Geojournal of Tourism and Geosites
ISSN 2065-0817, E-ISSN 2065-1198

Year XIX, vol. 65, no. 2, 2026, p.1149-1161
DOI 10.30892/gtg.65248-1753

GEO-TOURISM PERSPECTIVES ON THE IMPACTS OF CLIMATE CHANGE IN WADI RUM, JORDAN

Omar JAWABREH [1], Emad Al Dein Al FAHMAWEE [2*], Rami MAHMOUD [1], Ashraf JAHMANI [3], Ranea QADDHAT [4], Sumaya Abed ALQADER [5]

[1] The University of Jordan, Faculty of Tourism and Hospitality, Department of Hotel Management, Jordan, Amman; o.jawabreh@ju.edu.jo (O.J.); r.mahmoud@ju.edu.jo (R.M.)
[2] Applied Science Private University, Faculty of Art and Design, Department of Interior Design, Jordan, Amman; fahmawee@asu.edu.jo (E.A.D.A.F.)
[3] Horizon University Colleage, School of Business, United Arab Emirates; ashraf.jahmani@hu.ac.ae (A.J.)
[4] University of Jordan, Faculty of Tourism and Hospitality, Department of Tourism Management, Aqaba, Jordan; r.qaddahat@ju.edu.jo (R.Q.)
[5] Jagiellonian University, Krakow, Poland; sumaya.abedalqader@student.uj.edu.pl (S.A.A.)

Citation: Jawabreh, O., Fahmawee, E.A.D.A., Mahmoud, R., Jahmani, A., Qaddhat, R., & Alqader, S.A. (2026). Geo-tourism perspectives on the impacts of climate change in Wadi Rum, Jordan. *Geojournal of Tourism and Geosites*, 65(2), 1149–1161. https://doi.org/10.30892/gtg.65248-1753

Abstract: Purpose-This paper investigates the impacts of climate change on tourism in Wadi Rum, Jordan, focusing on how rising temperatures, shifting precipitation patterns, and an increasing frequency of extreme weather events threaten the area's natural and cultural assets as well as its tourism economy. Design/methodology/approach- A mixed-methods approach was adopted, combining analysis of long-term climatic data (1990–2025), projections from regional climate models, and stakeholder perspectives drawn from literature, policy documents, and field evidence. Key indicators including temperature trends, rainfall variability, flashflood and heatwave occurrence were synthesized with assessments of tourism infrastructure, visitor behavior, and economic vulnerability. Findings- Results reveal a marked rise in mean annual temperature (from ~20.7°C in 1980–2000 to >22°C by 2017) and a decline in rainfall reliability. Flash floods increased from one event in 1990 to seven in 2025, while heatwaves, previously absent, reached six by 2025. These shifts undermine visitor comfort, heighten safety risks, damage infrastructure, and erode revenue potential. Stakeholders highlight the need for adaptation measures of renewable energy, flood-resilient design, heat-sensitive scheduling, and community engagement to maintain the site's attractiveness and ecological integrity. Practical implications-Destination managers and policymakers should integrate climate adaptation into tourism planning for Wadi Rum. Measures include early-warning systems, climate-smart infrastructure, diversified visitor experiences, and participatory governance to strengthen resilience and secure local livelihoods. Originality/value-This study offers the first comprehensive synthesis of climate-tourism interactions in Wadi Rum, linking meteorological evidence, policy responses, and tourism dynamics. It advances understanding of how desert destinations can sustain heritage, ecosystems, and tourism competitiveness under intensifying climate pressures.

Keywords: climate change, Wadi Rum Protected Area, World Heritage Site

* * * * * *

INTRODUCTION

Wadi Rum, also known as "The Valley of the Moon," stands tall as one of the most awe-inspiring and wondrous desert landscapes that grace our planet. Its sheer natural and cultural splendor has propelled it into the realm of must-visit destinations for avid explorers from far and wide. Nestled in the heart of Jordan, Wadi Rum beckons with its magnificent red and white sandstone hills, canyons, and dunes, which paint an ethereal tapestry across the vast expanse of the desert.

Wadi Rum's allure is boundless, captivating the senses throughout the year with its unique charm. Its monumental beauty serves as a testament to the enduring spirit of adventure that resides within us all. Thrill-seekers and wanderers from every corner of the globe pilgrimage to this mesmerizing desert, eager to immerse themselves in its untamed grandeur. Yet, amidst the undeniable splendor, a remarkable yet pressing reality emerges (Gössling et al., 2023; Al Fahmawee & Jawabreh, 2022a). The potential impacts of climate change on the fragile environmental conditions of Wadi Rum have garnered scant attention, often overlooked in the pursuit of unparalleled scenic beauty. It is here that the importance of comprehensive studies becomes apparent, as they lay the foundation for understanding the intricate interplay between climate change and the tourism activities that thrive in this captivating oasis. Wadi Rum, located in the central Levant, is part of a region where early climate change has demonstrated its impact on the vast Mediterranean expanse.

* Corresponding author

Despite this knowledge, researchers have not yet directed their inquisitive gaze towards the profound implications that climate change may hold for the central part of Jordan, where Wadi Rum resides. With every sunset that tinges the desert horizon in hues of gold and rose, it becomes increasingly imperative for dedicated scholars and pioneers of knowledge to embark on a voyage of discovery, delving deep into the potential ramifications that climate change may have on this exquisite haven. Only through diligent research and open-hearted collaboration can we safeguard the future of Wadi Rum, granting it the resilience and fortitude it needs to thrive amidst an ever-changing world (Al Fahmawee & Jawabreh, 2023; Hall, 2015; Jawabreh, 2020; St Leger, 2025; Spector & Higham, 2025; Khater et al., 2024; Peeters et al., 2023).

As we look towards the uncertainties that lie ahead, let us remember the irreplaceable jewels that grace our planet. Wadi Rum stands as a testament to the power and beauty that nature bestows upon us, urging us to protect and cherish these sacred landscapes for generations to come. In our shared pursuit of sustainable coexistence, let us embrace the boundless potential that lies within the harmonious relationship between humanity and the natural world. Wadi Rum beckons us with open arms, inviting us to embark on a journey of discovery, enlightenment, and profound transformation (Jawabreh et al., 2025a; Moayedfar & Fatemi, 2021; Migoń, 2024; Michopoulou et al., 2021). This paper illuminates how a diverse group of key stakeholders, including local communities, tourism organizations, and governmental bodies, perceive and understand the impact of climate change on tourism in Wadi Rum, Jordan. The primary objective of this study is to provide an in-depth and comprehensive discussion of the climatic characteristics of the Wadi Rum region, analyze the existing climate patterns and dynamics, and establish a strong correlation between these factors and the current observed weather changes. Furthermore, this research aims to bridge the existing gaps and limitations in previous literature regarding climate change and its specific implications in the context of Wadi Rum. By critically reviewing and synthesizing the available literature, this paper seeks to explore the various dimensions of climate change, such as rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events, and how these changes intersect with the unique socio-economic and cultural dynamics of Wadi Rum.

In addition to examining the climate change impacts on the region, this paper delves into the identification and analysis of Jordan's official position and policies concerning climate change. By analyzing governmental reports, statements, and initiatives, this study aims to shed light on the strategies and measures implemented by the Jordanian government to mitigate and adapt to the challenges posed by climate change in Wadi Rum. This analysis will further provide insights into the alignment between national policies and local realities, highlighting potential areas of improvement and collaboration.

In conclusion, it is imperative to explore the multifaceted dimensions of climate change in the Wadi Rum area and analyze their possible long-term impacts on both the natural landscape and the tourists who frequent this mesmerizing destination. By understanding the intricate relationship between climate change and tourism, stakeholders can develop effective strategies to maintain the sustainability, resilience, and attractiveness of Wadi Rum as a leading tourist destination while simultaneously preserving its unique cultural and natural heritage (Arabeyyat & Aldweik, 2024; Zalloom, 2020).

Figure 1. Desert Landscape of Wadi Rum under Harsh Climatic Conditions (Source: Authors, April 2025)

The image in Figure 1 showcases the arid terrain of Wadi Rum, with scattered desert vegetation, dark sandstone cliffs, and Bedouin-style camps at the base of the rock formations. The image reflects the region’s vulnerability to extreme heat and drought, key characteristics of climate change in arid zones. It illustrates the setting where flash floods and heatwaves now increasingly threaten tourism operations and infrastructure.

