# STUDY ON THE IMPACT OF CLIMATE CHANGES FROM THE LAST DECADE ON TOURIST DEMAND IN ROMANIA

**Alina MARCUTA, Valentina Constanta TUDOR, Cristiana TINDECHE, Cosmina SMEDESCU, Marius Mihai MICU, Dragos SMEDESCU, Liviu MARCUTA**

University of Agronomic Sciences and Veterinary Medicine Bucharest of Bucharest, 59 Marasti Boulevard, District 1, 011464, Bucharest, Romania, Phone: +40213182564, Fax:+40213182888, Emails: marcuta.alina@managusamv.ro; tudor.valentina@managusamv.ro; cristina.tindeche@managusamv.ro; smedescu.cosmina@managusamv.ro; micu.marius@managusamv.ro; dragos.smedescu@managusamv.ro; marcuta.liviu@managusamv.ro

*Corresponding author*: marcuta.liviu@managusamv.ro

*Abstract*

*The purpose of this study was to identify and analyze how climate variables influence the behavior of tourists and the evolution of economic indicators specific to tourism, highlighting the relationships between climate change and tourism dynamics.The research methodology integrates the analysis of some essential climatic and economic indicators. The TCI (Tourism Climate Index) and HCI (Holiday Climate Index) indicators were used to measure the climatic attractiveness of tourist destinations, based on variables such as average temperature, relative humidity, hours of sunshine, precipitation and wind speed. The correlations of these indicators with the economic ones, such as: the total number of tourists, the share of foreign tourists, income from tourism, the degree of occupancy of tourist units and the contribution of tourism to GDP, allowed us a comprehensive analysis of the interactions between climate and tourist demand. The statistical analysis revealed correlations between climatic and economic indicators. For example, sunshine hours and average temperature had a positive influence on the number of tourists and tourism income, while precipitation and high wind speed reduced the attractiveness of certain destinations, affecting the occupancy of accommodation units. In addition, moderate thermal amplitude was associated with greater thermal comfort and increased demand during peak periods. The study's conclusions indicate that climate change has generated both opportunities and risks for Romanian tourism. Rising temperatures and the extension of warm seasons have favored tourist flows in certain regions, such as the coast and mountainous areas in the warm season. On the other hand, extreme phenomena, such as heat waves, drought or rains have affected the predictability of tourist seasons, underlining the need to adapt the infrastructure and diversify tourist offers.*

*Key words: tourism, climate changes, tourism demand, TCI, HCI*

## INTRODUCTION

In recent decades, globally, the climate has undergone significant changes, characterized by rising average temperatures, melting glaciers and rising sea levels. These climate changes have had important environmental and societal consequences. Thus, rising temperatures have contributed to rising sea levels, which threaten coastal communities and marine ecosystems, leading to the risk of flooding and shoreline erosion. Changes in rainfall patterns have led to more frequent and severe droughts in some regions, affecting agriculture and freshwater resources. In other areas, heavy rainfall caused devastating floods, destroying infrastructure and homes.

Climate change has also impacted biodiversity, causing species to migrate to higher altitudes or latitudes in search of suitable climatic conditions, which disrupts the balance of ecosystems and may lead to the extinction of species that cannot quickly adapt to new conditions [22, 25, 26 ]. To the same extent, all these changes also have effects on the economy, therefore tourism, which occupies a significant place in the economy, being an engine of economic growth, employment and regional development. Its economic contribution is manifested through the generation of income from various activities, such as accommodation, public catering, transport, cultural and leisure activities [18]. Tourism also stimulates

investment in infrastructure and services, having a multiplier effect on other economic sectors such as agriculture, trade and industry. The tourism sector represents a significant percentage of the GDP, but it also contributes to the development of local economies, especially in rural or isolated areas, where it represents an important source of income [23].

Moreover, tourism supports the valorization of natural and cultural heritage, transforming these resources into economic advantages. By promoting local destinations and attractions, tourism helps improve a country's image internationally and attracts foreign investment. Thus, the tourism sector has a strategic role in the global and local economy, being a key factor for sustainability and progress [6].

On the other hand, it has a significant impact on the environment, with both positive and negative effects, depending on how it is managed. The development of tourism can lead to the degradation of natural resources through overloading of ecosystems, pollution and uncontrolled urbanization. Tourism activities, such as transport, accommodation and associated infrastructure, contribute to greenhouse gas emissions, affecting climate change. In highly frequented destinations, overexploitation of water and energy resources, as well as poor waste management, can have a negative effect on biodiversity and environmental quality.

On the other hand, responsible and sustainable tourism can have a positive impact on the environment [17]. By generating funds and support for the conservation of nature and cultural heritage, tourism can help protect ecosystems and promote sustainable practices. Thus, the impact of tourism on the environment largely depends on the policies and practices adopted. A sustainable approach that integrates environmental protection, environmental education and the involvement of local communities is essential to minimize negative impacts and maximize long-term benefits

In order to mitigate these effects on climate change, specialists agree that it is essential to implement policies to reduce greenhouse gas emissions and adopt measures to adapt to the new climate conditions. Concerted global action can help limit global warming and protect the environment and society from the consequences of climate change [4, 20, 24].

