MAHDI RAHIMI PORDANJANI

# A COMPARATIVE STUDY OF IMPACTS AND IMPLICATIONS OF CLIMATE CHANGE ON TOURISM IN IRAN AND PORTUGAL

## (A case study of Kish Island and Algarve Region)

**UNIVERSIDADE DO ALGARVE**

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# A COMPARATIVE STUDY OF IMPACTS AND IMPLICATIONS OF CLIMATE CHANGE

## ON TOURISM IN IRAN AND PORTUGAL

### (A case study of Kish Island and Algarve Region)

PhD in Tourism

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# Resumo

Na atualidade, as preocupações com as alterações climáticas estão a crescer em grande escala, o que estimula a investigação relacionada a nível mundial, ainda mais por as mesmas terem implicações no setor do turismo. Pela revisão da literatura realizada, podemos deduzir que um dos tópicos a que os investigadores estão a dar especial atenção é o da relação entre as alterações climáticas e o sector do turismo. O interesse pelas interações entre o clima de determinado destino e o turismo aumentou, visivelmente, à escala global; no entanto, ainda há muita investigação empírica a fazer, sobretudo sobre a forma como os turistas reagem às condições meteorológicas com que se deparam e como o seu comportamento se poderá alterar de acordo com os possíveis cenários de, igualmente possíveis, alterações climáticas no futuro. Sendo o sector do turismo muito dependente das condições meteorológicas, a previsão de possíveis alterações climáticas será essencial para o desenvolvimento sustentável dos destinos turísticos a nível mundial, particularmente em regiões com elevada vulnerabilidade às alterações climáticas, ou seja, em regiões criticas. Entre os diferentes tipos de turismo, o turismo costeiro é o mais vulnerável às alterações climáticas devido às suas atividades ao ar livre, pois as mesmas só são possíveis de realizar sob determinadas condições climáticas.

Tendo como um dos objetivos primordiais o contributo para a literatura relacionada com o clima, numa visão holística, escolhemos duas zonas com vulnerabilidades climáticas diferentes, em dois países diferentes, mas pouco estudada(o)s até ao momento. Para tal, nesta tese é feita uma investigação intercontinental, um estudo em Portugal e outro no Irão. Os estudos realizados nos referidos países, em ambos os casos com uma eminente vocação turística, fornecem indicadores sobre alguns, possíveis, impactos das alterações climáticas no sector do turismo em ambos os lados do mundo.

Em ambas as regiões consideradas para estudo o turismo costeiro é um motor económico dominante, o que os torna ainda mais vulneráveis relativamente às alterações climáticas. Devido ao aquecimento global, os destinos, em geral, estão a lidar com diferentes tipos de impactos tais como: impactos causados por catástrofes naturais, por tempestades, por fenómenos climáticos extremos, pela erosão costeira, por movimentos de sedimentos, por ondas de calor severas e cada vez mais frequentes, pelo desmoronamento de falésias selvagens ou pelos incêndios florestais devastadores. Na ilha de Kish, para além destes fenómenos, as alterações climáticas provocaram também inundações, secas severas, escassez de água potável e consequente contaminação da mesma, por uma diminuição drástica dos caudais dos rios e

por uma elevada redução do nível da água do mar Cáspio. Estas catástrofes naturais também estão muito presentes em Portugal. Os casos de estudo foram selecionados através de um processo de *downscaling* em que serão comparados dois pontos muito semelhantes, homogéneos ao nível das alterações climáticas e de dependência do turismo costeiro, a Ilha de Kish e a região do Algarve.

Este trabalho pode classificar-se como uma investigação aplicada-descritiva, em que se utiliza uma abordagem positivista apoiada em métodos quantitativos. Nesta tese é utilizado um modelo analítico comparativo para estudar e investigar as semelhanças e diferenças entre dois estudos de caso. Com os resultados do estudo pretende-se contribuir cientificamente, de forma robusta e sustentada, no apoio às diferentes entidades do sector do turismo de forma a reduzir a vulnerabilidade das regiões e a melhorar os esforços de adaptação face à situação volátil.

Após uma relevante revisão crítica da literatura foi efetuada uma avaliação exaustiva da vulnerabilidade e da adaptação do turismo às alterações climáticas, com base numa abordagem ascendente nacional, utilizando os cenários do IPCC (Painel Internacional sobre Alterações Climáticas) de forma a modelar e a prever possíveis alterações futuras em ambas as regiões consideradas nos estudos de caso.

A literatura sobre o impacto das alterações climáticas foi utilizada para fazer um enquadramento para a comparação entre as duas regiões em estudo de caso, situadas nos extremos do globo, a fim de testar um modelo comparativo mais abrangente e de modo a avaliar os impactos das alterações climáticas no turismo costeiro. Nesse sentido, e recorrendo-se a dados climáticos secundários, foi utilizado o Índice Climático do Turismo (ICT), o mais utilizado para avaliar a adequação climática de um destino em atividades turísticas gerais, para investigar os impactos das alterações climáticas no turismo costeiro das duas regiões em estudo. Além do referido, foram utilizados programas informáticos, como por exemplo a calculadora TCI e o Minitab 19, bem como testes estatísticos específicos para dados climáticos, como por exemplo o teste de tendência de Man-Kendall, o teste de declive de Sen, além do modelo do programa Lars-WG6. Acrescente-se que os testes de tendência de Mann-Kendall e o teste de declive de Sen são ferramentas disponibilizadas pelo XLSTAT.xla, suplemento do Excel.

Apesar das dificuldades encontradas na obtenção de dados secundários, tanto em Portugal como no Irão, conseguiram-se fazer avaliações fiáveis e desenhar cenários para 2050 e para 2100 confiáveis. Os resultados obtidos mostram que, apesar dos impactos das alterações climáticas em cadeia, a maioria dos turistas continuará a viajar para a região do Algarve e para a Ilha de Kish, mas não durante as épocas altas. No essencial, os turistas manterão a sua fidelidade às regiões, contudo poderão alterar de época, o que poderá ser um, possível, bom indicador pois poderá suavizar sazonalidades intrínsecas às referidas regiões. Por outro lado, a investigação também indicia que as alterações climáticas poderão influenciar a escolha do destino, mas em menor escala. Tal como referido anteriormente, estes resultados contribuem para identificar os impactos potencialmente positivos e negativos das alterações climáticas em ambas as regiões de estudo de caso, o que permitirá aos gestores de destinos e aos decisores políticos tomar decisões apropriadas, sustentadas e robustas, de modo a minimizar os impactos potencialmente negativos e de forma a aproveitar as potenciais oportunidades do futuro.

Consequentemente, constatamos que existe uma janela de oportunidade para contribuir para a redução dos impactos mais nefastos das alterações climáticas no setor, mas que será uma oportunidade limitada no tempo, pois a degradação do planeta, em termos climáticos, não para: o mundo tem menos de uma década para mudar de rumo. As medidas a serem implementadas nos próximos anos, ou as que deixarem de ser implementadas, terão um enorme impacto no futuro do sector do turismo e no desenvolvimento de outras atividades humanas. O mundo precisa de mais recursos, sejam ao nível financeiro ou de capacidades tecnológicas, para atuar no imediato. Fundamentalmente, o que falta é um sentido de urgência, de solidariedade humana com os nossos e com os outros, em termos de futuro, ou seja, de um interesse/espirito coletivo.

Este estudo recomenda que se faça mais investigação, em particular a outras regiões de outros países com as mesmas preocupações, e sejam desenvolvidos novos métodos de forma a explorar novos índices e métodos que permitam prever situações críticas futuras bem como aplicações das referidas novas tecnologias de forma a mitigar a política de alterações climáticas e a reduzir o risco acrescido dos efeitos das alterações climáticas. Os assuntos tecnológicos, os investigadores, os cientistas metrológicos e os participantes internacionais, leia-se organizações mundiais, têm por obrigação apoiar estes objetivos.

Palavras-chave: Alterações Climáticas, Turismo, Índice Climático do Turismo (ICT), Cenários IPCC, Irão, Portugal.

## Abstract

Currently, the concerns about climate change are growing on a large scale, which stimulates the related research worldwide, even more so because they have implications for the tourism sector. From the literature review, one of the topics to which researchers are giving special attention is the relationship between climate change and the tourism sector. The interest in the interactions between the climate of a specific destination and the tourism sector has visibly increased on a global scale; however, there is still much empirical research to be done, especially on how tourists react to the weather conditions they encounter and how their behaviour can change according to the possible scenarios of, equally possible, climate change in the future. As the tourism sector is highly dependent on weather conditions, forecasting possible climate change will be essential for the sustainable development of tourist destinations worldwide, particularly in regions with high vulnerability to climate change, i.e., critical regions. Among the different types of tourism, coastal tourism is the most vulnerable to climate change because of its open-air activities, which can only be carried out under certain climatic conditions.

Considering the contribution to the climate-related literature as one of the main objectives, in a holistic vision, we have chosen two areas with different climate vulnerabilities in two countries, but little research so far. For this, in this thesis, intercontinental research is done, one study in Portugal and another in Iran. The studies conducted in these countries, both with a prominent tourism vocation, provide indicators of some possible impacts of climate change on the tourism sector in both places.

In both regions considered for the study, coastal tourism is a dominant economic driver, making them even more vulnerable to climate change. Because of global warming, the destinations, in general, are managing different types of impacts such as the impacts caused by natural disasters, storms, extreme weather phenomena, coastal erosion, sediment movements, severe and more and more frequent heat waves, the collapse of the wild cliffs or the devastating forest fires. On the island of Kish, in addition to these phenomena, climate change has also caused floods, a severe drought, a shortage of drinking water and its consequent contamination by a drastic reduction in river flows and a high reduction in the water level of the Caspian Sea. These natural disasters are also very present in Portugal. The case studies have been chosen through a downscaling process in which two very similar points, homogeneous regarding

climate change and the dependence on coastal tourism, the Island of Kish and the Algarve region, will be compared.

This work can be classified as applied-descriptive research using a positivist approach supported by quantitative methods. This thesis uses a comparative analytical model to study and investigate the similarities and differences between two case studies. The results of the study are intended to contribute scientifically, in a robust and sustained way, in supporting the different stakeholders of the tourism sector to reduce the vulnerability of the regions and improve adaptation efforts in the face of the volatile situation.

After the relevant critical literature review, a comprehensive assessment of tourism vulnerability and adaptation to climate change was carried out based on a national bottom-up approach, using the IPCC (International Panel on Climate Change) scenarios in order to model and predict potential future changes in the two regions considered in the case studies.

The literature concerning the impact of climate change was used to establish a framework for the comparison between the two case study regions located at the extremes of the globe, to test a more comprehensive comparative model and assess the impacts of climate change on coastal tourism. In this sense, and by using secondary climate data, the Tourism Climate Index (TCI), the most widely used to assess the climate suitability of a destination for general tourism activities, was used to investigate the impacts of climate change on the coastal tourism of the two case study regions. In addition to the above, computer programmes, such as the TCI calculator and Minitab 19, as well as statistical tests specific to climate data, such as the Man-Kendall trend test, Sen's slope test, in addition to the Lars-WG6 programme model were used. The Mann-Kendall trend test and Sen's slope test are tools made available by XLSTAT.xla, an Excel add-in.