GEOGRAPHICAL OVERVIEW OF WADI RUM

Known as the "Valley of the Moon,' Wadi Rum possesses immense geographic, cultural, and natural significance, which has made it a magnet for both domestic and international visitors from far and wide. Situated in the picturesque southern region of Jordan, this captivating wadi stretches over a vast expanse of 74,180 hectares, encompassing the southern arm of the Hisma Desert Polje. UNESCO proudly inscribed Wadi Rum as a World Heritage Site in 2011, acknowledging its unparalleled desert landforms, ever-evolving land-use patterns, and deeply rooted cultural values. Within this rugged and magnificent terrain, the towering mountainous rocks reign supreme, some proudly reaching an astonishing height of 1,800 meters above the glistening sea level. As one navigates through the wadi, they will encounter a myriad of narrow canyons, adorned with walls that extend an impressive 20 meters in height. These canyons stand as magnificent testaments to the intricate and age-old processes that have shaped the rocks throughout time. It is awe-inspiring to witness the evidence of centuries of gradual layering etched upon the majestic cliffs and revealed by the wider gaps that have withstood the tests of time. The mesmerizing landscapes of Wadi Rum are characterized by their monumental sandstone and granitic surfaces, enchantingly captivating the hearts and imaginations of tourists. Each meticulously sculpted curve and crevice tells a story of the ancient forces that once roamed the land, leaving behind masterpieces that continue to inspire and leave visitors in absolute awe. From the sprawling desert plains painted in hues of gold and ochre to the towering monoliths that punctuate the horizon, every inch of Wadi Rum is a testament to the raw beauty that nature so generously bestows upon this sacred land. Venturing into Wadi Rum unveils a harmonious blend of history and nature's awe-inspiring artistry. It is a sanctuary where visitors can revel in the sheer splendor of the natural world while also delving into the rich tapestry of Jordanian cultural heritage that permeates every grain of sand. Wadi Rum's allure is boundless, effortlessly captivating the senses and leaving an indelible mark on the souls of all who wander through its serenely beautiful landscapes (Wolniewicz & Górska-Zabielska, 2025; Groom et al., 2022; Badran et al., 2022).

Wadi Rum enjoys a Mediterranean climate, characterized by hot, dry summers and cool, rainy winters. Daily temperatures can exceed 30 degrees Celsius in the summer and decrease to 0 degrees in the winter. The weather is colder on the higher surfaces of rocks than at the wadi floors or the connecting valleys, known as Siq. Thus, moving from the lower area to the trapezoidal motives leading to higher rocks, visitors feel significant changes in temperature. However, when you appreciate the shaded and wind-sheltered areas of the rock, winter trekking offers a unique experience, shielded from the cold, despite the extreme heat that prevails during the summer months.

The wadi represents a variety of desert landscapes characterized by mountains, granite and sandstone cliffs, and canyons with small sand dunes. The area hosts a number of unfed, narrow canyons known as Siq and a broad sand and gravel plain known as Sabkha. Nestled in the west and north, the mountains encompass the Jebel Khaz'ali massif, split between large secondary masses where the principal wadi stream gathers, creating a wildlife corridor. Chief minerals of the Jebel Khaz'ali include desert cabbage, desert violets, and tough aster. The balance of the mountains hosts the silhouette of Ram and Al Agabat. The mountains of Wadi Rum accommodate narrow, steep-sided terraces indicating geological development in the higher hanging valleys. Hot, dry terrestrial conditions expose the surrounding sediments and metamorphism, which veer towards slightly wetter, semi-arid areas at lower altitudes down to the sub-optimal ocean. Besides these natural and cultural dimensions, Wadi Rum is home to a varied and unique desert fauna and flora. Despite their wide distribution, small mammals typically remain cryptic due to their association with the rock desert. At least 20 plant species are endemic to the wadi, where they grow in the wadi's sand, gravel, and granite outcrops.

1. Location and Climate

Wadi Rum is a desert valley located between 29°30' and 29°37' N and 35°25' and 35°36' E in Southern Jordan, approximately 45 km east of the strategically important port city of Aqaba on the Red Sea, and directly south of the King's Highway and the mountainous desert of Wadi Musa and Petra. The only city in the Arabian Peninsula to the south, Tabuk in Saudi Arabia, is approximately 59 km from the park boundary at its busiest protected area entrance. Madaba and central Amman, the capital city of Jordan, are 291 km and 324 km away, respectively.

Wadi Rum, a desert region, is well known for its arid characteristics. Its local climate falls under the category of a hyper-arid desert ecosystem. The Wadi Rum area, including Aqaba, experiences a hot desert climatic type, where temperatures range from approximately 30 to 42.5 °C, creating specific arid conditions. The annual average relative humidity (RH) remains relatively low, usually around 26-30%. However, it exhibits significant variability from month to month throughout the year. The humidity levels drop to as low as 9% during May and June and reach 11% from August through September. Among the low altitude plains in Wadi Rum, invasive trees thrive due to limited rainfall.

This phenomenon is particularly noticeable in the vicinity of Aqaba's northern industrial city. In the harsh deserts of Jordan, areas with cease-flowing groundwater witness a greater variety of vegetation. You can find local acacia, as well as native and invasive trees, flourishing in these regions. It is important to note that despite the arid climate, some plant life manages to sustain itself. However, their presence remains scarce. Interestingly, cannabis cultivation persists in Wadi Rum, even with the limited water resources. Infrequent water flow in the desert gullies results in the formation of reduced soil salt zones. Moreover, the presence of water stratification can be observed through distinct signs exhibited by various vegetation in the area (Karanisa et al., 2021; Bedair et al., 2021). As illustrated in Figure 2 the map highlights major landmarks such as Jabal Rum, Rum Village, and Ad-Disi, along with natural drainage channels and areas projected to be vulnerable to flash floods (dashed lines). The earthy tone reflects the region's desert character, while the topographic shading reveals elevation changes and terrain variations that influence water flow and human settlement. The map provides a succinct spatial overview of the primary geographical features of Wadi Rum. It assists readers in identifying key

landmarks, visualizing the protected area, and comprehending the fundamental hydrological layout (drainage channels) that affects tourism and the risk of flooding. The map represents the approximate boundaries of the Wadi Rum Protected Area (~74,000 ha), which is where most heritage and ecotourism activities take place. Rum Village is the main entry point for tourists and the center of camps and tours. Ad-Disi is a community located north of the reserve that is frequently associated with eco-lodges and farm stays.The famous sandstone massif of Jabal Rum is a popular destination for hikers and climbers. The Jebel Khaz'ali canyon is well-known for its short hikes and Thamudic inscriptions. Drainage Channels (dashed blue lines). To show how water flows off the nearby mountains toward the main valley floor, two schematic wadis are displayed. Following severe storms, these channels show the region's most at risk of flash floods.

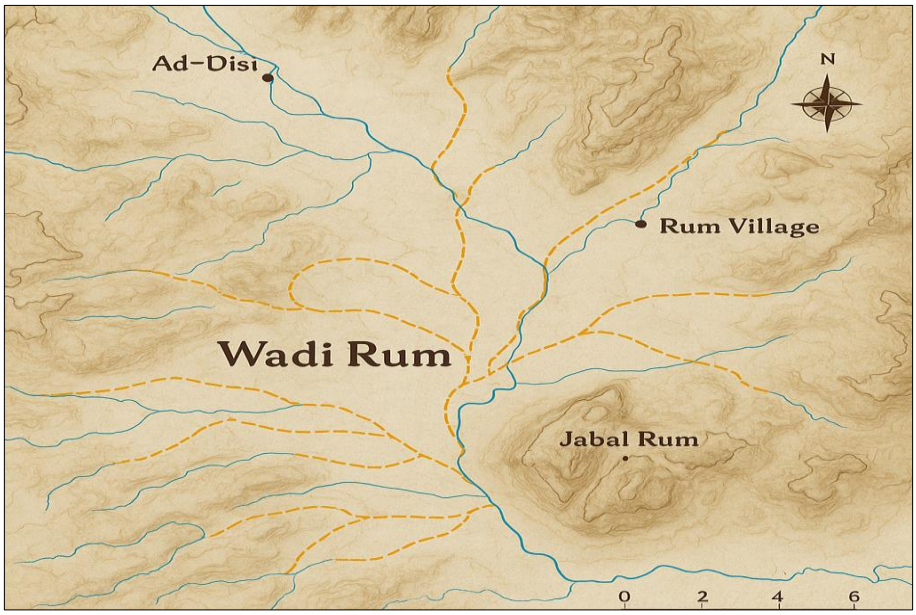

Figure 2. Topographic map of Wadi Rum showing key geographical features and areas sensitive to climate change Area (Source: Authors prepared by the researchers using Global Mapper software)

2. Geographic Background

Wadi Rum southern Jordan, approximately 45 kilometers east of Aqaba, according to longitude (35.4°–35.6°E) and latitude (29.5°–29.65°N) frames. Instead of emphasizing precise topographic relief, the scale of the map is simplified to emphasize relative positions. This section provides a visual reference for the geography, hydrology, and tourism attractions of Wadi Rum. aids in linking areas within the protected area to subsequent analyses (such as infrastructure vulnerability and climate impacts).