The relationship between climate change and tourism demand is complex and multidimensional, being influenced both by the direct effects of climate change on destinations and by changes in the behavior of tourists. These changes may reduce tourism demand for affected destinations and cause tourists to redirect their preferences to less vulnerable locations, but at the same time, these changes influence the behavior of tourists, who become increasingly aware of the impact of travel on the environment. This awareness can lead to an increase in demand for sustainable tourism and ecotourism, at the expense of mass tourism or polluting destinations. Thus, climate change not only transforms tourism demand, but also generates challenges and opportunities for tourism development in the future.

In Romania's economy, tourism has a high potential for economic growth and regional development. Although its direct contribution to GDP is moderate, being around 2-3%, its total impact, including indirect and induced effects, is much higher, considering the fact that it generates jobs, both in direct fields such as hotels and restaurants, as well as in related sectors such as transport, trade or agriculture, offering opportunities especially in rural and mountainous areas [21].

Romania benefits from a special tourism diversity, which includes natural landscapes such as the Danube Delta, the Carpathian Mountains and the Black Sea coast, alongside a rich cultural heritage, with traditional villages, medieval castles and fortified churches included in the UNESCO heritage. These attractions attract both national and international tourists, contributing to the increase in tourism export revenues [5, 19]. However, tourism in Romania is underdeveloped compared to other European countries, with considerable potential for capitalization by improving infrastructure, digitizing services and more intensive promotion of destinations.

The sustainable development of tourism can amplify its economic impact, contributing to the reduction of regional disparities and the diversification of the national economy. Investments in ecotourism, cultural and spa tourism can transform this sector into a strategic pillar for Romania's economy.

In this context, the research aimed to analyze the impact of climate change on tourists' behaviour and to emphasize the relationship between these two aspects.

## MATERIALS AND METHODS

The relationship between climate change and tourism demand can be analyzed using 2 indicators, namely: TCI (Tourism Climate Index) and HCI (Holiday Climate Index), which are tools developed to assess the climatic attractiveness of tourist destinations. These indicators combine climate variables such as temperature, humidity, precipitation, wind speed and solar radiation level, providing an integrated assessment of climate comfort from the tourists' perspective.

TCI is the indicator that focuses on measuring general comfort for tourism activities, such as walking and urban exploration, being calculated based on sub-indices that measure thermal conditions, physical comfort, precipitation and sunshine. Each of these factors is weighted, resulting in a total score that indicates the level of climatic attractiveness of a destination at a certain time of the year. By analyzing TCI scores over several years, it can be seen how climate change, such as rising temperatures or variations in rainfall patterns, affects the attractiveness of destinations.

TCI is determined as follows:

$$TCI = 2 \times CID + CIA + 2 \times P + W + S \qquad [7]$$

where:

CID – the thermal comfort during the day, calculated on the basis of the maximum average temperature and the maximum average relative humidity.

CIA – the thermal comfort during the day, calculated based on the average temperature and the average relative humidity.

P – average monthly amount of precipitation.

W – average wind speed

S – sunshine duration.

CID and P have the greatest impact, as daytime thermal comfort and lack of precipitation are considered most important for tourists.

CIA, W and S have normal weights, reflecting their moderate contribution to the overall rating.

Each sub-index is rated on a scale from 0 to 100, where 100 represents ideal conditions for tourism. The total TCI score can range from 0 (completely unfavorable conditions) to 100 (perfect conditions).

If a destination has climatic conditions with optimal temperatures, low humidity, low rainfall, moderate wind and many hours of sunshine, its TCI will be close to 100. Conversely, a destination with extreme temperatures, high humidity, frequent rainfall and conditions of severe wind will have a low TCI.

HCI, is an indicator specific to modern requirements, placing greater emphasis on recreational activities and tourist preferences and integrating factors such as perceived temperature and thermal comfort during vacations. Unlike the TCI, the HCI is based on a more detailed approach to tourist preferences for various activity categories (beach, skiing, hiking), providing a more nuanced perspective on tourism demand. The use of this indicator allows the identification of changes in seasonality and tourist preferences according to climate changes.

The calculation formula is the following:

$$HCI = \sum ( \text{Weight } i \times \text{Variable } i) \qquad [7]$$

where:

The weight $i$, shows the importance of each climate variable for the desired activity.

Variable $i$ represents the measured climate values (temperature, humidity, precipitation).

The main variables used are:

Perceived temperature that integrates air temperature and relative humidity to assess thermal comfort, being essential for activities such as relaxing at the beach or urban exploration.

Precipitation refers to the average monthly amount of precipitation, with a low value being preferred for most tourist activities.

Wind speed evaluates physical comfort based on average wind speed. Moderate winds may be beneficial in warm areas, but may reduce attractiveness in other contexts.

Sunshine hours show the percentage of daily sunshine, being important for beach tourism and other outdoor activities.