Even with the difficulties in obtaining secondary data in Portugal and Iran, it was possible to conduct accurate assessments and draw reliable scenarios for the years 2050 and 2100. The results show that, notwithstanding the climate change chain impacts, most tourists will keep travelling to the Algarve region and the Island of Kish, but not during the high seasons. In essence, the tourists will keep their loyalty to the regions. However, they may change the season, which can be a good indicator because it can smooth out the seasonality intrinsic to these regions. On the other hand, the research also indicates that climate change may influence the choice of destination, but to a more limited extent. As mentioned above, these results contribute to identifying the potential positive and negative impacts of climate change in both

case study regions, which will enable destination managers and decision makers to make appropriate, sustained and robust decisions to mitigate potentially negative impacts and to take advantage of the potential opportunities of the future.

Therefore, we see a time window of opportunity to contribute to reducing the most harmful impacts of climate change in the sector. However, it will be a limited opportunity in time because the planet's climatic degradation continues: the world has less than a decade to change course. The measures to be implemented in the coming years, or those that are no longer implemented, will significantly impact the future of the tourism sector and the development of other human activities. The world needs more resources, be they financial or technological capacities, to operate in the immediate future. Fundamentally, what is missing is a sense of urgency, of human solidarity with our own and others, in terms of the future, in other words, a collective interest/spirit.

This study recommends that further research be done, particularly in other regions in other countries with the same preoccupations and that new methods be developed in order to explore the new indices and the methods for predicting future critical situations as well as the applications of these new technologies in order to mitigate the climate change policy and reduce the increased risk of the effects of climate change. The technological affairs, the researchers, the metrological scientists and the international participants, in other words, global organizations, should support these objectives.

Keywords: Climate Change, Tourism, Tourism Climate Index (TCI), IPCC Scenarios, Iran, Portugal.

## Doctoral Program Title

Declarations

From the PhD student:

I declare that I accept to carry out this Thesis Project according to the referred plan.

Mahdi Rahimipordanjani..........................................................

Date: 13/06/2023

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From the supervisor(s):

I declare that I accept to supervise the accomplishment of this Thesis Project according to the plan presented by the PhD student.

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| (ANTÓNIA CORREIA) | (MANUEL DO CARMO) |
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## List of Abbreviations

| | |
|---|---|
| ANN | Artificial Neural Network |
| APA | Portuguese Environment Agency, I.P |
| AR5 | Assessment Report Five |
| AR6 | Assessment Report Six |
| ARC | Center of Excellence for Climate |
| ASHRAE | American Society of Heating Refrigerating and Air Conditioning Engineers |
| BA | Burnt Area |
| BCC-CSM | Beijing Climatic Center Control System Model |
| BSR | Baltic Sea Region |
| CC | Climate Change |
| CCMC | Chemistry Climatically Model change |
| CEP | Caspian Environment Protection Agency |
| CGE | Computable General Equilibrium |
| CIT | Climate Index for Tourism |
| CID | Daily Climate Comfort Index |
| CIA | 24 Hours Climate Comfort Index |
| CMIP | Coupled Model Intercomparison Project Phase |
| COSMO | Portugal Coastal Monitoring Program |
| CORDEX | Coordinated Regional Climate Downscaling Experiment |
| DPPRI | Departamento de Prospectiva e Planeamento e Relações Internacionais |
| EC-EARTH | European Community Earth System Model |
| ET | Effective Temperature |
| EEA | European Environment Agency |
| ECHAM | Ecological Climate Comprehensive Parametrization Package(Hamburg) |
| EU | European Union |
| FAR | First Assessment Report |
| GCM | Global Climate Model |
| GHG | Green House Gases |
| HADCM3 | Hadge Center Coupled Model Version3 |
| IC | Impact Chain |

| | |
|---|---|
| IRIMO | Islamic Republic of Iran Meteorology Organization |
| IPCC | International Panel of Climate Change |
| LARS WG | Long Ashton Research Station Weather Generator |
| LST | Land Surface Temperature |
| LW | Large Wildfire |
| MRI | Meteorological Research Institute |
| GDP | Gross Domestic Product |
| MSF | Mediterranean Spotted Fever |
| MRI | Meteorological Research Institute |
| M-K | Mann Kendal |
| PET | Physiological Equivalent Temperature |
| PMV | Predicted Mean Vote |
| PPD | Predicted Percentage of Dissatisfaction |
| RCM | Regional Climate Model |
| RCP | Representative Concentration Pathway(Model) |
| RMSE | Root Mean Square Error |
| SDSM | Statistical Downscaling Model |
| SIAM | Project "Climate Change in Portugal, Scenarios, Impacts and Adaptation Measures" |
| SST | Sea Surface Water Temperature |
| SRES | Special Report on Erosion Scenarios |
| TCI | Tourism Climate Index |
| USEPA | US Environmental Protection Agency |
| UNDP | United Nations Development Program |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNWTO | United Nations World Tourism Organization |
| UV | Ultra Violet |
| UNFCC | United Nations Framework Convention on Climate Change |
| WNV | West Nile Virus |
| WHO | World Health Organization |

# CHAPTER 1

# (Introduction)

## 1.1. Introduction

Tourism is one of the world's largest and most critical multidimensional industries, influencing the destination’s ecosystems. One of the most critical is the climate. While the tourism sector is highly resource-intensive, it is also a climate-sensitive sector, as the climate is a primary resource for the tourism sector. Climate is a significant aspect of destination selection since it impacts the suitability of destinations for a wide range of tourist activities and is an important driver of global seasonality in tourism demand. In most cases, a region's climate is a major determining factor for tourism and recreation possibilities (De Freitas, 2003; Metaracist, 2006). The tourism sector has recently gained attention as a significant contributor to climate change through greenhouse gas emissions and a sector that may be at risk due to expected global climate change (Walter et al., 2022). Climate change could be attributed directly or indirectly to human activity that alters the composition of the worldwide atmosphere in addition to natural climate variability observed over a comparable time (United Nations Framework Convention on Climate Change, 2007).

Climate change manifests itself as a growing global issue in several international agreements, such as the United Nations Framework Convention on Climate Change in 1992 (UNFCCC) Kyoto Protocol (UNFCCC, 2004) in 1997, which then led to the Paris treaty agreement. This legally binding international treaty on climate change limits global warming to significantly below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (UNFCCC, 2016).

Recently, publications in the field of climate and tourism increased, and it has become an increasingly interdisciplinary research topic. The Davos Declaration also appealed to the research community for 'targeted, multi-disciplinary research on impacts of climate change to address regional gaps in current knowledge and 'develop tools for risk assessment' (UNWTO, 2009).

This thesis aims to identify the impacts of climate change on coastal tourism, necessary adaptations, the coastal tourism sector's vulnerability, and tourism response to climate change at the regional scale. This thesis is one more step to enhance the global understanding of the impacts of climate change on tourism. To this end, an in-depth analysis of climate change in two case studies at the opposite extremes of the planet –one in Portugal in Europe and the other in Iran in Asia allows us to compare the steadiest climate changes trends regardless of the location.

Portugal is a small European country recognised as the best destination in the world due to its coastal features and mild climate. Nevertheless, the country, especially the south- Algarve-is suffering from severe climate change impacts. Algarve is a sun and sand mature destination with high seasonality and a massive demand during the high season.

On the other hand, Kish Island is also a coastal destination in a developing stage. Not as famous as the Algarve, not so massive and seasonal, but still with severe climate changes evidence. Overall, both regions are vulnerable to climate change and constraining tourism development and the quality of life of their citizens.

There is a significant knowledge gap in the studies discussing the impacts of climate change on tourism in these two case study regions, , as mentioned in several studies (Amiri and Eslamian, 2010; Karimi et al., 2018; Hugman, Stigter, Costa, and Monteiro, (2017); Berte and Panagopoulos, (2014)). The methodological framework to be used in this thesis comprises a comparative approach to cover the existing knowledge gap. This study uses available secondary data about the permissible evolution of climate change to identify several scenarios for dealing with the uncertainty of those changes in the two case study regions.

The investigation and analysis of historical climatic data trend changes in both case study regions and the forecasting of potential changes in the most critical climatic variables were used to achieve this goal.

The results of this thesis are critical to regional destination managers to adjust and adapt their policies to the changing environment to mitigate the impact of the climate on tourism.

### 1.1.1. Relationship between Tourism Sector and Climate

Weather and climate are essential for tourism and outdoor activities, and the interrelation is especially significant for coastal recreation. Climate influences the temporal distribution of tourists through the year and determines the environmental context (e.g., flora, fauna, and resources such as rivers or glaciers, among others) in which tourism activities develop. This environmental context is a tourist attraction itself (UNESCO, 2007).

Mora et al. (2018) present a comprehensive review of how climate change impacts different attributes of human life, including health, food, water, infrastructure, economy, security, and tourism. With each of these major influences on tourism being significantly impacted by climate change, the integrated effect is anticipated to be far-reaching in the decades ahead (Scott et al., 2012). The tourism sector is susceptible to weather and climate as these determine when, why and where tourists travel (Becken and Hay, 2007; Scott, Gössling, and Freitas, 2008), the types of activities they participate in, and the quality of the tourism/recreation experience (Gössling et al., 2012; Moreno, 2009). Climatic events may affect the natural resources that serve as tourism assets in a destination and potentially reduce the area's attractiveness if events such as natural disasters preclude visitors from travelling (Moreno and Becken, 2009).

Personal comfort is affected by weather, for example, in the case of extreme events such as hurricanes, flash floods, or heat waves. In this sense, and with few exceptions, regions where frequent climatic disasters are generally incompatible with mainstream tourism. Visitors' satisfaction is also influenced by experienced versus expected weather conditions. Because of this interdependency between weather and recreation, the profitability of climate-dependent segments of the tourism sector, such as coastal and marine recreation, is also at risk (Gómez Martín, 2005).

Scholarly interest in the relationship between weather and climate on the one hand and recreation and tourism on the other started around the 1950s (see Scott et al., 2007 for a review). Only recently, however, the relationship between climate and tourism became a significant area for research. Climate was considered a stable property of destinations, which could not account for long-term trends in tourism demand. This position is gradually being abandoned because of the increasing evidence that the global climate is changing (Abegg et al., 1998).

#### 1.1.1.1. Climate Change's Challenges for Tourism Sector

Climate change is one of the most pressing global environmental issues with repercussions for significant social, economic, and environmental sectors. Among economic sectors, tourism is considered one of the most vulnerable industries to climate change due to its frequent reliance on natural resources as primary assets (Lépy et al., 2014).