3. Tourism Importance

Wadi Rum is a strategically important destination for the tourism industry in Jordan and the broader Middle East. Dominated by inselbergs and surrounded by rugged mountains, the sandstone and granite valleys are dotted with Bedouin encampments, often located near waterholes at the base of towering rock faces offering some of Jordan's most spectacular climbing. There is much more to the protected area than the iconic dunes. Visitors to the area can enjoy a wide range of activities including, but not limited to, panoramic drives on the 'King's Highway, which crosses the reserve, and varied touring in 4x4 vehicles. Several tour operating companies offer services in Wadi Rum. Trekkers and hikers will find an extensive network of footpaths, both easy and challenging, and competent guides are available for those wishing to undertake more ambitious treks. Hiking and climbing trips are often planned in conjunction with overnight stays in the desert at a private tented camp or with Bedouin. The colorful and elegant Nabatean city of Petra is less than an hour's drive away, and most visitors, whether for hiking or other activities, visit both Wadi Rum and Petra during extended visits to Jordan.

Because the protected area is so splendid, so near to the sea, and so easy to get to from the capital and myriad sporting interests in Amman, there has been a sharp increase in the number of visitors in the last half-century (Al Dein, 2022). The pride and excitement the people of Jordan have for Petra is so great that in 1987, an astonishing number of foreign tourists visited Petra. Helped much of the time by air travel, tourism in general has long been one of the fastest-growing service industries in the Mediterranean. In Wadi Rum, the proportion of world travel at present is difficult to gauge. In Jordan as a whole, however, tourism has demonstrated with some clarity the positivist philosophy – the more things change, the more they stay the same. Over the last 20 years, the economic importance of tourism has grown annually by 10%. Wadi Rum is expected to flounder as a tourist destination only if the local or border environment becomes degraded.

METHODOLOGY

Design of the Study

This research adopted a mixed-methods design, integrating quantitative analysis of long-term climatic data with qualitative assessments of stakeholder perspectives. The design aimed to capture both the measurable trends of climate

variability in Wadi Rum (e.g., temperature, rainfall, extreme events) and the contextual insights of tourism stakeholders regarding impacts and adaptation strategies.

Population of the Study

The population of the study included two main groups:

1. Climatic Data Sources – historical weather records (1990–2025) and projections from regional climate models for southern Jordan.
2. Tourism Stakeholders – local community members, tourism operators, policymakers, and visitors whose activities and livelihoods are linked to the Wadi Rum Protected Area.

Sample Size and Sampling Technique

For the climatic data, the study analyzed over three decades (1990–2025) of meteorological records, focusing on temperature, rainfall, flash floods, and heatwave occurrences. For the stakeholder perspectives, a purposive sampling technique was used to identify relevant literature, policy documents, and field evidence representing government bodies, NGOs, and local tourism operators. This ensured that voices most directly engaged with tourism and climate adaptation in Wadi Rum were included.

Instrument for Data Collection

The instruments consisted of:

1. Climatic Indicators: mean annual temperature, rainfall patterns, flash flood frequency, and heatwave occurrences.
2. Document Analysis: official policy papers, adaptation strategies, and tourism vulnerability reports.
3. Secondary Sources: published studies, field reports, and stakeholder testimonies related to tourism in Wadi Rum.

Validity and Reliability

To enhance validity, multiple data sources were triangulated, including meteorological records, published academic studies, and national climate policy documents. Reliability was addressed by using standardized climatic datasets from recognized institutions (e.g., Jordan Meteorological Department, UNDP Climate Risk Profiles) and by cross-checking stakeholder perspectives with official reports and peer-reviewed research.

Method of Data Collection and Analysis

Data were collected in two phases:

1. Quantitative Phase: Long-term climate data (1990–2025) were compiled and analyzed for trends in temperature rise, rainfall variability, and extreme weather events. Graphical tools and projections were used to illustrate these changes.
2. Qualitative Phase: Policy documents, published research, and stakeholder evidence were systematically reviewed to assess tourism vulnerabilities and adaptation measures.

Analysis combined statistical trend interpretation for climate data with thematic analysis for stakeholder perspectives. This approach allowed for synthesizing numerical trends with socio-economic implications, thereby providing a comprehensive understanding of how climate change affects tourism sustainability in Wadi Rum.

CLIMATE CHANGE AND ITS EFFECTS ON WADI RUM

The earthly paradise of Wadi Rum, now nominated as a World Heritage Site and cut off from extensive human exploitation, hosts a wide range of tourist activities. Most activities are guided and carried out in specific areas and coexist without excessive conflicts with functioning nomadic life, which is adapted to solitude, extreme temperatures, and food availability. This work focuses on how climate change might potentially threaten the fragile environment of Wadi Rum, reducing its attraction for a rigid type of tourism. Climate change and drought situations are expected to increase in the future. Climate changes in Wadi Rum have been identified, and there is sufficient evidence of current effects characterized by a sharp increase in temperature since the mid-1980s and a change in rainfall. Temperatures on the planet are expected to rise, linked to the increase in greenhouse gases impeding heat dispersion. Much of the warming occurs in the higher latitudes, indicating modern and future climate change. This can be moderately attributed to the human increase in the concentration of greenhouse gases. The actual warming of the last 100 years has already been shown to be due to human activities. The temperature in southern Jordan is expected to rise from 3 to 4 °C by 2100. Rainfall is expected to decrease in the Mediterranean, the Middle East, South Africa, Central America, and Australia.

In early 2006, a group of experts studying population migration linked to climate changes was warned about the likely risk of a migratory crisis, particularly from regions with high pastures or very dry areas, where arable lands are not sufficiently abundant for production due to desertification. In Jordan, temperatures have increased steadily by 0.75 °C over 50 years. Social and energy issues are resulting in the population moving more and more towards the city, mainly in the south. In the last 30 years, the situation of drought has intensified, resembling the conditions of the 1920s. Jordan, in general, but specifically the village of Wadi Rum, includes various forms of environmental vulnerabilities, especially to variations in climate. In the long term, the survival of the population of Wadi Rum is directly linked to the scarce presence of water. In fact, irrespective of water supply developments, as rainfall diminishes, the area becomes progressively less attractive for traditional agricultural practices. Similar concerns affect the desert fauna, which migratory birds go through. Agencies are directly concerned with desert conservation and the preservation of such ecosystems and are actively working to accomplish it.

Temperature Changes

Temperature Historical weather data from the Park's Ove station Weather Centre indicates that the average annual temperature has been relatively stable during the 20 years from 1980 to 2000, showing a slight decreasing trend from the mean values only in the mid-eighties. A 20-year mean annual temperature in the Park stands at 20.7 °C. Consequently, a 20-year maximum and mean minimum annual temperature for the Park are 27.3 °C and 14.1 °C respectively. However, from 2000 to 2017, the annual temperature average continuously increased, reaching a new high in 2012. The increasing trend is about 1.9 times more than the decreasing one for this period. The 2000 to 2017 20-year trend for the Park is 22.1 °C. This result fluctuated without a clear direction in the 20-year trend analysis, with a higher fluctuation magnitude of 6.8% compared to 3% in the first 20-year period. Impacts of Temperature Increase Generally, temperature increases exert several negative impacts on the environment, with emphasis on the ecosystem, particularly biodiversity. It is likely that increased temperatures will drive the destruction of habitats for many species present in Wadi Rum, decreasing their populations or forcing their local extinction. Temperature increases in Wadi Rum will also impact tourists' comfort and safety. Extreme heat amplitude will also lead to the imposition of restrictions on outdoor activities. Additionally, as the temperature increases, the number of tourists and their duration of stay will most likely decrease. Because of the prevailing low humidity, a temperature of 20 °C to 25 °C in Wadi Rum will still be comfortable for our skin, but the lower threshold is 20 °C, above which discomfort will be perceived. The region of Wadi Rum is projected to experience a continuous rise in annual average temperatures throughout the 21st century. As illustrated in Figure 3, the mean temperature is expected to increase from approximately 22.1°C in 2000 to nearly 27.5°C by the year 2100. A consistent upward trend is expected, increasing climate-related stress on local ecosystems and tourism

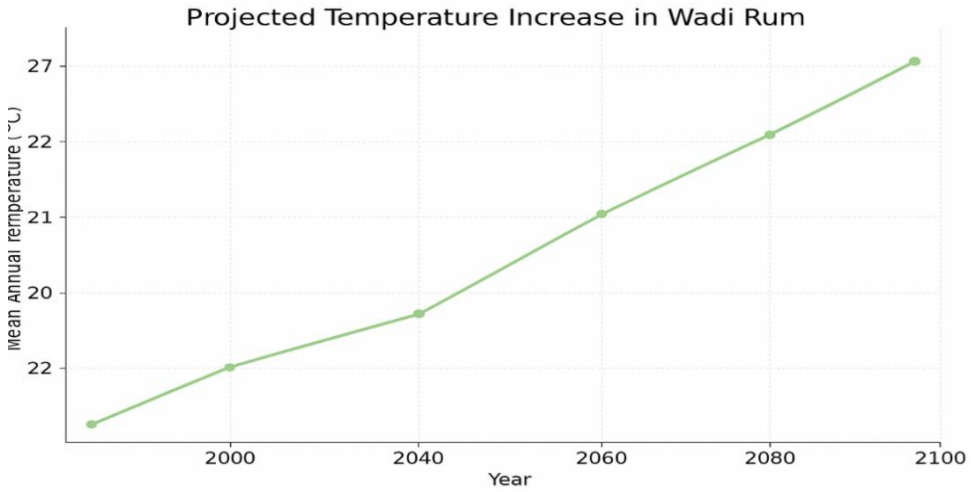

Figure 3. Projected increase in mean annual temperature in Wadi Rum from 2000 to 2100
(Source: Developed by the authors using (i) observed annual temperature from Jordan Meteorological Department (JMD) station records (station name(s), ID(s), coordinates, 1980–2017), and (ii) downscaled CMIP6 projections from NASA NEX-GDDP-CMIP6 (variable tas, scenario(s) SSP2-4.5/SSP5-8.5, extracted at Wadi Rum coordinates and aggregated to annual means, 2000–2100)