Sunny days represent the number of days with clear skies in a month, contributing to the climate attractiveness.

The HCI provides a score on a scale from 0 to 100, where 100 represents ideal conditions for the activity being analyzed. Each tourist activity (beach tourism, urban tourism, etc.) has a specific HCI calculation formula, with adapted weights for the relevant variables.

The research methodology involved both the collection of climate data for the period 2014-2023, as well as their integration into the TCI and HCI models, the climate comfort scores being calculated. These scores were correlated with tourism demand data such as visitor numbers, length of stay and revenue generated. Thus, we were able to identify the trends and risks associated with climate change, as well as the opportunities for adapting and diversifying tourist offers.

## RESULTS AND DISCUSSIONS

The indicators analyzed and which were the basis for the calculation of the two indices were: average temperature, thermal aptitude, relative humidity, amount of precipitation, degree of sunshine and wind speed. The indicators analyzed and which were the basis for the calculation of the two indices were: average temperature, thermal aptitude, relative humidity, amount of precipitation, degree of sunshine and wind speed.

In the last decade, the average annual temperature in Romania has increased constantly, varying between 10.7°C in 2014 and 2017 and 12.5°C in 2023, in line with global warming trends. This evolution reflects the impact of climate change, with more pronounced increases in the lowland regions (Muntenia, Oltenia, Dobrogea) and a more moderate warming in the mountainous areas. The average temperature increase in Romania was approximately 1.8°C compared to the pre-industrial period, following European trends. These changes underscore the need to adapt infrastructure and policies to manage climate impacts on the economy and the environment.

Thus, the climate influences regional tourism through the attractiveness of destinations and seasonality. In the plains of Muntenia, Oltenia and Dobrogea, high temperatures and hours of sunshine stimulate summer tourism, but drought and heat waves affect the resources and comfort of tourists. In mountain areas, shorter winters and less snow limit winter tourism, but milder summers favor hiking, Adventure tourism, etc. In Transylvania and Moldova, seasonal variations support cultural tourism, but extreme phenomena, such as storms or torrential rains, can reduce the attractiveness. In Banat and Crisana, the moderate climate supports diversified tourism, but local droughts affect long-term sustainability.

Therefore, climate change requires adaptation of the tourism offer and risk management.

Thermal amplitude, in turn, significantly influences thermal comfort in the tourist season in Romania, because large amplitudes, characteristic of mountainous and plain areas, create discomfort through large differences between day and night temperatures, affecting tourist activities. In regions with moderate amplitude, such as the coast or hilly areas, thermal comfort is more moderate, attracting tourists through more constant climatic conditions. Excessively high or low temperatures, amplified by thermal amplitude, can reduce the duration of outdoor activities and the attractiveness of destinations, underscoring the importance of adapted infrastructure and tourism promotion during periods with favorable conditions. In Romania, the thermal amplitude shows an increasing tendency in the lowland regions, as a result of global warming, with warmer summers and milder winters, although the differences remain marked between day and night. In mountainous areas, the thermal amplitude decreases slightly due to the

reduction in the duration of winters and the snow cover. These changes demonstrate the need to adapt tourist activities to the new climatic realities, by diversifying the season and modernized infrastructure.

Thermal amplitude, in turn, significantly influences thermal comfort in the tourist season in Romania, because the large amplitudes, characteristic of mountain and plain areas, create discomfort through large differences between day and night temperatures, affecting tourist activities. In regions with moderate amplitude, such as the coast or hilly areas, the thermal comfort is more moderate, attracting tourists through more constant climatic conditions. Excessively high or low temperatures, amplified by the thermal amplitude, can reduce the duration of outdoor activities and the attractiveness of destinations, underlining the importance of an adapted infrastructure and the promotion of tourism during periods with favorable conditions.

In Romania, the thermal amplitude shows an increasing trend in lowland regions, as a result of global warming, with warmer summers and milder winters, although the differences remain marked between day and night.

In mountainous areas, the thermal amplitude decreases slightly due to the reduction in the duration of winters and the snow cover.

These changes demonstrate the need to adapt tourist activities to the new climatic realities, by diversifying the season and modernizing the infrastructure.

Areas with more hours of sunshine, such as the coast and the southern plains, attract tourists during the summer, favoring outdoor activities and leisure tourism.

In mountainous and rural regions, the hours of sunshine stimulate spring and autumn tourism, supporting hiking and nature exploration. Periods with abundant sunshine are preferred by tourists for thermal comfort and predictability of the weather, reinforcing the seasonality of tourist flows.

Wind speed is another factor that directly influences thermal and tourist comfort, moderate winds being beneficial for reducing discomfort in hot periods, and strong ones affecting outdoor activities. In recent years, average wind speed has fluctuated moderately, with a slight increase in lowland and coastal regions, where strong winds can reduce the attractiveness of summer tourism. The most affected regions are Dobrogea and Muntenia, where strong winds can disrupt beach activities or water sports. In mountainous areas, strong winds can limit access to trails and the safety of seasonal activities.

