide. There is also a noticeable increase in climate change losses in Europe. In 2023, they accounted for 37.5% of damages worldwide. It is worth noting that it is also important to assess how a region deals with the effects of disasters. This is influenced by both the financial situation and methods of managing the risk of extreme events, e.g., through insurance. The regional analysis shows that damages as a proportion of GDP have increased in all regions. Australia & Oceania, Europe and Africa had the highest share of damages to GDP. It should be noted that in the case of Africa, the low level of development is also a major problem, as is the negligible level of insurance coverage for catastrophic events.

Damages due to climate change are caused by various weather events. They have a varying importance in each country, which is due to the specific geographical location and is visible in the share of climate damage in GDP. The results of the study relating to the period 2014–2023 are presented in Table 7.

The analysis of damage caused by weather events shows that each of the countries studied has specific weather events that affect them financially in different ways. The greatest weather damage occurred in the USA during the period under study and concerns tropical cyclones and severe convective storms. In China, where weather-related damage accounted for 0.22% of GDP, the biggest problem concerns tropical cyclones. A similar situation exists in India.

Having knowledge of the types of weather events specific to a country can provide the basis for developing climate risk management policies, which are also taken into consideration in the regional and tourism policies of a country or region. Tackling the consequences of economic losses caused by climate change can be done through adaptation actions. These

Table 7. Damage caused by weather events in the countries studied in relation to GDP (%)
(source: Swiss Re Institute, 2025)

Country	All weather perils	Floods	Severe convective storms	Winter storms	Tropical cyclones
France	0.14	0.04	0.05	0.05	–
Germany	0.14	0.08	0.03	0.03	–
Italy	0.11	0.08	0.02	–	–
United Kingdom	0.08	0.04	–	0.05	–
Switzerland	0.19	0.09	0.09	0.02	–
India	0.2	0.09	–	–	0.11
China	0.22	0.03	–	–	0.19
Japan	0.18	0.08	0.01	–	0.1
Mexico	0.12	0.05	–	–	0.07
USA	0.38	0.05	0.14	–	0.19
Canada	0.09	0.08	0.06	–	–
South Africa	0.06	0.06	–	–	–
Australia	0.19	0.07	0.08	–	0.05

include, for example, improving flood protection or forbidding settlement in areas at risk of natural disasters. Insurance can be an important factor in compensating for losses. However, it should be noted that their role is only compensatory and not preventive.

5. Discussion

The conducted research confirms that economic losses caused by climate change are a serious problem for the development of the tourism sector. This is consistent with the results of previous studies conducted by: Scott et al. (2019), Badulescu et al. (2021), Mateos et al. (2023), Atstāja and Cakrani (2024) and Dube (2024). It is worth noting that insurance can and does play a key role in mitigating economic losses caused by climate change. Bukowski and Lament (2024) point to the importance of the insurance sector in protecting against natural disasters. The authors emphasize in particular the importance of specialist knowledge in risk assessment, which the insurance sector can share with other entities. The importance of specialist catastrophe risk insurance in ensuring business continuity for economic entities is emphasized in their studies by, among others, Sood et al. (2023), Aburto Barrera and Wagner (2023), Swiss Re Institute (2024) and Li et al. (2022).

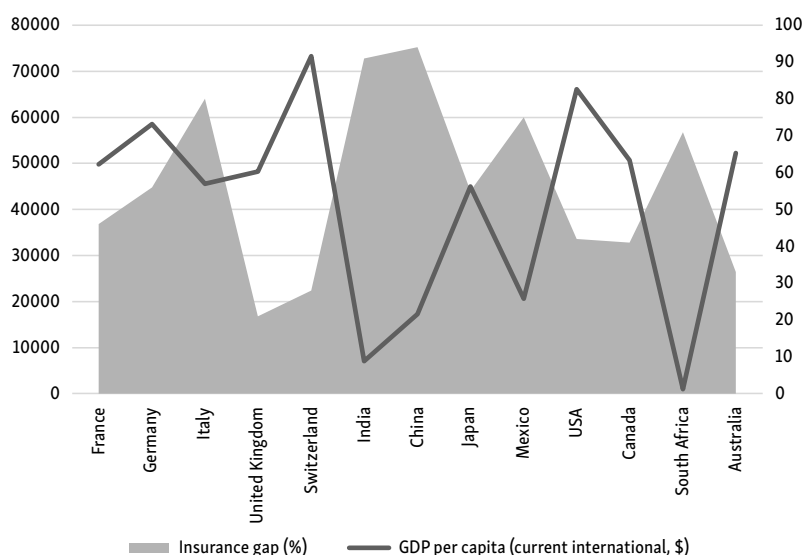
Climate change also poses challenges to the insurance sector itself, as described by Gupta and Venkataraman (2024). Authors emphasise the need for innovation in insurance companies in areas such as risk management, solvency assessment, and insurance product development. Scholer and Schuremans (2022) suggest that adaptation strategies should focus not only on risk transfer but also on preventive actions, thus supporting societal resilience.