Precipitation Patterns

It is well established that rainfall in the semi-desert ecosystems of Wadi Rum is very low and erratic, with the average annual rainfall between 40–80 mm. Moreover, flash floods can be caused by elevated precipitation occurring over relatively short time spans. Over the period, Wadi Rum received an average of approximately 15 mm in relatively intense rain from February to April. A large single seasonal rainfall event may even amount to a third of the annual average, with extremes of up to 15–20 mm in a single rainy day. We studied the impact of these changing precipitation patterns on the Wadi Rum ecosystem, identifying potential disruptions in the food web that might have negative consequences for the Wadi Rum tourist industry. The most easily invertible link in the food web leading to possible disruptions in the ecosystem is the change in freshwater availability for wildlife and wilderness tourists in protected areas. Desert ecosystems are highly vulnerable to shifts in precipitation, and streamflow can affect the tourist infrastructure in Wadi Rum. Shifts in precipitation can cause deserted ecosystems to dry up, resulting in fewer animals and thus reducing the authenticity of the setting. Two main impacts of decreased rainfall were identified: decreased availability of plants and invertebrate food sources for desert herbivores and associated carnivore animals, along with less availability of fresh surface water, reinforcing drought conditions. As a result, the feedback will lead to a decreased abundance and distribution of both wildlife and their associated demographic group of wilderness tourists. High rainfall events, on the other hand, would result in a surge of rapid reproduction of plants and increased freshwater availability to create localized temporary wetlands in the valleys (Jawabreh & Fahmawee, 2024; Müller, 2025; Coles et al., 2025; Gössling et al., 2022; Koskei & Glyptou, 2025; Al Fahmawee & Jawabreh, 2022b). This may reinforce the flooding impact but also resonate with the cultural value system, bringing additional improvement to local livelihoods. It appears that for a full impact study of the rapid change on the eco-cultural resilience system in Wadi Rum, further research conducted under current and potential climate scenarios is needed to alleviate the adaptive changes in service systems in Wadi Rum and the needs or choices among small niche markets.

Overall, the cultural and eco-cultural impact of floods on local tourism is locally dependent on land ownership and could possibly provide synergies in the alleviation of disruptions in cultural ecosystem services. Providing protection against heavy rainfall and potential flooding is a critical nature-based solution. Ecological management of such an intervention must also take into account dramatic changes in human behavior during flash flooding activities or rain stoppage in the valleys to ensure no social carryover occurs. A better understanding of the unexploited open niches, such as storm adventurers, might help Wadi Rum specialize and improve its infrastructure to offer sustainable high-end tourism (Al Dein, 2021). The impact is currently unknown and thus increasingly essential. Wadi Rum may shift the tourist demographics of who visits, as well as the choice of activities, more than attracting the developing niche segment markets that seek exclusive authentic destinations. Identifying these forms of adaptive storm eco-tourism is necessary to replicate this impact study to explore alternative outputs for Wadi Rum storm adaptive tourism products.

Extreme Weather Events

Wadi Rum is located in a low rainfall region of the desert of Jordan, which gives it a unique ecosystem. The climate data collected over the years show that the region is undergoing constant changes. Besides the changes in temperatures, rainfall patterns and frequency of events have been documented as well. Generally, it is estimated that changes under climate change will be stronger in the future. Changes in the climate have a direct link with visitor safety and recreation. The effects of climate change are being experienced at the local level at Wadi Rum and are mainly manifest through extreme weather events. Introduction: Climate change leads to changing weather patterns. One outcome of such changes is the increase in the intensity and frequency of extreme weather events. Examples can be given in the form of severe dust storms, extreme heat waves, the increase in erratic flash flooding, and heavy thunderstorms. Such weather events are an example of hazardous weather to tourism. Disruptive weather patterns tend to affect a tourist's schedule, reducing their satisfaction and increasing the potential safety hazards. The section will evaluate the consequences of these extreme weather events on the natural system and the infrastructure. Weather damage attempting to financialize the consequences of the weather will also be evaluated. Several case studies will be employed to support this data. The section will conclude that more environmental, historical, and case study research is needed to increase the understanding of such events.

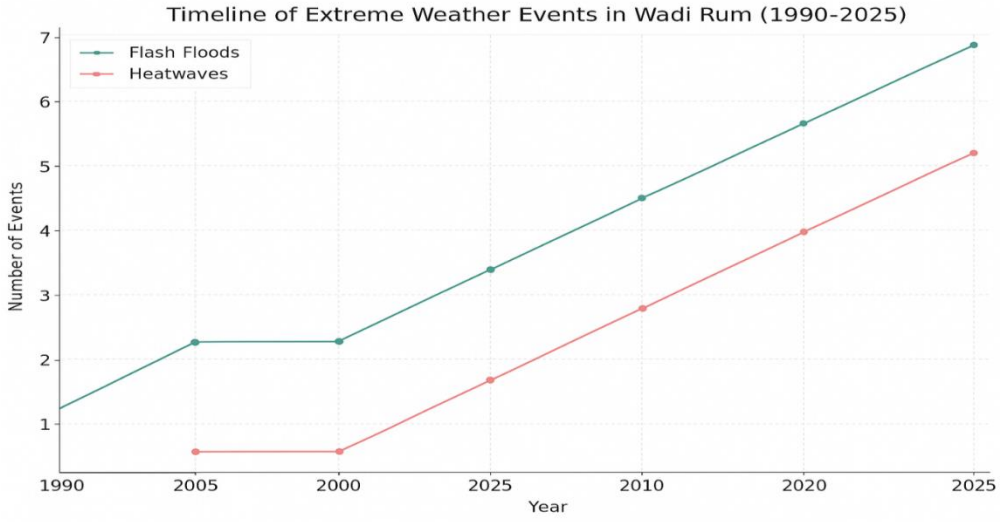

Figure 4. Timeline of Extreme Weather Events in Wadi Rum (1990–2025) (Source: Developed by the author based on climate studies, including flood event reports and heatwave data trends for southern Jordan between 1990 and 2025. The timeline reflects aggregated insights from national meteorological bulletins and projections from regional climate models. References: Jordan Meteorological Department reports; UNDP Climate Risk Profiles for Jordan.)

Figure 4 t illustrates the increasing frequency of flash floods and heatwaves in the Wadi Rum region over the past three decades. The upward trends reflect intensifying climate instability, with flash flood events rising from 1 in 1990 to 7 in 2025, and heatwaves increasing from none to 6 in the same period.

IMPACTS ON TOURISM SECTOR

In addition to climate impacts directly affecting natural wonders, they are anticipated to have several other repercussions within the tourism sector. Given the importance and revenue generation of Wadi Rum's two main offerings - desert safaris and adventure/eco-lodges - they are the points of primary vulnerability. It is likely that a changing climate in turn, will change the patterns of those visiting. Adventure and eco-tourists might be more sensitive to climate and weather changes than standard ratios or international tourists.

In the desert specifically, where investments can be destroyed overnight by just one storm, even though locals can pinpoint global climatic changes as less rainfall, more snow on the mountains, and increasing temperature and humidity during the summer, a short-term drought in northwest Jordan following an already long period of climatic adjustment challenges has already been imposed. At present, local stakeholders supported, turning away only 8% of visitors because of

the weather. Where shifting patterns might start to change, at baseline without climate change, travel preferences such as climate are already affected by larger averages; these could turn into significant issues. Results from worldwide computer models and the Middle East have shown that inland and seasonal tourism destinations, in general, suffer from reduced tourist volumes - such as those seen in Wadi Rum during the spring and fall (Jawabreh et al., 2024). Because eco-tourism is the growing edge of the vast tourism market and the Gulf state markets and trekking routes into the desert outside of the protected area have only been in recent development, and as some have investments lower in the valley, as opposed to the 'crumbled' mountains, the effects are anticipated to be more severe in Wadi Rum than for typical scenarios. These might not be realized as a result of a direct impact on the visitor count. However, climate change in the long run, increasing proportionally with the expected climate shift, would raise economic losses for the area. In order to maintain the earth's valuable scenic beauties for both current and future generations, the sustainability of natural and cultural resources is an inherent concern. Protecting the natural environment and that which sustains the primary product of the 'desert experience' is important for the desert's image and sustainable development, since current tourist satisfaction is associated with the health of the natural environment. Upland ecosystems comprising steep rocky wadis and desert sectors are required to actively monitor research on climate impacts on ecosystems and local livelihoods, and the activities of local communities and government associated with mitigating global climate change in the area. It is suggested that serious vulnerability studies like this one must be given to international scientists studying this subject so that they might start to help the public develop appropriate adaptation strategies and start to function in the tourism sector.