The tourism sector has recently attracted attention as both an essential contributor to climate change through its greenhouse gas emissions (Gössling, 2002) and an sector potentially at high risk given predicted changes in the global climate. The Baseline Report on Climate Action in Tourism of WTO (2022) declares a climate emergency all over the world, although the main research focus at this stage seems to be on the threat of a changing climate on tourist destinations (König, 1998; Maddison, 2001; Viner and Agnew, 1999; Wall, 1998).

For some destinations, specific climatic characteristics are marketed as an attraction on their own, and they are the main reason tourists travel to the regions. Weather influences certain activities' timing at the destinations, affecting participation rates. For many activities, a minimum value for specific weather parameters are required (e.g., warm and sunny weather for swimming and sunbathing) (Gómez Martín, 2005).

Recognising the role that climate and weather play in tourism and recreation acquired a new dimension over the last few years with the identification of climate change as an influential factor shaping tourism activities (Cegnar and Matzarakis, 2004; UNWTO et al., 2008). According to the IPCC (International Panel on Climate Change), the global mean temperature will likely increase by 1.1 to 6.4 degrees Celsius (best estimate: between 1.8 and 4 degrees) over this century. The international average sea level is projected to rise by 18 to 59 centimetres or more in the same period (IPCC, 2007).

These projections have led to a renewed interest in the relationship between the weather and tourism and the impacts that a changing climate could have on the tourism sector (see UNWTO et al., 2008 for an overview). In recent years, a range of impact assessments has been produced. Some of these studies are global (Agnew and Viner, 2001; Amelung et al., 2007a; Hamilton and Lau, 2005), whereas others focus on specific countries of origin, or destination types, such as ski areas (Elsasser and Bürki, 2002; Scott et al., 2003; Scott and McBoyle, 2001), parks (Jones and Scott, 2006; Scott and Jones, 2007), and coastal zones (Amelung and Viner, 2006; Perry, 2005, 2006).

Some of the tourism types are more climate-sensitive and vulnerable to climate change than others, such as Eco-tourism, winter tourism, and coastal tourism, because they are mainly outdoor activities, so tourists spend a large portion of their time outside of their accommodations. Coastal and marine environments are among the most popular outdoor recreation and tourism areas, and some scholars believe that, nowadays, coastal tourism is the largest segment of global tourism (Hall, 2001; Honey and Krantz, 2007).

## 1.1.1.2. A Comparative Study Approach

Several studies have made progress in profiling literature on climate change and tourism. Various angles have been presented in these analyses, including the relationship between climate, weather, and tourism (Martin, 2005), tourist perceptions and reactions to the impacts of climate change (Geossling, Scott, Hall, Ceron, and Dubois, 2012); quantitative approaches to evaluating the effects of climate change on tourism (Rosselló-Nadal, 2014); comprehensive reviews of tourism and climate change (Becken, 2013). Despite a vast range of tourism and climate change articles, only a small percentage of scientific literature develops with comparative research. Hence comparative studies are a relatively new method in this field.

Comparative tourism studies are justified by the strong sector global interconnectedness, tourism comprises. Comparative studies are essential to analyse the consequences of climate change and associated mitigation/adaptation responses for destination countries (Hamilton, Maddison, and Tol, 2005a, 2005b; UNWTO et al., 2008), including concerning the relative attractiveness of potential destinations (Scott et al., 2012). The climate change impacts within a country's borders and what Hedlund, Fick, Carlsen, and Benzie (2018) refer to as 'transboundary' and 'transnational' risks that reach across common borders as more distant countries. Consequently, diverse types of information need to be integrated to provide a fuller understanding of how multiple climate change impacts could simultaneously influence tourism (Mora et al., 2018; Scott et al., 2012, 2016).

The study of climate change impacts in isolation is typical within the comprehensive multi-sectoral literature reviewed by Mora et al. (2018) (over 3200 studies), which they warn provides an incomplete and potentially misleading assessment of the consequences of climate change for a location or sector of interest. Many publications, including papers and dissertations, have been published on climate change and tourism, an interdisciplinary blend of two separate forms of science. Climate change and tourism issues have become one of the most pressing concerns among policymakers, associated scientists, and international and national organisations since 2007 (Scott et al., 2016).

Another salient barrier to understanding the regional implications of climate change for tourism competitiveness and sustainability has been the need for assessments that consider the wide range of potential impacts and their interactions at the destination scale (Scott et al., 2016). Many countries recognise the salience of tourism to advance the climate agenda regarding prioritisation for adaptation, mitigation, and climate finance (Scott and Gössling, 2018). Despite growing sectoral awareness of tourism's vulnerability to climate change (WTTC, 2015; Gössling and Scott, 2018), the differential climate change impacts faced by the tourism sector at the regional and destination country scale remains uncertain.

Adaptation to an extreme environmental phenomenon necessitates a strong research focus in various areas, especially vulnerable hotspot countries such as Portugal and Iran, which can be done using comparative study methodologies. To expand on many international climate change impacts, this research investigates the potential effects of significant extreme climate events, such as climate change, on an intercontinental scale.

#### 1.1.1.3 Justification of Thesis Topic

As evidenced by tourism sector content in the regional chapters of the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports, potential impacts remain poorly understood in Africa, Asia, the Middle East, Central and South America, and Small Islands (Scott et al., 2016). These regional knowledge gaps are noteworthy, as they persist in many tourism regions with the fastest growth over the next 30 years. For example, there needs to be more research on tourism and climate change in Asia and the Middle East, the world's fastest-growing region for international tourist arrivals (Su and Hall, 2014). These regional gaps in knowledge regarding the effects of climate change on tourism remain in the more recent 2014 IPCC assessment report and the 2018 Special Report on Global Warming of 1.5 °C (IPCC, 2018).

Climate-sensitive tourism is widespread worldwide but is prevalent in northern Europe. Since British residents live in a very varied and unpredictable climate, so when they travel, they bring their sensitive habits with them. Most tourists to Portugal are foreigners who arrive from northern nations like Britain and Germany in search of sun, sand, and sea or 3S in brief. Unfortunately, coastal destinations such as Algarve are vulnerable to climate change, with coastal erosion, heat waves and sea-level rise. As such, if climate changes severely and unfavourably in this region, tourists will quickly choose another destination with better weather conditions. There will be a significant socioeconomic loss for the whole region and Portugal.

The Portuguese coastline's comprehensive links with the Atlantic Ocean and narrow connections with the Strait of Gibraltar result in a large volume of water exchange, making the Portuguese coastline distinctive and vulnerable to climate change. Furthermore, due to the smaller area of the basin, hot, dry summers, and little inflow from rivers, this overall link of the Atlantic Ocean with Mediterranean seawater can more efficiently heat up and evaporate. Besides heat waves, coastline erosion, drought, and the high ratio of UV ("*Ultra Violet*") pollution, the danger of jellyfish widespread and even Congo fever or yellow fever can be other impacts of climate change. Impacts reported on the 6th Assessment Report (AR6) IPCC scenarios published in the sixth report on 2021 with a view of the year 2050 under the near future and 2100 in the far future perspective.

According to the 4th Assessment Report- climate change scenarios- (AR4) by IPCC (2007), destinations with a Mediterranean climate, like the South of Portugal and Spain, will become too hot in summer. In contrast, northern latitude European destinations will have a more attractive climate and their coastal destinations reaching comfortable temperatures. Based on IPCC scenarios, climate change will lead to significant climatic issues in the Middle East by rising temperatures far beyond the comfort temperature thresholds, lack of sweet water availability, fastening rate of desertification and by generally reducing eco touristic attractions in countries like Iran. Therefore, Mediterranean destinations will become more pleasant in other seasons, like spring and autumn, whereas in summer, these destinations will be less attractive.

The Portuguese mainland and coastlines are in a transition zone between North Africa's arid climate and central Europe's temperate and rainy climate, influenced by both tropical climatic processes (such as droughts) and extreme mid-latitude events (e.g., strong winds). Climate change is already altering both terrestrial and marine features in Portugal, altering ecosystems and causing habitat alterations, generating favourable circumstances for the spread of non-indigenous and invasive species, according to a significant body of research. All these variables are combined to create a Mediterranean distinct from the one used. Evidence is mounting on a local and regional scale that Portugal is experiencing global warming and affecting the stratification of the sweet water for its population.

Climate change's adverse impacts will be severe in arid or semiarid areas such as Iran (Parry et al., 2004). Iran is one of the world's water-scarce regions and is highly vulnerable to the impacts of climate change due to its high dependency on climate-sensitive agriculture (Nassiri et al., 2006). Iran's per capita freshwater availability was about 2000 m3 per capita per year in the year 2000. However, it is predicted to reduce to 1500 m3 per capita per year by 2030 due to population growth (Yang et al., 2003).

Therefore, the occurrence of possible climatic changes in Iran has a disruptive impact on water resources. About 45% of the total water demand is satisfied through surface sources, and the other 55% is groundwater. Aggressive groundwater withdrawal has resulted in groundwater table decline in various regions, which will be a big issue for Tourism activities in Iran. Even though the impacts of climate change on Tourism are still shadowed with uncertainty, there is a consensus that Iran's Tourism sector will be influenced significantly (Nassiri et al., 2006). There is a big concern about the potential for climate change to disrupt tourism in Iran and prevent the country from achieving sustainable development (Vahid Karimi et al., 2018).

Climate change is expected to have different impacts on rainfall and temperature patterns across other regions of Iran and, consequently, water resources. As water resources in Iran and Portugal are shrinking due to climate change, therefore tourism sector which is one of the most water-vulnerable sectors, will be negatively affected in Iran and Portugal. However, it is estimated that if the $CO_2$ concentration doubles by 2100, the average temperature in Iran will increase by 1.5–4.5°C. In turn, it will cause significant changes in water resources, energy, agriculture and food production and forestry sectors and perspective of the Tourism sector; therefore, Iran must adapt to climate change in the Tourism sector (Amiri and Eslamian. 2010).

Based on the special report from IPPC about Global Warming Impact on natural and human systems published on March 2020, an increase of 1.5 degrees in the short term and an increase of 3 degrees Celsius in the long term is highly inevitable. It can be concluded that climate change is critical for the tourism sector because it may lead to severe temperature rises to 3 degrees Celsius, and the risk of prolonged heat waves during the high summer season will reduce tourist comfort. These climate change problems are growing each year severely, so it is a threat to the destinations in the northern hemisphere, which are more impacted, like Portugal in Europe and even in the Middle East, like the Persian Gulf tourism destinations such as Kish Island. In summary, this thesis is supported by the following reasons:

1. At the regional, national, international, and intercontinental levels, more studies must be conducted on how coastal tourism adapts to climate change's effects.

2. For the future development of the case study region, mitigation and adaptation policies to deal with the implications of climate change on both positive and negative levels are crucial.

3. Lack of research about the impacts of climate changes on coastal tourism in case studies.

4. In both case study regions, there is a noticeable communication gap between climate experts, local tourism policymakers, and practitioners.