Thus, the combination of average temperature, relative humidity and wind speed influences the comfort perceived by tourists. Moderate temperatures and low wind speed, combined with low relative humidity, offer optimal conditions for tourism, especially in the mountainous and rural areas of Romania. High humidity, associated with high temperatures, increases thermal discomfort in the southern and coastal plains, especially in summer.

Moderate winds can relieve discomfort in hot periods, but strong ones reduce the appeal of outdoor activities, especially in Dobrogea and Muntenia. The balance between these factors is essential for a positive tourist experience.

Climate variations influence peak tourism periods by changing seasonality and reducing the predictability of the weather.

Extreme temperatures and severe weather events, such as heat waves, torrential rains or droughts, can shorten the summer season in coastal areas and affect the consistency of snow in the winter season in mountain regions. Conversely, periods with moderate temperatures and more stable conditions become more attractive, expanding tourist flows in spring and autumn.

These variations underline the need to adapt tourism offers to new climatic realities and diversify activities to reduce dependence on seasonality.

Table 1 presents the dynamics of TCI and HCL in Romania in the period 2014-2023.

In Romania, climate patterns favor different types of tourism. Thus, mountain tourism is supported by moderate temperatures and low humidity in spring and autumn for hiking, and in winter, snow in the Carpathians supports winter sports. Coastal tourism in Dobrogea is favored in summer, with high temperatures,

many hours of sunshine and moderate winds, ideal for relaxation and water sports. Cultural tourism is practiced in spring and autumn, when comfortable temperatures and stable weather conditions allow visits to sights in Transylvania, Moldova or Muntenia. Adapting offers to these particularities can extend the seasons and attract more tourists.

Table 1. Evolution of TCI and HCL in Romania in the period 2014-2023

| Year | Average temperature (°C) | Thermal amplitude (°C) | Humidity relative (%) | Amount of precipitation (mm) | Hours of sunshine (h/year) | Speed wind (km/h) | TCI | HCI |
|------|------|------|------|------|------|------|------|------|
| 2014 | 10.70 | 22.00 | 75% | 700 | 2,100.4 | 9.00 | 579.40 | 838.01 |
| 2015 | 10.70 | 21.80 | 74% | 592 | 2,100.5 | 9.40 | 590.03 | 838.15 |
| 2016 | 11.20 | 22.50 | 76% | 713 | 2,150.3 | 8.60 | 593.47 | 858.12 |
| 2017 | 10.70 | 21.90 | 75% | 636 | 2,120.7 | 9.00 | 591.89 | 846.13 |
| 2018 | 11.60 | 22.30 | 74% | 750 | 2,180.2 | 9.00 | 598.50 | 870.48 |
| 2019 | 11.90 | 22.70 | 73% | 551.7 | 2,150.8 | 9.00 | 609.43 | 858.97 |
| 2020 | 11.88 | 23.10 | 75% | 650 | 2,180.2 | 9.40 | 608.81 | 870.52 |
| 2021 | 10.90 | 22.80 | 74% | 705.2 | 2,160.5 | 8.60 | 596.79 | 862.25 |
| 2022 | 11.77 | 22.40 | 73% | 512.07 | 2,170.3 | 9.00 | 619.19 | 866.71 |
| 2023 | 12.50 | 22.60 | 72% | *** | 2,190.7 | 9.00 | 676.61 | 875.33 |

Source: own processing based on the data from [1, 2, 3].

Based on the data analyzed for Romania, the TCI and HCI indices highlight a moderate to high climatic attractiveness for tourism, with notable variations between years, influenced by factors such as average temperature, relative humidity, precipitation, hours of sunshine and wind speed.

The average annual temperature had an increasing trend, from 10.7°C in 2014 to 12.5°C in 2023, reflecting an influence of climate change on the region. This increase in temperature favors climatic comfort for general tourism and vacations, but can generate discomfort during summer periods, especially if combined with high humidity. The thermal amplitude remained relatively stable, with values between 21.8°C and 23.1°C, indicating a predictable but tolerable seasonal variation for tourism activities. The average annual relative humidity varied between 72% and 76%, being moderate. Higher humidity, such as that of 2016 and 2021 (76% and 74%, respectively), reduced the comfort perceived by tourists, especially in combination with heavy rainfall. Conversely, years such as 2019 and 2023, with values of 73% and 72%, provided greater comfort due to lower humidity. Precipitation showed significant variability, from 512 mm in 2022 (a dry year) to 750 mm in 2018 (a wet year). High rainfall reduced tourism appeal, especially for outdoor activities, while drier years were more favorable for general tourism. The hours of sunshine, with values between 2,100 and 2,190 hours annually, were a constant positive factor, providing a competitive advantage for Romania in recreational tourism, especially in the years 2018, 2020 and 2023, when the number of hours of sunshine was maximum. The wind speed remained constant, around 9 km/h, having a minimal impact on tourist comfort.