According to Holliday et al. (2021), insurance has a significant macroeconomic significance. It concerns the impact on achieving sustainable development goals. Insurance, by covering the effects of random events, supports countries in implementing economic growth processes. Unfortunately, countries with underdeveloped insurance markets are particularly exposed to the risk of natural disasters, as emphasized by the Swiss Re Institute (2025). This is often due to their economic situation, as well as their geographical location. The “insurance gap,” defined as the ratio of uninsured economic losses to total economic losses caused by climate change, is especially pronounced in countries with lower socio-economic development, which are more vulnerable to catastrophic natural risks. The detailed results of the insurance gap for the studied countries are presented in Table 8.

Analysis of the insurance gap reveals that its size varies significantly across the surveyed countries, highlighting the dynamic and difficult to predict climate change and its effects in the form of natural catastrophes. This means that insurance can be and is an important instrument for mitigating climate change, but it is important to monitor changes and develop a climate risk management system both globally and within insurance companies. The study results further confirm that, from a tourism development perspective, the risk of climate change is a more significant issue in economically less developed countries – they are more vulnerable to climate loss due to natural conditions, while at the same time insurance is a less developed sector, which increases the disruptive impact of climate change both directly – the inability of tourism businesses to continue operating – and indirectly – limiting tourism development opportunities and the socio-economic development of the country. Figure 2 shows the averages over the study period for the GDP per capita and the insurance gap for the countries studied.

Table 8. Insurance gap in the countries studied in 2014–2023 (%) (source: own based on Swiss Re Institute, 2025)

Specification	Years										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	10-year average
France	38.0	27.0	17.0	73.0	61.0	25.0	16.0	77.0	41.0	20.0	46.0
Germany	39.0	22.0	36.0	28.0	72.0	23.0	27.0	68.0	26.0	27.0	56.0
Italy	92.0	78.0	94.0	80.0	88.0	85.0	75.0	79.0	92.0	89.0	80.0
United Kingdom	24.0	26.0	18.0	26.0	14.0	18.0	16.0	24.0	17.0	23.0	21.0
Switzerland	45.0	77.0	25.0	51.0	19.0	39.0	18.0	21.0	73.0	17.0	28.0
India	92.0	87.0	91.0	97.0	95.0	99.0	97.0	95.0	100.0	76.0	91.0
China	99.0	93.0	95.0	93.0	95.0	95.0	94.0	93.0	92.0	90.0	94.0
Japan	55.0	37.0	80.0	70.0	42.0	34.0	63.0	65.0	57.0	46.0	55.0
Mexico	48.0	82.0	98.0	85.0	93.0	88.0	84.0	80.0	–	67.0	75.0
USA	38.0	43.0	49.0	52.0	33.0	40.0	30.0	44.0	40.0	40.0	42.0
Canada	57.0	13.0	27.0	26.0	15.0	51.0	33.0	65.0	35.0	31.0	41.0
South Africa	–	100.0	43.0	66.0	100.0	92.0	–	90.0	60.0	100.0	71.0
Australia	23.0	22.0	28.0	40.0	16.0	32.0	23.0	43.0	43.0	23.0	33.0

**Figure 2.** Relation between insurance gap and GDP per capita of studied countries (10-years average) (source: own based on Swiss Re Institute, 2025)

The research conducted allows us to conclude that climate change is an important factor in the tourism development of the countries studied, affecting it in a destimulatory way. However, some diversity can be observed among the group of countries studied, which should be taken into account when designing future tourism development policies. The diversity of the

countries studied is due to the specific weather events and their impact on a country's position, as measured by GDP. The level of the insurance gap is also important. In order to show the diversity of the countries studied, the damage caused by weather events in relation to GDP (%) and the 10-year average insurance gap (%) are compared for the entire period studied (Figure 3).