### 1.1.2. Statement of the Problem

Climate change is the biggest threat to the long-term sustainability of tourism in the 21st century, accordingly to the Davos Declaration on Climate Change and Tourism and the subsequent Tourism Minister's Summit in London. Evidence of changing global climate system and its impacts on societal and environmental systems has multiplied over the past decade. The "Second International Conference on Climate Change and Tourism" organised by The United Nations World Tourism Organization (UNWTO) in 2007 emphasised the importance of an adaptive response to climate change which was the most severe threat factor to sustainable tourism development.

Moreover, World Tourism Day 2008, held in Lima, focused on the tourism sector's constructive response to the challenge of climate change. Scientific research, as a result, grows, with a growth rate of 85.71% compared to 2006 (UNWTO, 2012). On the other hand, it shall be noted that climatic dimensions under the aspect of comfort or well-being cannot be a single aspect of research on climate/weather and its relation to tourist behaviour. The large variety of traveller interests and motives must be considered. For instance, for sunbathing/beach escapes, weather and climate are imperative to travel motivation and hence crucial to tourists' evaluation. In contrast, in other cases, weather/climate is only a framework condition that must be considered (Denstadli et al., 2011).

In recent years, the evidence for and our understanding of the effects of climate change have undergone significant advancements. Unflinching signs of the planet's ongoing, rapid warming have emerged, and it has been learned a lot about how variations in extreme weather are related to climate change. The World Meteorological Organization reported in March 2021 that 2016 and 2020 were the warmest years since 1850. The five warmest years in the instrumental record have occurred from 2010 to 2020, continuing a multi-decade upward trend in land and sea surface temperatures. As expected, given changing climate, extreme heat, heavy precipitation, and drought events are occurring more frequently, getting worse, and staying longer in most continental regions (IPCC, 2016). Global warming speeds up the water cycle, causing extreme regional weather patterns and even more frequent droughts, (https://scied.ucar.edu/).

There is plenty of evidence that climate change is already having a significant impact on the Portuguese coastline, altering ecosystems, causing habitat changes, and fostering the spread of invasive and non-native species like jellyfish and malaria mosquitoes. As a result, this climate-induced change is crucial for marine protected areas like Ria Formosa in the Algarve region. There are many examples of how climate change impacts natural landscapes and resources. Namely: coastal erosion, the disappearance of natural sediments owing to changes in water flows, and the collapses of natural cliffs in places like Lagos in the Algarve region. A region that has been under progressive analysis by indicators provided by Portugal´s Coastal Monitoring Program (COSMO), which started in June 2018 (Pinto et al., 2021a). Therefore, all of these causes contribute to developing every new coastline shape. In the case of Iran, during the past years, severe effects of climate changes have been observed: such as the drying of a large part of Lake Urmia, dust storms in the south, west, and centre of the country, and drying of wetlands (Mardi et al., 2018), a sharp rise in temperature in summer (Daneshvar et al., 2019), decrease in precipitation (Rahimi et al., 2020) and drought (Keshavarz et al., 2013) have been observed. A significant part of the Caspian Sea's low-elevation coastal zone, fundamental to tourism in this area, has been submerged during the past years. Impeded drainage seriously affects tourists, residents, and agricultural production, and submerged houses and wastewater wells are hazardous for swimmers in Iran's northern and southern regions (Mirzaei, 2013).

Khorana, Monjazeb and Marvdashti (2014) examine the effects of climate change on the number of Hengam Island visitors. Hengam Island is located quite close to Kish Island, and the general circulation model results show that Hengam Island will face warmer temperatures in winter and spring and lower temperatures in autumn and summer in the next 30 years. As a result, the number of visitors will increase relatively in autumn and summer and decrease in winter and spring. There are several types of these negative impacts of climate change on tourist destinations, especially the coastal tourist ones in the south of Iran.

#### 1.1.2.1. The Existing Knowledge Gap

Knowledge gap means issues that still need to be covered by the literature review. There is also a significant gap in the case of interdisciplinary works in the case of Tourism and Meteorology. Support for multidisciplinary research has the potential to involve different scientists in climate change studies that concentrate on the tourism sector. The fragmentation of the available knowledge can be solved using interdisciplinary study. It is necessary to develop multidisciplinary research tools and learn how to incorporate climate knowledge into tourist studies and policy texts. Coastal tourists' experience in these two case study regions shall be studied using hypothetical weather scenarios and seasonal means for predicting possible changes in future.

Little is known about whether tourists know how their travel impacts the global climate and, conversely, what impact a changing climate may have on tourist destinations. Moreover, there needs to be more research on the willingness of tourists to mitigate such effects. Climate-change-related risks and impacts pose severe threats to managing many social, economic, and ecological systems and industries, such as Tourism. Managing these risks requires knowledge-intensive adaptive management and policymaking actively informed by scientific knowledge, especially climate science (Gössling and Hall, 2006)

However, potentially useful climate information often needs to be used because there is a considerable knowledge gap in the case of the impacts of climate change on the Tourism sector. That suggests a gap between what scientists understand as helpful information and what users recognise as usable in their decision-making. The literature suggests a dynamic conceptual model to address this gap and highlight strategies to move data from users to reduce climate-related risks. (Lemos, et al., 2012).

In some parts of the world, the climate is the primary source of attraction that promotes tourists, such as coastal tourism. There need to be more investigations into the case of relationships between weather, climate, and tourism. Weather-sensitive tourism includes coastal and winter tourism because any significant change during summer or winter can make a big change in the attraction of a coastline, beach, or ski resort.

As the tourism sector encompasses a wide range of interests and activities, both indoor and outdoor, this work focuses on outdoor tourism activities that could be better studied in these two case study countries, Portugal and Iran. Because the tourism business deals directly with tourists, who are customers who use a range of goods and services, it is inextricably linked to human behaviour. However, this topic has received little attention, particularly from an interdisciplinary perspective. The study of the effects of climate change on tourism is akin to bridging the gap between two domains of human and natural science, primarily tourist management and climatology. This gap makes the main research question of this study ***how climate change can impact the tourism sector in Portugal and Iran.***

Recent studies on the role of weather parameters for decision-making concentrated much on the pre-trip destination choice and tourism flows in the context of a changing climate. Less attention has been paid to tourists' perceptions and experiences of weather and activities undertaken in the situation, and even less so in destinations which live off predominant weather features like sunshine and warm temperatures (Jacobsen et al., 2011). However, some other studies examined the potential impacts of climate change on Iran's agriculture and environment (Roshan et al., 2016; Karimi et al., 2016). The climate change impacts on tourism still need to be better understood, mainly what concerns the possible climatic effects and consequences on Iran's tourism. These are unknown and have yet to receive much attention.

The research aims to evaluate the climate scenarios of IPCC for the short and long terms up to the year 2050 and 2100 and its impacts on tourism.

### 1.1.2.2. The Research Question

Climate scientists are confident about the significant changes in global climate over the 21st century (Hallett, 2002). Despite their optimism, there is a need for academic research to raise awareness about climate change and to get the necessary information for decision-making on adaptation and mitigation strategies (UNWTO, 2003).

Researching climate change on tourism is essential for regions such as Kish Island and Algarve region, mainly because the tourism sector is one of the primary economic sources of revenue and income for the area's people.

Consequently, this thesis will attempt to provide an answer to the main question but not only the question of the study:

▪ How will climate change affect the coastal tourism destinations of Kish Island and the Algarve region in the near and far future? Also, to see through a comparative peer-to-peer comparison between the two regions if the changes are impacting tourists satisfaction.

This question will guide the research and will help to achieve the following objectives: Exploring the climate change on Coastal tourism satisfaction in future in both case study regions of Kish and Algarve.

They are contributing to the literature on climate change impacts on Portugal's and Iran's tourism policies to tackle possible negative impacts of climate change in Kish Island and the Algarve region.

### 1.1.2.3. Study Goals

This research examines the impacts and implications of climate change scenarios on tourism in Iran and Portugal as a case study. Evaluate the significance of climate change's impacts on tourism to understand this region's phenomenon better, cover the lack of a global overview, and fill the knowledge gap in this area. Therefore, the research objectives of this work are the following:

1. To understand the climate change phenomenon and its relationship with the Coastal tourism sector in Kish Island and Algarve region.
2. To identify possible implications of climate change on Portugal and Iran's tourism sector.
3. To define scenarios and methodologies suitable for the possible impacts of climate change on tourism destinations in Portugal and Iran, especially the Algarve region and Kish Island.

### 1.1.2.4. Hypothesis

Climate is the main asset and attraction for destination selection for coastal tourists in Kish Island and Algarve region under possible climate change scenarios in future. This hypothesis allows to understand the climate change phenomenon and its relationship with the Costal Tourism (Research Objective 1).

Climate Change Impacts on the Coastal Tourism of the Kish Island and the Algarve region are severe in the near and far future. This hypothesis allows to define scenarios and methodologies suitable for the possible impacts of climate change on tourism destinations in Portugal and Iran, especially the Kish Island and the Algarve region (Research Objective 2).

Urgent adaptation strategies and mitigation policies are needed to combat climate change challenges in the Kish Island and the Algarve region case study regions. This hypothesis allows to identify possible implications of climate change on Portugal and Iran's tourism sector ( Research Objective 3).

### 1.1.3. Organization and Structure of the Thesis

This thesis follows the organisation of a classic thesis, comprising five chapters. Thus, the final work of the thesis will include five chapters, including the following:

- ***Chapter I: Introduction; Including Goals and Objectives of Study***

Chapter one introduces the research and outlines the purpose of the study. Further, it provides background information on the topics under investigation, a statement of the problem; the research gap and justification for the comparative approach used in this research; and an overview of the methodology.

The research goals and objectives clarify the research questions, thesis hypothesis and data collection methods.

- ***Chapter II: Literature Review***

This chapter provides background information on coastal tourism, climate change and the tourism sector facing climate change challenges. The chapter is divided into two parts: The first part reviews the literature on tourism and climate change, presenting a critical overview of the contemporary literature on tourism and climate change. The second part discusses climate change impacts on tourism destinations in each case study region. This part continues with the literature review on climate change impacts on coastal tourism, followed by the discussion of tourism and climate change in two case study regions.

- ***Chapter III: Study Site and Methodology***

This chapter is divided into two parts. The first part presents the description of the chosen study case study sites, including their geography and location, followed by the explanation of the tourism sector within the case study regions, as well as the changes in the area's climate in recent years. The second part discusses the chosen methodology presenting detailed information based on secondary data collected from the governmental institutions of meteorology, which were designed based on the IPCC scenarios describing the climate change in Iran and Portugal and respectively in Kish Island and Algarve region.

- *Chapter IV: Results and Discussion*

This chapter presents the main findings of the research, which has been done through analysis of the secondary data collected from the different meteorological stations in the Algarve region in Portugal and Kish Island in Iran. The chapter is mainly about quantitative results of meteorological assessments of climatic variables in the past and finding trend changes and forecasts of future changes based on the IPCC scenarios presented by figures and charts.