Wadi Rum has seen varied progress in implementing climate adaptation strategies. Figure 5 displays the implementation levels of various adaptation strategies. High implementation areas include renewable energy use and community engagement, while infrastructure and transport adaptation remain modest. While this vulnerability study is fine to inform the Ministry of Tourism and its development programs and plans, what really needs to be done is to directly involve the local stakeholders who live and breathe the matter of such an area. Only they know how to realistically include on-the-ground issues necessary for long-term adaptation, instead of getting scientists to analyze estimated world-wrecking data. Climate change presents multiple risks to tourism in Wadi Rum. As shown in Figure 6, the highest impact is associated with visitor comfort and flash flood risks, followed by reduced tourist numbers and economic consequences.

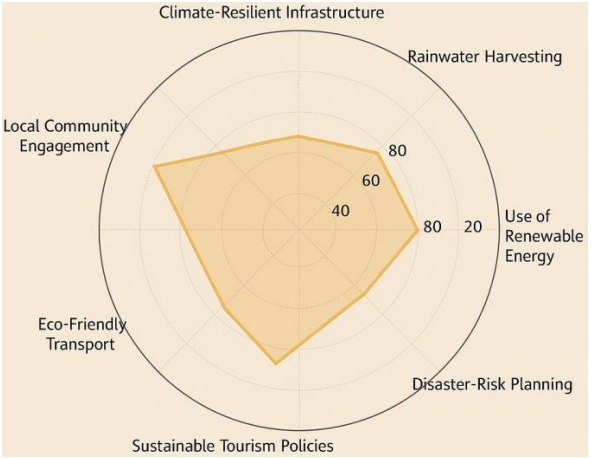

Figure 5. Level of implementation for climate adaptation strategies in Wadi Rum. *(*Source: Author's synthesis based on national climate policy documents and local adaptation efforts in Wadi Rum (e.g., Jordan Climate Change Policy 2022–2050)

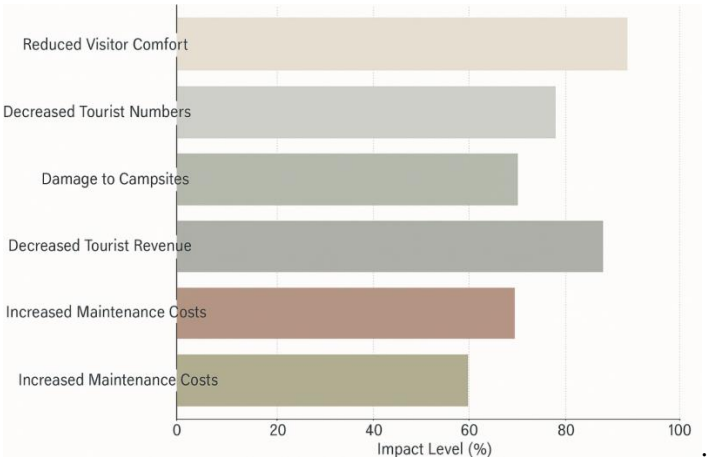

Figure 6. Key perceived impacts of climate change on the tourism sector in Wadi Rum (Source: Prepared by the authors based on analysis of relevant climate policies, published sectoral studies, and tourism vulnerability assessments in Wadi Rum)

Changes in Visitor Patterns

Climate change is projected to influence visitor patterns in Wadi Rum. Insights about historical data at Petra indicate differences in events over time with regard to incoming visitors and changing tourist behaviors, not least visiting before or after the summer season to avoid heat. Similar up-to-date statistics that are available for Wadi Rum, however, are not available. Anecdotal evidence gathered in March 2019 during conversations with local tourist guides indicates a trend of change among visitors in Wadi Rum. One of the guides claims that there was no problem with tourists and these days are completely empty. The villages of Disi and Abu Khashbah, connected to the park, are increasingly profiting from the possibilities of residence tourism in Wadi Rum as they spotlight the chance to stay longer (Jawabreh et al., 2021; Jawabreh et al., 2023). While it might still be feasible to develop sustainable tourist accommodation strategies to cater to tourists with a strong personal interest in Wadi Rum and its contrasting shock landscape to counterbalance climate change impacts, such a version needs to reconsider the draw factors of the site and will call for additional studies to understand the trade-offs involved in managing tourism in such a place. Again, a thorough visitor survey, which touches upon changing visitor behavior aspects due to ongoing climate change and explains implications on visitor management, is needed to better figure out the potential clients of Wadi Rum in the future. It is suggested that different target groups, including, for instance, people interested in outdoor activities or birdwatching, should be approached. Tourist-grade data can provide entrepreneurs with an idea of which activities are expected to attract more and fewer participants given predicted changes in climatic suitability.

This dual-axis chart in Figure 7 shows the correlation between average monthly temperatures and tourist arrivals. Visitor numbers peak in spring (March–April) and autumn (October), when temperatures are moderate. During the peak summer months (June–August), tourist numbers decline significantly as temperatures rise above 35°C.

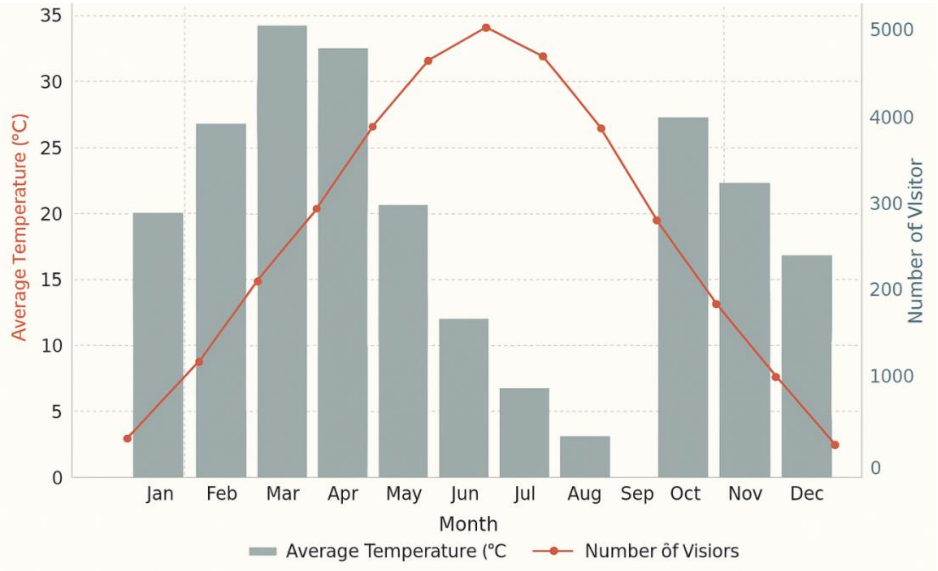

Figure 7. Impact of Monthly Temperature on Visitor Patterns in Wadi Rum (Source: Author's visualization integrating (i) monthly Wadi Rum visitor counts from Jordan Ministry of Tourism & Antiquities (MoTA), "Monthly Number of Visitors to Wadi Rum by Nationality, 2023–2024" (Excel series), and (ii) monthly mean 2-m air temperature from ERA5-Land monthly averaged data (Copernicus Climate Data Store; DOI referenced in ERA5-Land documentation)

Infrastructure Vulnerability

The tourism infrastructure in Wadi Rum is similarly vulnerable to climate change as tourist activity. The most critical components include lodging at the many desert camps, transportation networks, and recreational facilities like the homestay and the interpretation center. Inclusion of accessibility for all visitors has driven the construction of the asphalt main gate arrivals road. The physical presence of the tourism industry in Wadi Rum demonstrates its deep integration with the local environment. The wadi and several tourist camps are in the natural course of flash floods. A major flood could shut down the tourist attractions, reaching the level of tourist lodging, damaging land use resources, and potentially the support infrastructure; potentially resulting in a loss of life, threatening the sustainability of the tourism industry in Wadi Rum.