An analysis of the relationship between the weather damage load on a country's economy and the insurance gap identifies three countries – USA, India and China – as being especially at risk. USA is the country with the highest impact of weather disasters on the economy – 0.38% of GDP. However, these are significantly mitigated by insurance, as indicated by a relatively small insurance gap of 42%. India and China are the countries with the highest impact of weather disasters on the economy – over 0.20% of GDP. They are also countries with a very large insurance gap – over 90%, which means that insurance does not fulfil its compensatory function and does not mitigate the impact of climate events.

In general, the countries studied can be divided into three main groups:

1. Countries at risk of climate change strongly affecting the economy, with a well-developed insurance market, which means awareness and identification of climate risks and the development of methods to manage climate risks. These are: USA, Germany, France, Switzerland, Australia, Japan, Canada, United Kingdom.
2. Countries at risk of climate change strongly affecting the economy, with a poorly developed insurance market, which is largely due to the lack of developed climate risk management methods. These are: Italy, China and India.
3. Countries at risk of climate change strongly affecting the economy, with a poorly developed insurance market, due to the country's weak economic development. These are: Mexico and South Africa.

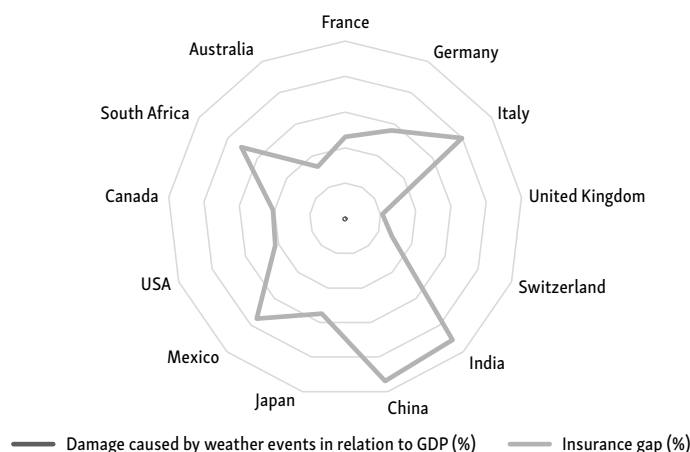


Figure 3. Relation between weather events in relation to GDP and insurance gap (10-years average) (source: own based on Swiss Re Institute, 2025)

6. Conclusions

Climate change is undeniably one of the major global challenges, impacting the tourism sector among others. The impact of climate change on tourism should be studied on a global, regional or national scale. This is due to the importance of climate as a very important resource for tourism, as well as the links between tourism sectors in different regions and countries. The conducted studies confirm a research hypothesis and the destimulating impact of economic losses caused by climate change on the development of tourism in countries with the greatest economic losses caused by climate change. The results show that the value of damage caused by climate change is increasing and poses a direct threat to tourism activities in the countries studied. The results obtained are in line with previous research in this area. The subject scope of the research – countries with the highest value of climate damage – should be considered original. It turned out that the subjects studied are internally heterogeneous in terms of the strength of climate change impacts. This is due to both the level of development of the country in question and the level of development of the insurance market. In addition, the research results confirm that the risk of climate change is a greater problem in less economically developed countries due to the poorly developed insurance sector, which results in a large insurance gap and increases the adverse effects of climate change on the tourism sector.

The results of the conducted research expand knowledge in the discipline of economics and finance on the development of tourism, and in particular the impact of climate change and the economic losses generated by it. In addition, the conducted research allowed to indicate the factors determining the development of tourism in the countries studied. These are factors stimulating development, i.e., the number of tourists and revenues from tourism, as well as destimulating factors – economic losses caused by climate change. It is worth noting that this is a topic that requires constant updating, due to the continuity and dynamics of climate change. Regulatory and institutional elements related to climate change risk management were not included in the study. These may have an influence on the strength of the impact of realised events in the countries studied.

Future research may focus on natural disasters and the economic losses they generate and their impact on the development of the tourism sector. The research may include institutional and regulation factors governing climate risk management and different groups of countries or geographical regions studied. An important area for future research is also the use of insurance by the tourism sector. Research in this area may concern both the range of insurance products offered and the financial impact on entities in the tourism sector.

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Author contributions

The contribution share of authors is equal and amounted to 25% for each of them. Conceptualization: V. M., M. L., P. K. and S. B., methodology: V. M., M. L., P. K. and S. B., software: V. M., M. L., P. K. and S. B., formal analysis: V. M., M. L., P. K. and S. B., investigation: V. M., M. L., P. K. and S. B., resources: V. M., M. L., P. K. and S. B., writing – original draft: V. M., M. L., P. K. and S. B.

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Authors declare that they do not have any competing financial, professional, or personal interests from other parties.

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