- *Chapter V: Conclusion*

This chapter is divided into two parts. The first part discusses the main empirical findings more in-depth, making a comparison to the existing literature. The second part of the chapter presents the thesis summary by highlighting the essential findings and presenting the realisation of objectives, mentioning the limitations and contributions, and providing recommendations for future research.

#### 1.1.3.1. Planning Framework

This thesis used a concise planning framework to depict the relations and links between climate, weather, and tourist flows. Figure 1.1. illustrates the structure of the thesis.

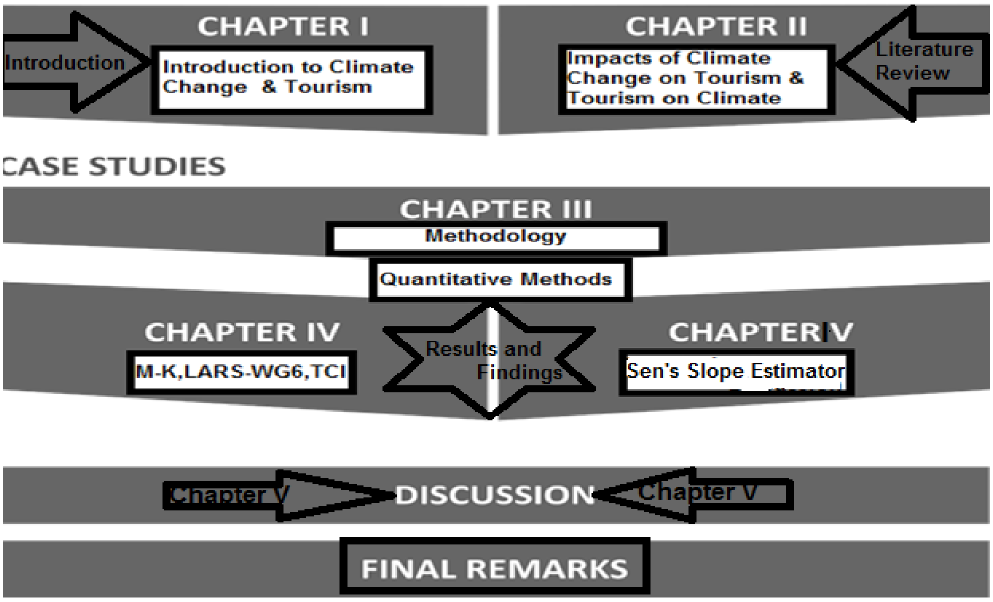


**Figure 1.1. Thesis general structure**

### 1.1.4. Overview of Methodology

The foundation of this research is critical realism (Bhaskar, 1978). Critical realism views all knowledge as imperfect and does not pretend to have a fully comprehensive understanding of a situation. This research introduces a quantitative method as a form of triangulation. Because of this acknowledgement, supporters of critical realism also assert that all theory is subject to revision. Additionally, combining various approaches can result in a more comprehensive understanding of the issue or problem.

This research builds upon the initial literature review, which involved gathering and analysing secondary data from journal articles, case studies, government and sector reports and books to gain solid background knowledge of the issues surrounding climate change adaptation in tourism.

The first part of the research involved developing and designing some objectives that require an extensive review of the adaptation models available in the literature and the identification of potential shortcomings or areas for improvement. The proposed objectives aim to build upon the existing adaptation models and create the most suitable composition for national tourism destinations. This research utilises a case study approach to apply the comparative study model. Using this approach, both qualitative and quantitative data are collected and analysed by incorporating secondary data collection.

Several indices have been developed to measure climatic elements that most affect the quality of the tourism experience. Namely: The Tourism Climate Index (Mieczkowski, 1985), the Beach Comfort Index (Becker, 1998; Morgan et al., 2000), the Physiologically Equivalent Temperature Index (Matzarakis and Mayer, 1996), the Climate Index for Tourism (De Freitas, Scott, and McBoyle, 2008), and the Modified Climate Index for Tourism (Yu, Schwartz, and Walsh, 2009). All these indices have been widely used to assess the impacts of projected climate change on the tourism sector at a national scale, as well as regionally and locally (e.g., Amelung et al., 2007b; Fang and Yin, 2015; Vitt, Gulyas, and Matzarakis, 2015).

This study tested to evaluate the climate change impacts on both case study regions by assessing the observed data trends through the non-parametric Mann-Kendall method. This study is concerned with detecting temperature and precipitation changes as to the number of changes in rainfall, minimum and maximum temperature, and frequency of heat waves in Kish Island and the Algarve Region. The application of the Coordinated Regional Climate Downscaling Experiment (CORDEX) database outputs leads to the determination of the future temperature and precipitation, subject to RCP Model scenarios. They are used to forecast the likely changes in climatic trends, which may have meaningful impacts on tourism activities in case study regions.

### 1.1.5. Conclusion

A better understanding of climate change impacts tourism is needed (Scott and Becken, 2010). There is a need to validate existing tourism climate indices on fundamental knowledge of climate conditions (Scot and Lemieux, 2010).

After all, the significant consequences of climate change in the two case study locations of Kish Island and Algarve region's coastal tourism activities, as well as issues with adaptation and mitigation, are highlighted in this study's thorough investigation of the relationship between climate change and coastal tourism by studying the past climate data trend changes and forecasting possible future modifications based on well-known globally recognised climate scenarios.

The TCI or similar metrics significantly facilitate analysis for Climate change-induced socio-economic impacts; the economic impact of climate change, explicitly increasing temperature, which results in thermal stress, has received wide attention in the literature. As a result, more study in this area is required. The fact that climate models for island destinations and coastal regions are highly unclear is another critical concern; in this regard, scaled evaluations addressing the physical consequences and tourists' perceptions from a comparative perspective would be appreciated.

The choice of this research holds several important implications, including:

Two case study regions, especially the case of Portugal, a heliocentric destination, attracting visitors through its climate and geographical location,

Both case studies' regions are among the most vulnerable projected areas to changes in climate and, accordingly, potential relationships between weather and touristic activities may render some critical insights into tourists' decision-making,

There is a limited possibility of "escaping" actual weather conditions or changing itineraries over the year in these two-case study region tourism calendars. Many Portugal's and Iran's holidaymakers are repeated visitors from northern latitudes source markets.

The main effects on destinations that this research will attempt to pinpoint are as follows:

- **a)** Direct effects from altered weather patterns, extreme events, and rising temperatures.
- **b)** Indirect effects from environmental change brought on by climate change, such as biodiversity loss, diminished landscape aesthetic, coastal erosion, and sea-level rise.
- **c)** Consequences of mitigation policies with adverse effects on coastal tourism mobility.
- **d)** Potentially indirect societal effects on the economy and politics.

# CHAPTER 2

# (Literature Review)

## 2.1. Introduction

Tourism is particularly vulnerable to climate change because of its deep connections to climate and natural ecosystems. Impacts such as warmer air temperatures, fluctuations of precipitations like periods of drought and unpredictable floods, more frequent and stronger storms, and rising sea levels have a variety of consequences for tourism locations, ranging from altered seasonality and greater fire danger to beach erosion and coastal erosion. The destination's infrastructure and ecosystems will be affected, and the ability to adapt to these changes will ultimately determine the destination's long-term sustainability.

The volume of literature on the impact of climate change on the tourism sector is increasing due to the recognition of the growing concerns about a more precise understanding of climatic changes globally. For instance, climate change has a profound and vast range of impacts on the coastline and its ecosystems, jungles and landscapes and even human health at tourist destinations. It will sooner or later affect the tourism sector's demand all over the globe; therefore, an understanding of local climatology is becoming increasingly crucial in studying tourism prospects (Makita and Kikuchi, 1977; Renaudin, 2002).

This study's primary focus is on how climate change will affect the tourism industries in Kish Island and the Algarve Region, respectively. Many areas in both case study regions may have benefited from various aspects of climate change. For example, coastal activities and tourism are receiving more attention due to more favourable local climatic conditions as an advantage. As a result, this chapter attempts to conduct a more thorough analysis of earlier works as a literature review from many points of view using a systematic approach to review previous works.

Climate considerations play a significant role when choosing specific holiday destinations. According to Lohmann and Kaim (1999), German citizens rank weather third on the list of essential destination characteristics, after landscape and price. Given this importance, surprisingly, little is known about the empirical relationship between temperature and climate and tourism and recreation. (Aguilar, Mounier, and Renaudin, 2002).

One explanation for the discrepancy between the importance of climate for tourism and the limited interest in it among academics may be that the climate has been considered a stable factor (Abegg et al., 1998; Baker and Olsson, 1992), with little predictable and structural change from year to year. Similarly, unlike tourists' preferences and behaviours, weather and climate are typically unchangeable; tourism marketers may not deliberately manipulate them.

For at least the last 150 years, there has been a growing realisation that the earth's climate is not fixed. Indeed, global climate has changed many times throughout history, with often significant impacts on human well-being, communities, and development (e.g., Brooke, 2014). The Intergovernmental Panel on Climate Change has noted that "climate change is any change over time, whether due to natural variability or human activity" (IPCC, 2014). Driven by a heightened sense that climate change is already happening and will increasingly impact tourism, interest is growing amongst tourism researchers and practitioners in the interactions between climate change and tourism (Gren and Huijbens, 2014).

Climate and weather are critical ingredients of a destination's geography: they influence tourist flows, have significant on-site impacts on the tourism resource base and influence tourists' activity participation, satisfaction, and safety. Therefore, considerable attention has been paid to climate as a destination attribute (Hu and Ritchie, 1993). Climate and tourism have a complicated relationship, as suggestions note that for sustainable tourism to exist, there is a need for optimal permitting weather at a tourist destination (Kaján and Saarinen, 2013).

Climate change is a significant risk for the tourism sector, which is more important in countries where tourism growth is projected to be higher (Scott and Gossling, 2018). Analysis of 27 indicators concludes that Western Europe, Central Asia, and Canada fall into the low-risk category. At the same time, countries in the Mediterranean are at higher risk in the case of climate change vulnerability. While Africa, the Middle East, South Asia, and small island states face the most significant threats, particularly those countries where tourism is a substantial part of the economy (Scott and Gossling, 2018).

The tourism sector is global and interconnected; there are no borders regarding the challenges and consequences of climate change. Coral reefs, beaches and cities are already being damaged, with some projected to be wiped off the map. Put bluntly; it is difficult to overstate the significance of climate change for the competitiveness and sustainability of tourism (Scott and Gössling, 2018).