Extreme precipitation in Wadi Rum results in flash floods with peak discharges of between 300 to 1400 m³/sec. An intense thunderstorm released 10.8 mm of precipitation in 23 minutes into a dry wadi channel, generating flash flooding with peak discharges of 26 to 40 m³/sec that closed the wadi route to tourists between Rum village and the Desert Highway. An event of magnitude equivalent to the September event occurring in a 20-year period centered on 2010 could close the services route for between 840 and 1260 days, equivalent to a loss of business of between USD 4.6 and 7.0 million. Trends in international tourism suggest that the business will have to reduce in the face of declining visitation availability. The livability and care of cultural places based on economic well-being as just an asset to Wadi Rum is not addressed by the study. Resilience can be built into tourism infrastructure, including transportation networks, through strategic planning depending on recent regional forecasts for Northern Arabia and the Levantine Mediterranean basins. The potential vulnerabilities of the wadi's rare flooding attractions and transportation networks have not yet been examined. Constructions such as lodges and parking facilities are currently permitted to be built much too close to visit areas to be sustainable. Cultural heritage valued by all stakeholders is not being protected nor harvested in the wadi in any way. Strategic planning for appropriate adaptability to long-term threats of utility-based hazards of climate change specifically, and sustainable tourism linking incentives in general, requires a multi-stakeholder model to reduce the threats to all stakeholders. The tourism economy in Wadi Rum faces financial challenges due to climate risks.

Figure 8 shows that flood-related damage and reduced visitor spending account for the largest projected losses.

Economic Consequences

The reduction in visitor numbers projected because of climatic extremes is reducing the appeal of specific attractions and the potential knock-on effect of waning general interest in desert-based travel and adventure tourism. The result of this would be decreased district revenues. Local people and businesses rely on visitor-generated income. A drop-off in tourism earnings of up to 23 percent is estimated if there is a loss of investor interest due to weather-related attractions. Financial stress on an already disadvantaged community with limited potential for economic diversification and reliance on informal income from tourism and visitor-related activities is significant. The lack of cash not only places initial limitations on the ability of the community to repair infrastructure and attract new investors but also has longer-term implications (Majewski et al., 2025). It raises the question of whether such a significant initial investment is financially sustainable when the payback period before any return on the investment is possible would be so protracted.

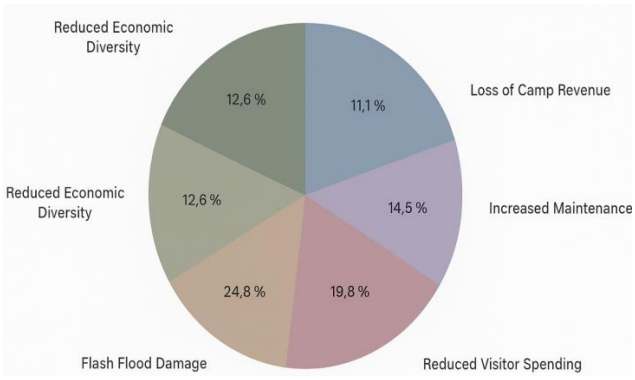

Figure 8. Estimated distribution of economic losses in Wadi Rum caused by climate change impacts (Source: Author's analysis integrating (i) exposure layers for camps, visitor facilities, and access routes from WRPA/UNESCO monitoring baseline (2024) and digitized road/track network from OpenStreetMap (ODbL 1.0); (ii) terrain-derived flow accumulation and flood-prone corridors from SRTM 30m DEM (USGS/NASA); (iii) climate/hazard context from ERA5-Land precipitation/temperature series (Copernicus CDS; DOI per ERA5-Land documentation); and (iv) business interruption estimates based on MoTA monthly Wadi Rum visitor counts (2023–2024) and expenditure proxies from MoTA tourism reviews / TSA-referenced spend estimates)

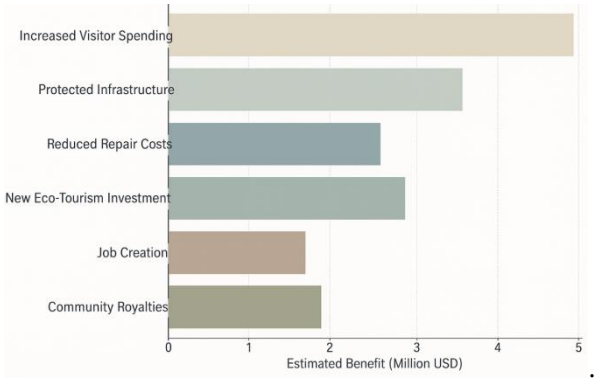

Figure 9. Projected economic benefits of implementing climate adaptation measures in Wadi Rum (Source: Author's cost–benefit analysis integrating (i) monthly Wadi Rum visitor counts from MoTA (2023–2024); (ii) tourism receipts and revenue trend context from MoTA Tourism Annual Review 2024 and CBJ tourism revenue statistics; (iii) expenditure-to-impact relationships (spend, value-added and employment linkages) informed by Jordan Tourism Satellite Account (TSA 2016) and DoS visitor survey methodology; (iv) climate exposure baselines (temperature/precipitation extremes) from ERA5-Land (Copernicus CDS); (v) adaptation measure portfolio and investment rationale aligned with Jordan Climate Change Policy 2022–2050, Jordan NAP, Jordan Updated NDC, Tourism Sector Green Growth National Action Plan)

Increases in damage costs as infrastructure becomes more aged due to increasing climatic extremes require remediation. Of relevance in destinations where tourists are likely to drive their own vehicles is the cost of recovering stranded vehicles, costs that are usually expensive and time-consuming (Kanu & Przezbórska-Skobiej, 2025). However, what is not quantified is the potential long-term tourism revenue loss resulting from adverse media coverage of a tourism disaster scenario. In destinations with a marketing emphasis on adventure and activities, this potential to heighten risk perception among relaxation tourists visiting the area is worthy of attention. Long-term sustainability of climate-resilient investments in the precinct is a valid point. A community rating framework for pro-community tourism operators suggests such actions also have the potential to deliver cost offset benefits in downturns in the general economy. The community is reliant on the revenues generated by tourism. It is pertinent that a focus on climate change and resilience may draw investment funds, but these investments still need to deliver the economic benefits of stimulating further investment through tourism business expansion and new business entrants to the area. Such investments need to fit into a tourism precinct economic development plan that considers existing and potential new business mix and target markets.

Implementing climate adaptation strategies can lead to substantial economic gains. As highlighted in Figure 9, these benefits include increased visitor spending, investment security, job creation, and local royalties.

RESULT

National Nature Reserves Wadi Rum's unique landscapes and diverse attractions have the potential to protect ecosystems, local communities, and the tourism sector from the effects of climate change. Expanding research and investment in this tourism area could contribute to sustaining life in Wadi Rum. 1. Adaptation and Mitigation Strategies To address these changes and their potential impacts, different adaptations and mitigations are required, particularly in the tourism sector. Economic and technological innovations are crucial, as safe climate-soft tourism is being introduced. These are the primary methods designed to protect the prosperous tourist destination from the effects of global warming. Moreover, these solutions will protect tourist areas, local life and habitats, as well as the earnings and livelihoods of local inhabitants. Local and national levels can employ these solutions, with appropriate tailoring of policies and actions. 2. Climate policy and instructions Drawing up and specifying the rules is a successful tool for reducing GHG emissions from the region while also reducing cumulative impacts resulting from long periods. 3. Community Power Policies Assisting, encouraging, and involving neighboring communities are critical for community-expanding efforts. 4. Techniques The use of renewable energy is beneficial to the whole world. There is a substantial reduction in GHG-related items and air contamination. 5. Tailor-made policies for tourism. Using suitable tourism sector policies. We can pursue tailored policies in the tourism industry and focus on specific cases. Tourists, neighboring communities, and organizations may receive best practices for preventing climate impact in destinations similar to Wadi Rum. This practical application could establish sustainability as a key marketing perspective. Community awareness of climate impacts on the essence of Wadi Rum is also affected by technological changes and other climate change adaptation methods. We are studying how to draw attention to and involve the community in regional work, devise a practical method to complete the task, and maintain close communication with neighboring communities. It is also crucial to incorporate best practices and case studies of relevant solutions from other peri-arid zones as a source of guidance and indicative methods. To achieve a complete outcome in tourism destinations like Wadi Rum, adaptation requires numerous measures, such as reducing the scale of effects, enabling quick rehabilitation, engaging the population in practical decision-making, and limiting potential damage. 6. Multi-Faceted Strategy We are addressing the expected effects of climate change on

tourism in Wadi Rum and devising a multifaceted strategy to ensure the tourism industry and the four national nature reserves can withstand current and future challenges. Tourist areas, which utilize distinctive desert landscapes for their unique values and attractiveness, have been recognized as UNESCO World Heritage sites due to these values and qualifications. Researchers consider this location to be among the top ten tourist wonders in the world. The analysis also scrutinizes several crucial preservation sites and practical ecological regions in the area, in addition to other natural assets that hold significant value within the global ecosystems and natural diversity. The aim of this approach is to build a tourism model or provide a spatial diversity of tourism that could act as essential destinations if the world's tourist industry is damaged because of climate change.