An improvement in the TCI and HCI climate indices can increase the tourist flow, due to more favorable weather conditions for recreational and vacation activities. At the level of Romania, a general growth trend can be observed during the period 2014-2023. The TCI increases from 579.40 in 2014 to 676.61 in 2023, reflecting an improvement in climate conditions favorable to tourism. Also, the HCI rises from 838.01 to 875.33, indicating greater attractiveness for vacations due to better climatic comfort conditions and greater sustainability for tourist activities throughout the year.

With more attractive climates, local economies can benefit from increased visitor numbers and tourism spending, and tourism operators can plan seasons optimally, increasing occupancy and revenue.

Romania's tourism data, presented in Table 2, reflects the evolution of tourism in the period 2014-2023, highlighting fluctuations in the

total number of tourists, incomes, and contribution to GDP.

Table 2. The evolution of Romania's tourist data in the period 2014-2023

| An | Total number tourists (millions) | Foreign tourists (%) | Income from tourism (billion euros) | Degree of occupancy (%) | GDP (billions of Euros) | Contribution in GDP (%) |
|---|---|---|---|---|---|---|
| 2014 | 8.44 | 22.6 | 7.65 | 24.80% | 150.00 | 5.1 |
| 2015 | 9.90 | 22.6 | 8.33 | 25.60% | 160.30 | 5.2 |
| 2016 | 10.92 | 22.6 | 8.99 | 26.40% | 169.60 | 5.3 |
| 2017 | 12.10 | 22.7 | 9.95 | 30.90% | 187.80 | 5.3 |
| 2018 | 12.81 | 21.8 | 11.03 | 31.20% | 204.30 | 5.4 |
| 2019 | 13.26 | 20.1 | 12.08 | 31.50% | 223.70 | 5.4 |
| 2020 | 6.34 | 6.9 | 6.35 | 22.90% | 219.00 | 2.9 |
| 2021 | 9.22 | 9.1 | 1.50 | 26.40% | 241.90 | 3.1 |
| 2022 | 11.30 | 14.0 | 3.50 | 30.20% | 284.00 | 4.0 |
| 2023 | 13.65 | 20.1 | 3.50 | 30.40% | 321.00 | 4.5 |

Source: Own processing based on the data from [8, 9, 10, 11, 12, 13, 14, 15, 16].

The total number of tourists increased steadily between 2014 and 2019, reaching a maximum of 13.26 million. The COVID-19 pandemic had a significant impact in 2020, reducing the number of tourists to 6.34 million, with a drastic decrease in the percentage of foreign tourists (6.9%) and tourism income (6.35 billion €). After 2021, tourism gradually recovered, reaching 13.65 million tourists in 2023, although tourism revenues (3.50 billion €) remain below pre-pandemic levels.
Facility occupancy followed a similar trend, decreasing in 2020 (22.90%) and returning to 30.40% in 2023. Tourism's contribution to GDP decreased significantly in 2020 (2.9%), but gradually increased up to 4.5% in 2023.
Although tourism was severely affected by the COVID-19 pandemic, it has gradually recovered, although revenues and percentage contribution to GDP have not yet reached pre-pandemic peaks. The revitalization of tourism requires strategies to attract foreign tourists and increase revenues, and tracking and analyzing the impact of climate change contributes to improving these strategies.

Table 3. Matrix of correlations between the relevant variables for tourism

| | Average Temperature (°C) | Total Tourists (million) | Sunshine Hours (hours/year) | Tourism Revenues (billion EUR) | Precipitation (mm) | Occupancy Rate (%) |
|---|---|---|---|---|---|---|
| Average Temperature (°C) | 1 | 0.371522822 | 0.838778689 | -0.157697437 | -0.324929423 | 0.357657 |
| Total Tourists (million) | 0.371522822 | 1 | 0.233001801 | 0.29575065 | -0.199684007 | 0.934611 |
| Sunshine Hours (hours/year) | 0.838778689 | 0.233001801 | 1 | -0.336049836 | 0.068079164 | 0.282522 |
| Tourism Revenues (billion EUR) | -0.157697437 | 0.29575065 | -0.336049836 | 1 | 0.067921246 | 0.268944 |
| Precipitation (mm) | -0.324929423 | -0.199684007 | 0.068079164 | 0.067921246 | 1 | -0.28492 |
| Occupancy Rate (%) | 0.357656878 | 0.934610567 | 0.282522045 | 0.26894439 | -0.284922433 | 1 |

Source: own processing.