Climate change is now recognised by most governments and scientists throughout the world as a significant social and environmental issue facing the global population and its resources. WHO (2009) has also reported that climate change was responsible for about 3% of dengue fever deaths worldwide in 2004. In some regions, changes in temperature and precipitation because of climate changes led to the severity of fire events, for example, the current circumstance of wildfire on land, which occurred in southern latitudes even in European countries such as Portugal. Similarly, events such as the European heatwaves of 2003 and 2019 (Perry, 2020), the increased incidence and severity of wildfires across the Mediterranean and the American West (Pinol, Terradas, and Lloret, 2018; Westerling et al., 2019), and the recent increase in the frequency of intense hurricanes across the southeastern United States and Caribbean (Fossell, 2015) have increased the public's awareness of and interest in the issue of climate change. For the Mediterranean region, there is evidence that temperatures will become too hot in the summer season, but destinations would be more pleasant in the shoulder seasons. In the case of the Balearic Islands, these changes are positive from the resource management and biodiversity point of view, while social and economic effects are likely to be detrimental (Amelung et al., 2007; Amelung and Viner, 2006).

Only a few empirical studies have compared the effects of climate change on tourism worldwide, and most of those studies have concentrated on the impacts of climate change on tourism at the regional level. Tourism and climate change interact in a complex and dynamic way. It involves multiple linkages between actors and entities over many different temporal and spatial scales. This study will critically and comprehensively evaluate the potential consequences of this interaction under various future climate change scenarios.

This chapter focus on a literature review that accomplishes the complex dynamics of environmental and meteorological drivers of climate change.

## 2.2. Climate Change and Tourism

As the body of literature on climate change and its multifaceted implications expands, it is increasingly evident that the climate change challenge appears to be a version of Hardin’s ‘‘tragedy of the commons’’ (1968). Climate change is the single most important global environmental and development issue facing the world today and has emerged as an important topic in tourism studies. The tourism sector is a sector relying on many of its activities taking place in the outdoor public domain. Therefore, complexity places tourism operators in a challenging environment (Schott, 2010).

The tourism sector and destinations are susceptible to climate variability and changes; therefore, in its general aspects with its close connections to the environment and climate itself, the tourism sector is a highly climate-sensitive economic sector, like agriculture, insurance, energy, and transportation (Wilbanks et al., 2007). Moreover, climate and tourism have affected each other as components of one system. Martin (2005) defined a “tourism climate” as the convergence of two branches of geography, namely the geographies of tourism and climatology, to demonstrate how tourist activities are shaped by climate. Regarding motivation for tourists, studies have shown that climate is either the most or one of the most critical factors that tourists consider when choosing a destination (Kozak, 2002; Martín and Belén, 2005; Scott et al., 2008).

## 2.3. The Importance of the Tourism Sector

The tourism sector is one of the biggest industries worldwide. UNWTO has determined that tourism is a primary source of foreign exchange earnings in 46 countries out of 50 of the world’s Least Developed Countries (UNWTO 2007, see also UNDP 2005; Hall, 2008). Tourism has the potential to lift people out of poverty through the employment and entrepreneurial opportunities it provides, and the recognition of tourism’s role in poverty alleviation has made it a substantial component of the international development and trade agenda (Hall and Coles, 2008). The tourism sector also embraces and has the potential to significantly contribute to the achievement of the United Nations’ Millennium Development Goals (UNWTO, 2007). This, however, demands that the sector adapts to climate change and, as necessary, reduces its contribution to climate change through emissions of greenhouse gasses and the overall environmental footprint of tourism. Both aspects require substantial changes in tourism production (Hall and Coles, 2008).

Undoubtedly, tourism is a critical driving force for socioeconomic progress. It accounts for 5% of the direct global Gross Domestic Product, offering 235 million jobs worldwide. In 2014, international tourist arrivals reached 1138 million, and the corresponding turnover approximated US$1200 billion (UNWTO, 2015).

The largest market segment of global tourism is coastal tourism, which strongly depends on the destination's thermal climate. To date, outdoor bioclimatic comfort assessments have focused exclusively on residents in open urban areas, making it unclear whether outdoor comfort is perceived differently in non-urban environments or by non-residents (i.e., tourists) with different weather expectations and activity patterns. Coastal tourism is the largest market segment of global tourism (Hall 2001; Honey and Krantz 2007; United Nations Environment Program 2009), with “coastal destinations, beaches and beach resorts synonymous with tourism, tourism growth and economic success” (Jones and Phillips, 2011, p. xvii).

Climate and weather have been push-pull factors in visitor destination selection and activity engagement (Agnew and Palutikof, 2006; Bigano et al., 2006; Hamilton et al., 2005; Huebner, 2012). Several studies have demonstrated that weather is essential in tourism development (Denstadli, Jacobsen, and Lohmann, 2011; Gössling et al., 2006; Maddison, 2001).

Specifically, tourism and outdoor recreation activities in coastal and marine environments are highly sensitive to weather conditions and climate patterns (Moreno and Becken, 2009). Push factors are origin related and refer to tourists' desires or undesirable aspects of the climate in their home region. Pull factors are attributes of destinations that determine their attractiveness, such as their natural resource base, cultural attractions, and climate (Kozak, 2002).

Behavioural observations of tourists reveal that microclimatic conditions substantially affect the usage of coastal areas, with tourists responding to the combined effects of weather elements (i.e., thermal, physical, aesthetic) (De Freitas, 2003). Sunshine and higher temperatures are correlated with crowded beaches, while cool temperatures, rain and windy conditions deter users and result in low levels of beach use (De Freitas, 1990; Moreno et al., 2008; Martinez Ibarra, 2011). Studies of stated climatic preferences have found that tourists' ideal conditions for a beach holiday range from 27 to 32 °C (Scott et al., 2008; Moreno, 2010; Rutty and Scott, 2010; Rutty and Sott, 2015). Studies also have found that tourists 'thermal preferences can vary by nationality, climatic region of origin and age (Scott et al., 2008; Credoc, 2009; Wirth, 2010; Rutty and Scott, 2015).

Tourism has a considerable level of significance in many countries economies and has a significant portion of contribution to creating jobs in each tourism destination. It is commonly believed that each tourist in a destination will create up to 7 direct jobs. On the other hand, tourism is crucial for different industries, mainly air transportation. In recent years, the tourism sector and other industries have s been impacted severely by the pandemic of Covid-19 across the globe due to quarantine in tourist generator countries in Europe, North America, Asia, and in tourist destinations around the world. Based on recent studies, there will be over tourism soon in every famous tourist destination due to postponed travel due to the pandemics among frequent travellers. Europe is the most important tourist region in the world. According to the report by UNWTO (2006), nearly 55% of all international tourist arrivals (461 million) were to European destinations. According to the UNWTO (2006) report, about 165 million tourists have visited southern European countries, including Portugal, Spain, Croatia, Greece, and Italy, which are the favourite holiday destinations in Europe.

The latest assessment report released by IPCC concluded that "after the year 2050, tourism activity will be projected to decrease by volume in Southern Europe such as Mediterranean destinations like Portugal and Spain and will be increasing in Northern Continental European destinations. Moreover, the report identified the tourism sector as one of Europe's three sectors " which could most likely be affected severely by climate change". The findings of this report indicate that during summertime, the climatic conditions could deteriorate in the Mediterranean destinations but could improve significantly in northern European ones (IPCC, 2007).

## 2.4. Coastal Tourism Definition

Coastal and marine tourism as a tourism sector includes recreational activities involving travel away from one's residence and focusing on activities mainly in the marine environment and/or the coastal zone (ICMTS, 1999). The marine environment can be defined as those waters that are saline and tide-affected areas in the coastal zones. The coastal zone is defined as those areas of land which have a border with the marine environment zone. In general, there are many sectors in the Tourism sector, but many tourists are attracted to coastal areas to look for sea air, beaches, sun, seafood and scenic views (Davenport, 2006).

Beach tourism involves sunbathing, swimming, surfing, kitting, beach volleyball and football, running, walking, cycling and other sports and activities in children's playgrounds. Any increase in beach tourism will mean that new tourism infrastructure, such as upgraded transportation networks, and the expanded provision of accommodation, catering, and safety, is required to provide capacity for an increase in visitors in the region (Coombes and Jones, 2010).

WTO estimated that a report announcing that tourists only using the Mediterranean coastal region will reach 350 million by 2020 (WTO, 2004). In general, due to overpopulation in coastal areas worldwide, coastlines are subjected to high human pressures (Noronha et al., 2011). At the beginning of the second half of the 20th century, many coastal areas of Spain, Italy, Greece, and Portugal, among other south European countries, began to attract tourism flows from northern Europe, motivated by pleasant thermal conditions and sun and sea experiences (Bramwell, 2004). In general, coastal tourism is a dominant and significant market segment in many countries worldwide.

The intensity and diversity of coastal tourism are continuously growing (Hall et al., 2007). For example, the European Union estimates that about 60% of trips within Europe with at least four overnight stays take place by the seaside; climate and scenery are the predominant motives for choosing the holiday destination (Leidner, 2004).

## 2.5. Tourism Seasonality

Regional climate influences the characteristics of seasons. The duration of the daytime, temperatures, precipitation, and other climate parameters create seasons traditionally crucial for the public and school holidays and, thus, for tourism and recreation activities. According to climate model projections, the length and characteristics of seasons are expected to change. Global warming will result in a more extended summer tourism season versus a shrinking winter. For the 2080s spring season, all climate model results at the European scale show a straightforward extension toward the north of the zone under good conditions. The autumn season has comparable changes. In summer, the area of good conditions also expands toward the north but at the expense of the deteriorating climatic conditions in the south (Ciscar et al., 2011).

Tourism seasonality or temporal changes of annual concentration in tourist demand and supply are defined by natural and institutional factors and are a reason for traditional holiday seasons, seasonal traditions, the high season, and off-season (Ahas et al., 2007; Higham and Hinch, 2002).

In Europe, the future tourism volume might be twice, spread along the summer and winter (ESPON-IRPUD, 2011). Also, the air and sea temperatures will likely increase during the summer, along with less precipitation that encourages a more extended season of outdoor activities, beneficial for the northern part of Europe. Summer tourism's season conditions will be enhanced, and warmer temperatures and less precipitation will prolong its length in the summer; the northern part of Europe will likely benefit from improved conditions. Warming-up will also shift the tourist season into spring and autumn, although more likely in southern European destinations. Although improvements in the relative conditions in the shoulder seasons will not change, beach tourism requirements are significant in Europe (Amelung and Viner, 2006; Moreno and Amelung, 2009).

Experts have agreed that climate change has already begun and is threatening tourist enterprises. An efficient integrated management system in companies and tourist destinations will be required to cope with its damaging effects. The predicted changes in tourists' behaviour and destination assessment will give rise to an increase in the current trend towards shorter average stays by tourists; a greater "Deseasonalization" of demand since certain seasons of the year will offer better climate conditions; a decline in traditional tourism and an increase in residential tourism; a reduction in the most critical area of tourist attraction due to deterioration of coastal infrastructures; and an increase in human health hazards (Valls et al., 2009).

## 2.6. Weather, Climate and Tourism

Climate is derived from the Greek word Klima, "slope', 'zone' from Klinien 'to slope', the term originally denoted a zone of the earth between two lines of latitude, then any region considered with references to its atmospheric conditions (Oxford Dictionaries, 2014). Climate is a prevailing atmosphere or environment over a long period, usually about thirty years-thirty-five years (Oguguo and Ajuonuma, 2013); Akuakanwa and Urenyere, 2013); Aboho and Anderson, 2010; Akani, 2013).