Tourism is part of the adaptation solution in Wadi Rum. Integrating climate considerations will help improve resilience in the long term. The plan to integrate tourism with local development plans is important. The development of the Wadi Rum Fund is also a key priority to ensure that the resources received from tourism filter back to the community through distributed royalties. A policy framework, in terms of promoting sustainable tourism and instilling an ethic of stewardship among the tourism operators, will ensure that environmental conservation remains in the future. This means achieving a working agreement between the stakeholders, including government departments, local people, and private business owners, to ensure a cohesive response to climate impacts for the whole of the tourism industry, including accommodation and attractions. The relevant bodies should monitor climate adaptation and update and adjust policies accordingly. Participation and access to relevant information are essential in all of these activities.

The relevant authorities should establish a long-term regional policy planning process that involves local people, businesses, the tourism industry, and the government at Wadi Rum. This process should include the review and updating of local development plans, as well as the incorporation of the Wadi Rum policy into the future strategy for the development of tourism and related activities. The purpose of the long-term plan is to provide Wadi Rum local people and businesses with a structure within which they can develop environmentally and socially responsible economic activities.

A bottom-up approach is a better practice to address climate change adaptation in the tourism industry. Active community engagement is essential for the Wadi Rum tourism industry when it comes to planning for any climate change adaptation. The communities in Wadi Rum have an in-depth understanding of their environment and can provide valuable input for decision-making. This will increase their awareness and their commitment to looking for sustainable practices that will enhance their knowledge and experience in their daily work. Local residents may also participate in existing meetings that major stakeholders hold for Wadi Rum in order to foster partnerships and enable a structured and fruitful exchange of ideas.

It is crucial to educate the local Wadi Rum people about the potential impacts of climate change on the rangelands and the tourism trade, enabling them to prepare for the impending effects. Residents of Wadi Rum and Shabeh should possess a comprehensive understanding of the local, national, and global climate change landscape and their expectations. Drawing on current perceptions can define the structure of public participation in possible tourism strategies and develop channels of communication between all the stakeholders. Therefore, we must promptly take action to equip residents, Wadi Rum businesses, and the broader Wadi Rum community and social fabric for sustainable tourism, which may incorporate climate change. One way to achieve this goal is to mount awareness campaigns that inform the public with guidance on sustainable tourist behavior. Additionally, these campaigns can focus on specific conservation issues, like energy efficiency, and operate within the boundaries of the protected area. Investing in the capacity building of future partners for any sustainable project in the area is crucial (De León et al., 2025). Today, the tourism industry is designing several fundamental technological solutions for mitigating the impacts of climate change with a focus on sustainable operation. The integration of renewable energy technologies such as wind or solar power can ensure an uninterrupted power supply and contribute to climate neutrality. All new camps constructed over the past few years have installed water conservation systems. Rainwater harvesting is crucial in a hot desert climate and aids the new hospitality infrastructure in becoming drought resistant. All running water systems installed in new camps have water efficiency measures. Several new camps use sanitation technology like dry toilets to reduce water consumption (Zhu, 2025; Light et al., 2025). Vehicle manufacturers continuously reinvent their transport products. Solar-powered cars are already available on the market today. Therefore, using such vehicle technology for tourism can enhance the visitor experience and environmental impact.

Technological advances have led to rapid innovations and cost decreases, increasing the competitiveness of such systems (MacAskill & Becken, 2025). This paper introduces the technological solutions currently available and their benefits and challenges. Developing and using new technologies are important for adaptation to climate change. The technological solutions discussed include renewable energy harnessing, water conservation, water desalination, waste recycling, eco-efficient transportation and accommodation facilities, and communications. This solution not only constitutes an opportunity to reduce energy, water, and waste but also reduces the greenhouse gas impact. Innovative technologies will improve building energy performance, vehicle fuel efficiency, zero CO2 emissions in the case of electric vehicles, and green waste management. Measuring an environmental resilience index and establishing long-term environmental and visitor monitoring programs closely relate to adapting to climate change and implementing sustainable technological solutions. Partnerships with technology companies and research institutes will be a key ingredient for innovation and technology transfer. To facilitate a rigorous analysis of implementation best practices, we propose a set of critical questions, supported by empirical evidence from field projects within Mediterranean agricultural systems and the Egypt-Aqaba region, categorized under the themes of "Best Practice" and "Effectiveness of Adaptation." Furthermore, this study draws upon illustrative case studies that focus on the agricultural framework within the Mediterranean basin and the water resource management strategies implemented along the Aqaba coastline.This section's methods and results provide general background information on the techniques used in the case studies, the activities carried out, and the resulting outcomes, including their success or failure. The variables encompass the outcome of the adaptation and the critical factors that influenced its transferability. Studies, quality results frameworks, and

case study frameworks all provide valuable lessons. We build Best Practice on the expertise of similar, smaller-scale projects, utilizing community involvement and a set of practical, demonstrable pilots to showcase ideas. Integration across a wide range of stakeholders is based on the feedback loop of observation, information exchange, engagement, and learning offered by the integrated interpretation of the natural sciences, social sciences, arts, and communication chain.

Best Practice demonstrates learning by doing and adaptive management. It also requires participatory approaches and local stakeholder collaboration to facilitate the adaptive process of management reform. The evaluation framework contextualizes effectiveness in relation to the needs and ambitions for conservation, education, dissemination of research, and socio-economic regeneration. The designed framework should consequently be adapted according to the selection of target sites chosen based on ideal diversification in criteria relevant to the socio-political or economic positioning of tourist destinations.

CONCLUSION

The findings suggest that, while Wadi Rum remains a unique landscape in southern Jordan, the experiences provided by the site are highly commodified and unauthentic due to the pressures and impacts of mass tourism and environmental degradation. Consequently, the long-term sustainability of Wadi Rum's tourism is linked to the maintenance of a healthy and attractive desert ecosystem. Prior to considering any future outlook for tourism in Wadi Rum, the related case studies serve to demonstrate the interconnectedness between environmental health and long-term tourism sustainability. Nature, landscapes, and outdoor adventure are both products of tourism and necessary prerequisites for the development of the tourism industry. Thus, the protection and maintenance of natural and cultural resources inside the protected areas is of vital importance if future tourism potential is not to be compromised because of environmental degradation. This recommendation is even more critical as global stressors impact the rate and intensity of Wadi Rum's climate change.

Our proposed policy responses for climate adaptation and management are necessary to ensure mitigation of negative impacts and maximization of the positive opportunities. Climate change research in tourism has not, by and large, been longitudinal, focusing on forecasting changed climate impacts on tourism enterprises. In order to establish the precedent of global climates on Wadi Rum, there is an important need for exploratory research and longitudinal monitoring of climate in Wadi Rum across two or three decades, at least to understand ranges of variations and trends. The data demonstrates the emergent vulnerabilities and adaptations that result when a sedentary population experiences climate change. These impacts vary from dependency on internal and external income sources, the use of indigenous or modern architecture, the location of the human habitat, and tourism strategies. In conclusion, interpretive explanations of culture, environment, and development, using sustainable tourism and adaptive resilience frameworks, must be utilized for a complete understanding of these systems and environments. Upper Wadi Rum is becoming a global environment, paramount in necessity for being socially, culturally, and ecologically conserved. For this to occur, the interpretation of climate change and pathways to sustainability must achieve a higher profile, particularly among government and tourism stakeholders. Strategies of adaptation and resilience require multi-party involvement. Tackling our current systems of care and development, risking conflict and chaos, may unleash the creation of new life and social and natural environments, habitat-worthy of human life and tourism development.

Author Contributions: Conceptualization, O.J and E.F; methodology, O.J. and R.A.; software, R.A. and O.J.; validation, S.A. and E.A.; formal analysis, S.A. and A. J; investigation, A.J. and O.J.; data curation E.A. and O.J; writing - original draft preparation, O.J. and E.A.; writing - review and editing, S.A. and A.J; visualization, S.M and A.J.; supervision, O.J.; project administration, O.J. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study may be obtained on request from the corresponding author.

Acknowledgements: The research undertaken was made possible by the equal scientific involvement of all the authors concerned.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Al Dein, H. A. F. E. (2021). GIS methodological approach to developing and forming a visual image of downtown Amman. *Architecture and Engineering*, 6(3), 49-61. https://doi.org/10.23968/2500-0055-2021-6-3-49-61

Al Dein, H. A. F. E. (2022). Semiotics as an approach to the analysis of symbolism in Islamic architectural arts. *Architecture and Engineering*, 7(2), 3-19. https://doi.org/10.23968/2500-0055-2022-7-2-03-19

Al Fahmawee, A., & Jawabreh, O. (2022a). Adaptive reuse of old structures into heritage hotel buildings: A post-occupancy evaluation in Jordon. Amman, *ISVS e-journal*, 9(5), 16-32.

Al Fahmawee, E., & Jawabreh, O. (2022b). Narrative Architectural Interior Design as A New Trend to Enhance the Occupancy Rate of Low-Class Heritage Hotels, *New Design Ideas* 6, (2,), 207-228.