Table 3 and Fig. 1 show the correlation between the average temperature and the number of tourists indicates a moderate positive relationship (coefficient of 0.37), which suggests that an increase in the average temperature attracts a larger number of tourists. This is due to the fact that higher temperatures favor tourist activities, especially in the summer season, and contribute to the attractiveness of destinations. However, there are other factors, such as tourist infrastructure, seasonal events or marketing, which also play an important role in attracting tourists.
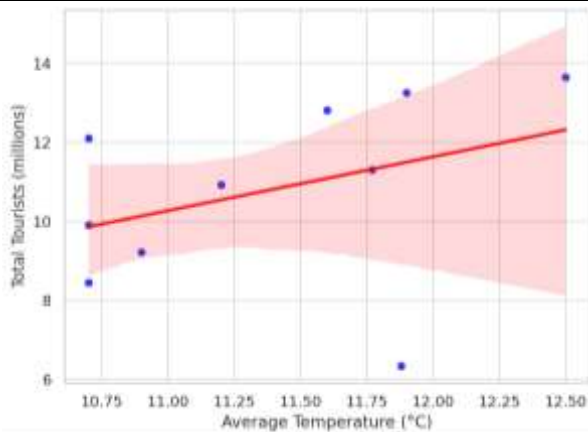
Fig. 1. The correlation between average temperatures and the number of tourists
Source: Own processing.

In the case of the correlation between sunshine hours and tourism income, the high coefficient of 0.84 reflects a direct and very strong relationship (Fig. 2).
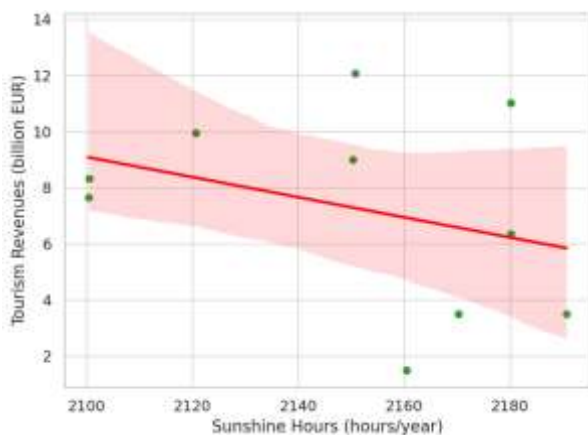


Fig. 2. Correlation between sunshine hours and tourism income
Source: Own processing.

Regions with more hours of sunshine are more attractive to tourists, which causes an increase in their spending and implicitly in tourism income. This aspect underlines the importance of promoting sunny destinations, especially in the context of seaside or nature tourism. Also, this correlation shows that sunshine hours are one of the main climatic factors that stimulate the tourism economy.

The correlation between precipitation and the degree of occupancy of accommodation units is negative (-0.28), which shows that frequent or heavy precipitation can discourage tourists from traveling or staying in the respective destinations (Fig. 3).
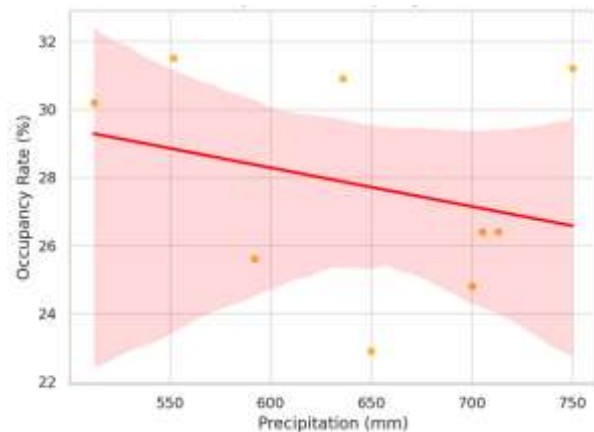


Fig. 3. The correlation between the amount of precipitation and the degree of occupancy of accommodation units
Source: Own processing.

Regarding the correlation between average temperature and tourism income, the coefficient is slightly negative (-0.16), which shows a weak and indirect relationship (Fig. 4).
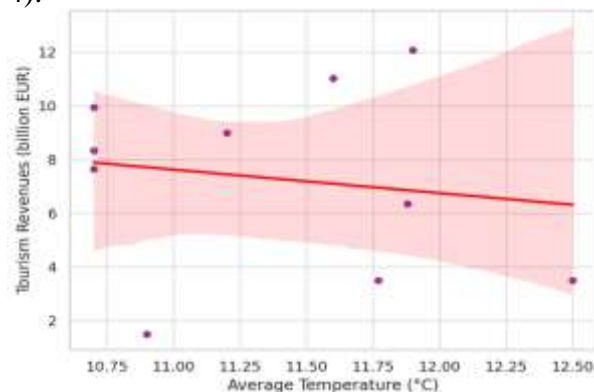


Fig. 4. Correlation between average temperature and tourism income
Source: Own processing.

Also, excessively high temperatures associated with heat waves can have a deterrent effect, especially in the context of climate change and tourists' preference for more comfortable conditions.

Therefore, tourism development strategies should focus on adapting the offer to climatic conditions and promoting destinations in seasons with moderate temperatures. These correlations demonstrate the importance of tourism management adapted to local climatic conditions and tourists' preferences, highlighting at the same time the crucial role of diversifying the offer and promoting

destinations in the context of climate variability.