Climate, according to the Oxford English Dictionary (5ed. 1999), 'is the usual weather condition of an area. Wikipedia defines climate as "encompassing the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle counts and numerous other meteorological elements in each region over a period. Climate and weather are closely related concepts, especially to the public, as the climate is the long-term average of weather conditions (Forland et al., 2012; Scott, Jones, and Konopek, 2007).

Climate, weather, and climate change are capable of enhancing or constraining recreation experiences, particularly in nature-based tourism destinations that rely on environmental conditions to attract visitors and as settings for specific recreation opportunities (Beaudin and Huang, 2014; Dawson and Scott, 2013; Forland, Denstadli, and Jacobsen, 2012; Gossling and Hall, 2006; Hendrik and Jeuring, 2017; Scott and Lemieux, 2009). Ideal weather or climate is highly subjective, shaped by individuals' preferences for and responses to environmental conditions. However, impacts sustained from adverse weather or climatic conditions (flooding, extreme temperatures, fire, among others, hereafter, climate-related impacts) are generally perceived negatively by nature-based recreationists (Forland et al., 2012).

There is such a strong relationship between weather and climate with tourism and recreation activities that it can highly determine the destination, time, and quality of travel. The travel and tourism sector is particularly vulnerable to changes in climate and resulting physical (increased sea levels), ecological (bleaching of coral reefs), economic (increased cost of long-haul travel) and social impacts (changes in consumer attitude) (Garnaut, 2008; IPCC, 2007).

Tourism activities engaged outdoors are most affected by weather and climate. Furthermore, tourism has a complicated multi-aspect relationship with the climate; in fact, the climate plays an important role which affects many aspects of tourism (Scott et al., 2012). Some of the critical characteristics of the climate as a resource of tourism and ecotourism include free, renewable, and non-degradable aspects and the fact that it cannot be transported or stored (Gomez., 2005).

Climate condition is considered a travel variable for many tourists and has an actual weight in most decisions (Lazaro et al., 2014).

The three climatic aspects of thermal, physical, and beauty characteristics are the climate conditions for tourism activities (Lin and Mazarakis, 2008). The physical part includes precipitation and wind speed as influential factors for tourism activities. The beauty part has sun, cloudiness, fog, and sky colour. Although climate plays a crucial role as a resource for a tourism destination, it might act as a restrictive factor because of the heterogeneous distribution of global water resources and the seasonal differences (Gomez, 2005).

Climate and weather are two very significant factors in tourists' decision-making. They significantly influence the success of a Tourist destination and the tourism business there. Climate is defined as the condition which can be observed in a long-term time in a specific location. However, weather, in contrast to climate, is the manifestation of climate in a short duration of time in a place. So, while tourists might expect certain climatic conditions when they travel to a site, they will experience the actual weather, which might be quite different from the average conditions (Gossling, 2015).

Therefore, tourists and tourism businesses are likely to be affected by weather conditions, although, in the long term, these will follow systematic changes as projected under different climate change scenarios. For this reason, tourist destinations will benefit from understanding potential climatic changes in their area and how they might impact their operations in advance.

The relationship between climate and tourism has been extensively studied, which has built a solid foundation for climate change and tourism research. Climate is an essential factor in the location of tourism centres. For example, a warm temperate zone is optimal for sun, sand, and sea (3S) tourism (Burton, 1995). Also, it is regarded as an essential tourism resource and an attraction for tourists. Climate (e.g., temperature, sun hours, snow, or wind) is a critical resource in tourism, especially for nature-based tourism, including 3S tourism, winter tourism, health tourism and sports tourism (Smith, 1993).

The implications of climate change on tourism have been examined since 1990 (Smith, 1993), and since then, many scholars have devoted themselves to this issue (Giles and Perry, 1998; Harrison, Winterbottom, and Sheppard, 1999; Nicholls and Hoozemans, 1996; Pendleton and Mendelsohn, 1998). In the recent century, more and more studies on the impacts of climate change on tourism have been carried out, which has broadened the scope of this field. On the one hand, climate's direct and indirect effect on tourism has been examined (e.g., changing climate conditions at places of origin and destination, influencing natural snow cover or water supply). On the other hand, consumer behaviour the demand response of tourists to climate change have been evaluated (e.g., tourist destination choices and tourism flows). Vulnerability assessments drive robust adaptation strategies and are widely used in nature-based tourism (Moreno and Becken, 2009; Perch-Nielsen et al., 2010).

A mature vulnerability framework for the beach tourism sector has been developed by Perch-Nielsen (2010). It includes three dimensions (i.e., exposure, sensitivity, and adaptive capacity) based on the IPCC's vulnerability concept. Integration of adaptation measures has recently been adopted in impact analysis studies, investigating how to engage tourism stakeholders (e.g., investors, insurance companies, tourism enterprises, governments, and tourists) in climate change adaptation (Turton et al., 2010).

Moreover, extreme events impacting tourism have been considered in climate change adaptation and disaster reduction (Tsai and Chen, 2011). The challenge of climate change is also an opportunity for tourism to become more systematic, intelligent, strategic, and sustainable (Becken, 2007). As a result, the issue of achieving sustainable tourism by focusing on climate change has been of growing interest to researchers (Scott, 2011; Weaver, 2011).

Mediterranean tourism has traditionally been characterised by strong seasonality, with significant differences in occupancy rates between winter and summer. In the early 1990s, tourist expenditures were around 50% higher in the peak month of August than in an average month and about 30% lower in February (González and Moral, 1995). In Spain and Portugal in 2003, more than three times as many hotel nights were spent in August as in December (INE, 2004).

## 2.7. Climate Change Detection and Projection

Climate change as a climatic phenomenon has been detected for nearly thirty years. According to Anyadike (2009) is "a situation in which a change continues in one direction at a rapid rate and for an unusually long period". However, the changes are cyclical or essentially noticed, except by climatologists. Eboh (2009) agrees with the IPCC that climate change is "statistically significant variations that persist for an extended period, typically decades or longer". It comprises discrepancies in the occurrence and magnitude of sporadic weather events and a concomitant rise in world mean surface temperature (Oguguo and Ajuonuma, 2013).

The UNWTO et al. (2008, p: 38) recognise climate change as "the greatest challenge to the sustainability of tourism in the 21st century." In 2018, World Travel and Tourism Council joined the UNFCCC Climate Neutral Now initiative, committing to becoming climate neutral by 2050 and much needed to collaborate on accelerating sector-wide climate action. The implications of climate change for developing countries that plan for tourism to be a critical future development strategy need to consider in planning and policy-making, development assistance programs, and international adaptation negotiations (Scott, Hall, and Gössling., 2012).

Climate change is a continuous prolonged alteration of climate in one direction for them; it is the variation in global or regional climates over time; it reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. At the same time, US Environmental Protection Agency (2012) sees climate change as any significant changes in the measures of climate lasting for an extended period and a global alteration in the climate due to human activities such as deforestation (Oguguo and Ajuonuma, 2013).

Climate change is a significant departure of climatic behaviours from familiar or established patterns. It implies a statistical change in measurement of either the mean state or variability of the climate for a place or region over a given period. It is essential to differentiate climate change from climatic variability. The latter refers to departures of weather behaviour from annual patterns with aggregate impacts that do not amount to an area's permanent shifting climatic regime. Two points are necessary concerning this. First climatic variability can devastate wholly climate-dependent activities such as rain-fed agriculture. Second, a year of extreme wetness or dryness in a tropical environment like Nigeria may not necessarily be a part of some climate changes. However, establishing a variability pattern as a norm may become an element of climate change (Adesina, 2012).

Ayoade (2004) defines climate change as the synthesis of weather at a given location or area over at least 30 years. He went further to state that climate change is associated with global warming. Global warming refers to the process whereby certain gases in the earth's atmosphere allow the sun's warming energy to pass through on its way into the atmosphere. Also, global warming is affected by increasing greenhouse gas levels.

IPCC declared in its report in 2007 that 'warming of the climate system is unequivocal'. Also, the global mean temperature has increased by 0.76°C between 1850–1899 and 2001–2005. It concluded that most of the observed increase in global average temperatures since the mid-20th century is 'very likely' (> 90% probability) the result of human activities that are increasing greenhouse gas (GHG) concentrations in the atmosphere. The IPCC scenarios published in 2007 predict that the pace of climate change is 'very likely' (> 90% probability) to accelerate with continued GHG emissions at or above current rates, with globally averaged surface temperatures estimated to rise by 1.8°C to 4.0°C by the end of the 21 centuries.

Changes in temperatures and other climatic features will vary globally. Hot extremes, heat waves and heavy precipitation events will likely become more frequent. Tropical cyclones will likely become more intense, with more significant peak wind speeds and heavy precipitation associated with increasing low sea surface temperatures. Decreases in snow cover, already observed in some regions, are projected to continue. The regions affected by these extreme events, including many major tourism destinations, will expand (IPCC, 2007).

These predicted changes highlight the need for awareness and preparedness for natural hazards at the local level through systematic capacity building and strategies for disaster risk management (UNWTO, 2007). Climatic factors, such as temperature, sunshine hours, and (the absence of) rain, determine a large share of European international tourism flows. Statistical analyses by Maddison (2001), Lise and Tol (2002), Hamilton and Tola (2004), and a simulation study by Hamilton et al. (2004) show the relevance of climatic factors as determinants of tourist demand.

According to Maddison (2001), the max daytime temperature should ideally be close to 30ºC, while Tol (2002) estimate the optimal 24-hour mean daily temperature to be around 21ºC. In tourism, climatic conditions have long been taken for granted because of their long-term stability. There is overwhelming evidence that the global climate is changing because of emissions of greenhouse gases. Therefore, the climate is not stable anymore (Abegg et al., 1998).