Al Fahmawee, E. A. D., & Jawabreh, O. (2023). Sustainability of green tourism by international tourists and its impact on green environmental achievement: Petra heritage, Jordan. *GeoJournal of Tourism and Geosites*, 46(1), 27-36. https://doi.org/10.30892/gtg.46103-997

Arabeyyat, A. R., & Aldweik, R. (2024). A comprehensive exploration of the Jordan Tourism Board's 2023 Strategic Planning, news, and social media. *Emirati Journal of Business Economics & Social Studies*, 3(1). https://doi.org/10.54878/79sfh467

Badran, A., Abu-Khafajah, S., & Elliott, S. (2022). Community heritage in the Arab region. *In One world archaeology*. https://doi.org/10.1007/978-3-031-07446-2

Bedair, R., Ibrahim, A. A., Alyamani, A. A., Aloufi, S., & Ramadan, S. (2021). Impacts of Anthropogenic Disturbance on Vegetation Dynamics: A Case Study of Wadi Hagul, Eastern Desert, Egypt. *Plants*, 10(9), 1906. https://doi.org/10.3390/plants10091906

Coles, T., Jones, K., Curry, R., & Frater, C. (2025). Weather, climate and the administration of the visitor business at heritage properties. *Journal of Heritage Tourism*, 20(4), 603–620. https://doi.org/10.1080/1743873x.2025.2495021

De León, C. G. R., Clavé, S. A., Sanz-Ibáñez, C., & Arce, A. Z. (2025). Agency and coevolutionary path development in tourism destinations. *Tourism Geographies*, 1–28. https://doi.org/10.1080/14616688.2025.2519327

Hall, C. M. (2015). Heritage, heritage tourism and climate change. *Journal of Heritage Tourism*, 11(1), 1–9. https://doi.org/10.1080/1743873x.2015.1082576

Gössling, S., Humpe, A., & Sun, Y. (2023). On track to net-zero? Large tourism enterprises and climate change. *Tourism Management*, 100, 104842. https://doi.org/10.1016/j.tourman.2023.104842

Gössling, S., Balas, M., Mayer, M., & Sun, Y. (2022). A review of tourism and climate change mitigation: The scales, scopes, stakeholders and strategies of carbon management. *Tourism Management*, 95, 104681. https://doi.org/10.1016/j.tourman.2022.104681

Groom, K. M., Bevan, G., Al-Noaimat, S., Al-Zalabiah, M., & Allen, C. D. (2022). Community engagement in geologic assessments of Thamudic inscriptions and petroglyphs in the Wadi Rum Protected Area, Jordan. In Routledge eBooks 302–316. https://doi.org/10.4324/9780429355349-20

Jawabreh, O., Fahmawee, E. A. D. A., Jahmani, A., Qaddhat, R., Alqader, S. A., & Saleh, M. (2025a). Ecosystem restoration as a nature-based solution: A case study of Wadi Rum. *Geojournal of Tourism and Geosites*, 61(3), 1430–1442. https://doi.org/10.30892/gtg.61303-1513

Jawabreh, O. (2020). Innovation management in hotels industry in Aqaba Special Economic Zone authority; hotel classification and administration as a moderator. *GeoJournal of Tourism and Geosites*, 32(4), 1362–1369. https://doi.org/10.30892/gtg.32425-581

Jawabreh, O., & Fahmawee, E. A. D. A. (2024). Architecture, authenticity and the construction of memorable tourists experiences. *New Design Ideas*, 8(1), 33–49. https://doi.org/10.62476/ndi.8133

Jawabreh, O., Abdelrazaq, H., & Jahmani, A. (2021). Business sustainability practice and operational management in hotel industry in Aqaba Special Authority Economic Zone Authority (ASEZA). *GeoJournal of Tourism and Geosites*, 38(4), 1089–1097. https://doi.org/10.30892/gtg.38414-748

Jawabreh, O., Fahmawee, E. A. D. A., Jahmani, A., Ali, B. J. A., & Jahameh, S. S. (2023). A comprehensive analysis of coastal and marine tourism: evaluating the impact of activities, intentions, and reason for visiting on visitor satisfaction: the moderating influence of visitor types.*GeoJournal of Tourism and Geosites*, 50(4), 1339–1349. https://doi.org/10.30892/gtg.50414-1132

Jawabreh, O., Fahmawee, E. A. D. A., Masa'deh, R., & Abdelrazaq, H. (2024). Service quality and organizational excellence and their relationships with the Wadi Rum Protected Area employees' job satisfaction. *GeoJournal of Tourism and Geosites*, 53(2), 599–610. https://doi.org/10.30892/gtg.53223-1235

Jawabreh, O., Fahmawee, E. A. D. A., Al-Ansari, R. W., Mahmoud, R., & Nassar, U. A. (2025b). Geomorphological Structure of Landform Characteristics As a Reference for Development Recommendations in Wadi Rum Protected Area. *GeoJournal of Tourism and Geosites*, 58(1), 433–445. https://doi.org/10.30892/gtg.58140-1425

Kanu, I. M., & Przezbórska-Skobiej, L. (2025). Socio-Economic Determinants of Climate-Smart Agriculture Adoption: A Novel Perspective from Agritourism Farmers in Nigeria. *Sustainability*, 17(12), 5521. https://doi.org/10.3390/su17125521

Karanisa, T., Amato, A., Richer, R., Majid, S. A., Skelhorn, C., & Sayadi, S. (2021). Agricultural production in Qatar's hot arid climate. *Sustainability*, 13(7), 4059. https://doi.org/10.3390/su13074059

Khater, M., Al-Leheabi, S. M. Z. M., & Faik, M. (2024). Navigating the challenges of over-tourism: comparative insights and solutions from Petra and Karnak. *Journal of Heritage Tourism*, 1–32. https://doi.org/10.1080/1743873x.2024.2426457

Koskei, A., & Glyptou, K. (2025). The multiple land use dilemmas of the Ngorongoro Biosphere Reserve. Tourism Geographies, 1–22. https://doi.org/10.1080/14616688.2025.2500965

Light, D., Creţan, R., Chapman, A., Dragan, A., & Arba-Harambaşa, F. Y. (2025). Trigger events, moments, and destination evolution in a post-socialist context. *Tourism Geographies*, 1–20. https://doi.org/10.1080/14616688.2025.2481886

MacAskill, S., & Becken, S. (2025). Geographies of hotel guest electricity, water and gas consumption. *Tourism Geographies*, 1–22. https://doi.org/10.1080/14616688.2025.2516098

Majewski, L., Bittlingmaier, S., Frieser, A., Woltering, M., & Job, H. (2025). Evaluating the economic impact of tourism in Germany's Biosphere Reserves. *Tourism Geographies*, 1–21. https://doi.org/10.1080/14616688.2025.2536120

Michopoulou, E., Al-Qasmi, I., & Melpignano, C. (2021). Co-creating value in desert tourism experiences. *Tourism Planning & Development*, 18(2), 245–265. https://doi.org/10.1080/21568316.2021.1873835

Migoń, P. (2024). Geosites and Climate Change—A Review and Conceptual Framework. *Geosciences*, 14(6), 153. https://doi.org/10.3390/geosciences14060153

Moayedfar, S. (2021). Sustainable Tourism Development in Historic Cities of Arid Regions with the Revival of Qanat (Yazd City). *GeoJournal of Tourism and Geosites*, 35(2), 428–436. https://doi.org/10.30892/gtg.35222-669

Müller, D. K. (2025). Polar tourism and the changing geographies of the Arctic and the Antarctic regions. *Tourism Geographies*, 1–9. https://doi.org/10.1080/14616688.2025.2462777

Peeters, P., Çakmak, E., & Guiver, J. (2023). Current issues in tourism: Mitigating climate change in sustainable tourism research. *Tourism Management*, 100, 104820. https://doi.org/10.1016/j.tourman.2023.104820

Spector, S., & Higham, J. (2025). Space tourism and sustainable trajectory. *Tourism Geographies*, 1–19. https://doi.org/10.1080/14616688.2025.2525815

St Leger, L. (2025). When the street talks: understanding the impact of climate change on heritage tourism and sense of place in Wales. *Journal of Heritage Tourism*, 1–17. https://doi.org/10.1080/1743873x.2025.2552687

Wolniewicz, P., & Górska-Zabielska, M. (2025). Palaeoclimatic Geoheritage in the Age of Climate Change: Educational use of the pleistocene glacial and periglacial geodiversity. *Geosciences*, 15(8), 294. https://doi.org/10.3390/geosciences15080294

Zalloom, B. (2020). Enhancing tourism by reconnecting the fragmented landscape of Wadi Araba in Jordan. *Journal of Urban Planning and Development*, 146(3). https://doi.org/10.1061/(asce)up.1943-5444.0000592

Zhu, Y. (2025). Contested sacred space: state power, spatial politics, and heritage tourism. *Tourism Geographies*, 1–25. https://doi.org/10.1080/14616688.2025.2495192

Article history: Received: 16.10.2025 Revised: 08.02.2026 Accepted: 15.05.2026 Available online: 23.06.2026