Climate has an essential role in influencing GDP, having direct and indirect effects on economic sectors sensitive to climate variables. Average temperature has a moderate positive correlation with GDP (0.78), demonstrating that comfortable temperatures stimulate economic activities such as tourism, agriculture and trade. However, extreme temperatures can reduce productivity, especially in sectors dependent on outdoor work, such as agriculture. Sunshine hours have a strong positive correlation with GDP (0.84), indicating that a sunny climate favors tourism, increased tourist numbers and associated spending, which contribute significantly to the economy. Sunny destinations benefit from a steady flow of tourists, which indirectly boosts other related sectors such as transport and hospitality.

On the other hand, precipitation has a moderate negative correlation with GDP (-0.47), highlighting that unstable or rainy weather conditions can affect tourism and other economic activities. For example, floods or heavy rains can lead to economic losses in agriculture, destroy infrastructure and reduce the attractiveness of tourist destinations.

Tourism acts as a major channel through which climate influences GDP. Favorable climatic variables such as moderate temperatures and hours of sunshine increase tourism revenues, which contribute directly to GDP. The strong correlation between sunshine hours and tourism income (0.84) underlines the importance of a pleasant climate in attracting tourists. At the same time, the occupancy rate of accommodation units decreases in high rainfall conditions, affecting tourism income and local consumption.

Climate change presents risks and opportunities. Higher temperatures and longer periods of sunshine can boost the economy in certain regions, but extreme events such as heat waves, droughts and floods can cause significant damage, reducing the contribution of affected sectors to GDP. Adapting the infrastructure to cope with these changes and diversifying the economy are essential measures to minimize the negative impact.

Tourism revenue has a strong correlation with tourism's contribution to GDP, indicating that as revenue increases, the sector contributes significantly to the economy through job creation, increased consumption and infrastructure development. Occupancy of accommodation units is closely correlated with tourism revenue, reflecting that a high demand for accommodation boosts revenue both directly (accommodation rates) and indirectly (tourists' expenditure on transport, restaurants and entertainment).

The number of tourists has a moderate to strong correlation with tourism revenue, showing that although more tourists contribute to an increase in revenue, this effect is influenced by the expenditure per tourist and the type of tourism practiced (luxury vs economy). The relationship between GDP and tourism's contribution to GDP is positive but moderate, indicating that tourism plays an important but more limited role in diversified economies. In contrast, in tourism-dependent regions, the occupancy rate of establishments and the income generated are key factors for GDP growth.

Rainfall has a negative impact on tourism, affecting employment and income, which underlines the economy's vulnerability to climate conditions. In conclusion, the relationships between tourism and the economy are essential for strategic planning, and maximizing the impact of tourism requires sustainable infrastructure management and promotion.

**CONCLUSIONS**

The study of climate impacts on the economy and economic correlations highlights the importance of understanding the relationships between climate variables and economic sectors, particularly tourism, as a driver of economic growth. The analysis of this topic is important for the foundation of economic strategies and adaptation to climate change, offering solutions for capitalizing on opportunities and minimizing risks, especially because tourism has a multiplier effect,

generating benefits in sectors such as transport, trade and agriculture.

Climate change brings both risks and economic opportunities. Extreme temperatures and severe weather events can reduce tourism attractiveness, affecting climate-dependent sectors. However, they can extend tourist seasons in regions where conditions become more favorable.

The use of TCI and HCI indicators allows making strategic decisions in tourism, including the development of climate change adaptation policies, the promotion of alternative destinations or the optimization of the tourist calendar. By understanding the climate impact on tourism demand, operators and authorities can develop sustainable strategies to ensure the competitiveness of the sector in the long term.

The results of the study demonstrate the need for investments in resilient infrastructures, renewable energy and sustainable tourism, which counteract the negative impact of climate change. Effective public policies, such as tax incentives, VAT reduction in tourism and international promotion, can amplify the positive economic impact. Digitization and diversification of tourist offers are also essential for extending the season and increasing competitiveness.

In conclusion, the analysis highlights the role of the integrated strategy between tourism, climate and economy, to ensure sustainable development and long-term economic growth.

# REFERENCES

[1]ANM, National Administration of Meteorology, 2023, Meteorological characterization, https://www.meteoromania.ro/clim/caracterizare-anuala/cc_2023.html, Accessed on 11 Nov. 2024.
[2]ANM, 2022, Meteorological characterization, https://www.meteoromania.ro/clim/caracterizare-anuala/cc_2022.html, Accessed on 11 Nov. 2024.
[3]ANM, 2021, Multiannual meteorological characterization 1961-2021, https://www.meteoromania.ro/clim/caracterizare-multianuala/cc_1961_2021_04.html, Accessed on 11 Nov. 2024.
[4]Ciurea, I. V., Mihalache, R., Ungureanu, G., Brezuleanu, S., 2011, Studies Regarding the Evaluation of the Tourist Potential of Oituz Hydrographical Basin–Bacau County, Bulletin UASVM Horticulture, 68(2), 49-54.

[5]Croitoru, A.-E., Banc, Ș., Scripcă, A.-S., Rus, A.-V., 2024, Climatic Suitability for Outdoor Tourism in Romania's Big Cities, Atmosphere 2024, 15, 996. https://doi.org/10.3390/atmos15080996
[6]Damian, C.M., Smedescu, D.I., Panait, R., Buzatu, C.S., Vasile, A., Tudor, V.C., 2024, The impact of the Covid 9 pandemic on rural tourism in Europe. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(2), 407-412.
[7]Hu, L., Guo, X., Yan, P., Li, X., 2024, The Construction and Application of a Model for Evaluating Tourism Climate Suitability in Terraced Agricultural Cultural Heritage Sites: A Case Study of Longji Terraced Fields in China, Atmosphere, 15(7), 756.
[8]INSSE, National Institute of Statistics, 2024, Breviar turistic, https://insse.ro/cms/sites/default/files/field/publicatii/turismul_romaniei_2021-2023_breviar_statistic.pdf, Accessed on 14 Nov. 2024.
[9]INSSE, 2023, Breviar turistic, https://insse.ro/cms/sites/default/files/field/publicatii/turismul_romaniei_2020-2022_breviar_statistic__0.pdf, Accessed on 14 Nov. 2024.
[10]INSSE, 2022, Breviar turistic, https://insse.ro/cms/files/Publicatii_2022/74.Turismul_romaniei_breviar_statistic/turismul_romaniei_2019-2021_breviar_statistic.pdf, Accessed on 14 Nov. 2024.
[11]INSSE, 2019, Breviar turistic, https://insse.ro/cms/sites/default/files/field/publicatii/turismul_romaniei_2019_breviar_statistic.pdf , Accessed on 14 Nov. 2024
[12]INSSE, 2018, Breviar turistic, https://insse.ro/cms/sites/default/files/field/publicatii/turismul_romaniei_2018_breviar_statistic.pdf, Accessed on 14 Nov. 2024.
[13]INSSE, 2017, Breviar turistic, https://insse.ro/cms/sites/default/files/field/publicatii/turismul_romaniei_2017.pdf , Accessed on 14 Nov.2024.
[14]INSSE, 2016, Breviar turistic, https://insse.ro/cms/sites/default/files/field/publicatii/turismul_romaniei_2016.pdf , Accessed on 14 Nov..2024.
[15]INSSE, 2015, Breviar turistic, https://insse.ro/cms/files/publicatii/Breviar%20turism/turismul%20romaniei_2015.pdf, Accessed on 14 Nov. 2024.
[16]INSSE, 2014, Breviar turistic, https://insse.ro/cms/files/publicatii/Breviar%20turism/Turismul_Romaniei_2014.pdf, Accessed on 14 Nov. 2024.
[17]Marcuta, L., Marcuta, A., Popescu, A.; Tindeche, C., Tudor, V., Smedescu, D., 2020, Study on the development of adventure tourism in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.20(4), 339–345.
[18]Marcuta, A., Marcuta, L., Popescu, A., Tindeche, C., Tudor, V., Smedescu, D., 2020, Possibilities of development of the slow tourism concept in Romania,

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 2020(4), 331-338.

[19]Mihăilă, D., Bistricean, P. I., Gaceu, R. O., Emandi, E. M., Mihăilă, E. V., Horodnic, V. D., 2024, A bioclimatic evaluation of sustainable tourist activities in western Romania, Heliyon, 10(8) e29510.

[20]Nuta, F. M., Nuta, A. C., Ahmed, F., Duan, H., Khan, I., 2024, Editorial: Exploring new development patterns for climate change resilience and mitigation. Frontiers in Environmental Science. 12.

[21]Popescu, A., 2016, Research on the economic efficiency in Romania's tourism, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 16(1), 411-416.

[22]Onoh, U. C., Ogunade, J., Owoeye, E., Awakessien, S., Asomah, J. K., 2024, Impact of Climate Change on Biodiversity and Ecosystems Services, International Journal of Geography and Environmental Management (IJGEM), 10(1), 77-93.

[23]Stanciu, M., Popescu, A., Sava, C., Moise, G., Nistoreanu, B. G., Rodzik, J., Bratu, I. A., 2022, Youth's perception toward ecotourism as a possible model for sustainable use of local tourism resources, Frontiers in Environmental Science, 10, 940957.

[24]Ștefan, P., Crețu, R. C., Micu, M. M., 2012, Economic crisis and the implications on rural tourism and sustainable development in Calarasi county, 19th International Economic Conference - IECS 2012, Sibiu, Romania, 15 June 2012.

[25]Tabără, N., Nuță, F. M., Nuță, A. C., 2013, A review of the actual state of environmental performance of Romania–EPI 2012, Journal of Public Administration, Finance and Law, Alexandru Ioan Cuza University, Faculty of Economics and Business Administration, vol. 4(4), pages 203-207, December.

[26]Wang, B., Hua, L., Mei, H., Wu, X., Kang, Y., Zhao, N., 2024, Impact of climate change on the dynamic processes of marine environment and feedback mechanisms: an overview, Archives of Computational Methods in Engineering, No. 3377-3408.