## 2.8. Climate Change in Numbers

Based on the Sixth Assessment Report (AR6) published by IPCC in 2021, global climate change can seem abstract to many. Nevertheless, multiple lines of evidence reveal how the global climate system is already changing, which can be mentioned below:

• Global land surface temperature was 1.83°C above the 20th century average in 2022; (https://www.climate.gov/)

• 16 of 17 warmest years on record globally have occurred since 2000; the five warmest have occurred since 2010; (NASA's Goddard Institute for Space Studies (GISS))

• Over 1 trillion tons of Greenland ice was lost between 2011 and 2014 alone; (Breslin, 2016)

• Global mean sea levels continue to rise, reaching a record high in the satellite era; (UNFCC, 2022)

• Global climate change can seem abstract for many, but multiple lines of evidence reveal how the global climate system is already changing; (UNFCC, 2022)

• 2022 was the warmest year on record globally since measurement began in 1880; (UNFCC, 2022)

• Land surface temperatures (LST) of 60° have warmed at more than twice the global rate (+3.5°C); (IPCC, 2016)

• Oceans absorb more than 90% of the excess heat caused by greenhouse gases and have warmed at all depths, with surface temperatures reaching a record 0.75°C above the 20th-century average; (IPCC, 2016)

• 2022 marked the 40th consecutive year (since 1977) that the annual temperature has been above the 20th-century average; (World Metrology Organisation, 2022)

• For any given month in 2016, 12% or more of global land areas were experiencing at least severe drought conditions, the most on record (since 1950); (UNFCC, 2020)

• Oceans absorb about 25% of the carbon dioxide produced by human activities and, as a result, have become 30% more acidic, a rate unprecedented over the last 300 million years (IPCC, 2021). (IPCC, 2021)

## 2.9. The Emergence and Speeding up of Climate Change

The tourism sector recognises that the world's climate will directly impact natural landscapes (Becken and Hay, 2007). Although destinations will be differentially affected, scholars claim that coastal and mountain landscapes, vital for tourism activities and local and regional economies, are at significant risk (Scott and McBoyle, 2007). Tourism depends on coastal landscapes, which may suffer grave damage from the effects of climate change through rising sea levels, higher storm surges, more extreme temperatures, and changes in precipitation patterns (Moreno and Becken, 2009).

Beach erosion has been identified as one of climate change's most pressing and dramatic manifestations (Phillips and Jones, 2006; Schleupner, 2008). Although erosion may occur in the absence of climate change due to alterations of sediment flows induced by urban and touristic development (Baldwin, 2000), climate change can exacerbate extant environmentally degraded areas.

There are numerous uncertainties regarding the exact mechanisms through which climate change may increase the intensity of beach erosion. However, mounting evidence points to a relationship between climate change effects (i.e., sea level rise, intense storms, coral bleaching) and beach erosion (Cambers, 2009; Buzinde et al., 2017). Early tourism research on climate change focused on sector adaptation (Koenig and Abegg, 2017). When it refers to climate, it means average patterns in weather, the product of processes occurring in the earth's climate system e which is composed of interactions between the atmosphere, the hydrosphere, the land surface and the biosphere (Richardson, Steffen, and Liverman, 2011).

Climate, the natural environment, income and discretionary wealth, personal safety, and travel costs are critical factors in travel motivations and destination choice (Hall, 2005). Because all these factors appear likely to be affected by climate change (Scott, Hall, and Gössling, 2012), the implications for tourist behaviour and demand patterns at local, national, and international scales could be profound.

Tourist perceptions of environmental change are significant for destinations sensitive to climatic change (Gössling and Hall, 2006; Hall and Lew, 2009; Scott, 2006; Scott, Jones and Konopek, 2008). Compelling evidence shows that the global climate is changing rapidly. Climate change has become a challenging issue which has emerged as one of the most significant and controversial areas of academic research and policy development in recent years.

As one of the world's fastest-growing industries involving many aspects, tourism is particularly sensitive to climate change because of its close connections to the environment and climate. For example, the climate directly impacts the resources available for tourism and its participants (e.g., perception of weather, thermal comfort, and safety). The importance of the tourism sector in the IPCC assessments, therefore, has evolved since the First Report in 1990 and was strengthened in the recent Fifth Assessment Report (IPCC, 2014), particularly concerning the recognition of transboundary impacts, the sector's contribution to climate change, and its mitigation requirements (Scott, Hall, and Geossling, 2016).

Evidence of the continuing, rapid warming of the planet has been unrelenting and significant advances have been made in our understanding of changes in extreme weather associated with climate change. Land and sea surface temperatures have continued the multi-decade warming trend, with the five warmest years in the instrumental record occurring since 2010. Consistent with the expected physical responses to a warming climate, the frequency, intensity, and duration of extreme heat, heavy precipitation, and drought events are increasing in most continental regions of the world (Scott et al., 2016).

A warming planet accelerates the water cycle, generating unfamiliar regional weather patterns and more extremes of rainfall and drought. The observed changes are rapid compared to the pace of the natural variations in climate that have occurred throughout Earth's history. Its most recent assessment report of IPCC in 2020 concluded that climate change is "unequivocal" and that human influence on the climate system is evident.

## 2.10. Extreme Weather Events

Climate change affects sea levels and ocean wave extremes mainly because of changes in duration, frequency, intensity and path of tropical and extratropical storms, which are considered the main drivers of waves and sea level extremes (IPCC, 2012, 2014a). Because the sea level is rising, the heights of these extreme events are increasing. Even if there were no changes in storm behaviour, such increases would exacerbate wave run-up resulting in coastal inundations in the form of storm surges and tsunamis (IPCC, 2014a). Temperate and tropical regions are where storms are expected to increase the most (IPCC, 2010b).

The effects of storm floods have their peak related to spring tides. A storm can flood a coastal area for days if storm winds push the waters toward the coast during spring tides, resulting in larger flooded areas for a more extended period, which can last even during the ebb tide (IPCC, 2010b). Such increases in storm intensity will result in an acceleration of coastal erosion processes, bringing disruption to beaches and dunes systems. In many locations, artificially restocking these areas will be more difficult due to short supplies in nearby areas and the costs associated with beach and dunes nourishments, reducing resilience in those territories (IPCC, 2014b).

Floods can have huge impacts on livelihoods and businesses. They damage and destroy property and houses and kill people, livestock and wildlife. Of all the natural hazards, floods are considered to be the costliest hazard and affect the most people (National Research Council, 2015). The population exposed to 1 in a 100-year coastal flood in 2010 was about 270 million, expected to rise to 350 million in 2050, considering only socioeconomic development as the most relevant driver. However, there are other drivers, including population growth, economic growth, and urbanisation (IPCC, 2014b).

The flood disaster declaration in the United States of America (US) rose from 5 in the 1950s to 51 in 2008 and 2010. Such an increase is partly caused by climate change but also because more people live in exposed areas (National Research Council, 2015). Asia and sub-Saharan Africa are the regions where such exposure is the most expected due to socioeconomic development (IPCC, 2014b).

## 2.11. Climate Change Trends and Possible Predicted Scenarios

Climate change has been identified as a "Mega Risk" globally. As such, a title is chosen since climate change is a long-term issue, it is difficult to quantify its impacts, and it is not "owned" by anybody (Bicknell et al., 2009). So, it can be said that the tourism sector will be endangered by climate change in future. The most vulnerable tourist destination is the natural landscape, such as the hilly, mountain and coastal areas. Coastal areas are destinations that are negatively affected by climate change.

There is ample evidence of the physical and environmental impacts of climate change. Continued emissions of greenhouse gases into the atmosphere will continue to affect the climate and the oceans in the future substantially. Scientists have prepared a range of projections and models related to emission scenarios and the different policies that governments might choose (IPCC, 2018).

Projections of global warming and global mean sea level rise from the IPCC Sixth Assessment Report (IPCC AR6 WG1) are explained below for the mid and late 21st century (2046–2065 and 2081–2100 averages, respectively). The projections are relative to temperatures and sea levels in the late 20th to early 21st centuries (1986–2005 average). Temperature projections can be converted to a reference period of 1850–1900 or 1980–99 by adding 0.61 or 0.11 °C, respectively annually, as it goes toward the future years.

## 2.12. Air Temperature

Most climate models, including the Sixth Assessment Report (AR6) of IPCC, suggest that during the 21st century, the Mediterranean region will experience a warming period, with an average air temperature increase of 3.2 °C, which is higher than the global average (2.6 °C). Warming is expected to be greater in summer than in winter. The most elevated mean temperatures are expected in summer over Iberia, the Balkans and Anatolia, where the temperature increase will likely reach +5 °C by the end of this century.

Based on the AR6 assessment report published by IPCC in august 2021, climate predictions also indicate an increase in the number of hot events across the region. The number of warming events is likely to increase threefold by 2025, with three warming events expected every four years, compared to the current rate of one warming event every four years. Moreover, the frequency and intensity of these events will increase with heat waves maintaining higher temperatures for extended periods, particularly in the second half of the century.

## 2.13. Precipitation

Precipitation (rainfall and snow) is expected to decrease by 25% in summer (per the A1B scenario1 of IPCC published in 2014) and 10% in winter by 2100. By the end of this century, the most significant decrease in summer precipitation (by more than 60%) may occur in the areas affected by the most considerable warming (Iberia, Anatolia, and the Balkan region). In winter, the most critical season for replenishing water resources in many Mediterranean areas, precipitation is expected to experience only minor changes (a slight increase might even occur) in the northern part of the Mediterranean.

In contrast, significant reductions in rainfall are expected in the southern Mediterranean. Though the line's location separating these opposite tendencies is uncertain, climate models agree that the south of the Mediterranean and the Middle East, where water resources are already scarce, will experience a further rainfall reduction by 2100 (about -20% in winter and -35% in summer).

## 2.14. Sea-Surface Temperature and Salinity

Climate change has a deep and vast range of impacts on the coastline and its ecosystems and even human health at the coastal destinations and will sooner or later affect coastal tourism demand all over the globe.

Coastal environments, in general, are among the most physically dynamic environments on Earth, yet there exists a tremendous stability bias concerning coastal development. Coasts are influenced by short-term extreme storm events that can alter shore areas in a matter of hours and long-term gradual processes, such as changes in sea level. Both methods are projected to accelerate significantly in the twenty-first century because of anthropogenic climate change (IPCC, 2012; Solomon et al., 2007).

When discussing climate change and global warming at a coastal tourism resort, tourists are mainly aware of more tangible factors like temperature and humidity. However, these two factors, especially temperature alone, never represent "climate" or "weather" (Gössling et al., 2006; Scott et al., 2008).

Most tourists going to a warm coastal destination are only afraid of global warming and temperature rise or heat wave during the summer.

## 2.15 Impacts on Sea Level Rise

The scientific community assumed the link between climate change and sea level rise. It acquired more considerable institutional recognition with the work carried out by the Intergovernmental Panel on Climate Change (IPCC), more precisely since the publication of the First Assessment Report (FAR), the first significant report of global importance on the subject (IPCC, 1990). Successive IPCC reports further recognised this link and its consequences (IPCC, 1996, 2001, 2007, 2014a).

Sea levels have changed over time, with amplitudes around 100 m between cooler (Glacial ages) and warmer (Interglacial ages) periods (IPCC, 2007). However, since the last Glacial period, sea levels have risen more than 120 m (Lambeck et al., 2004). A rise of 21 cm since 1880 was considered stable. This stability ended in the second half of the Twentieth century with an acceleration in sea levels (Church and White, 2011) associated with greenhouse gases (GHG) generated from human-related activities (IPCC, 2007).

According to IPCC Fifth Assessment Report (AR5), it is very likely that between 1901 and 2010 sea level has risen globally at an annual average of 1.7 mm, with an increase to 2.0 mm between 1971 and 2010 and 3.2 mm between 1993 and 2010 (IPCC, 2014a). Projections for this century continue to point to an increase in the annual global mean sea level rise in all scenarios. (IPCC, 2014a).

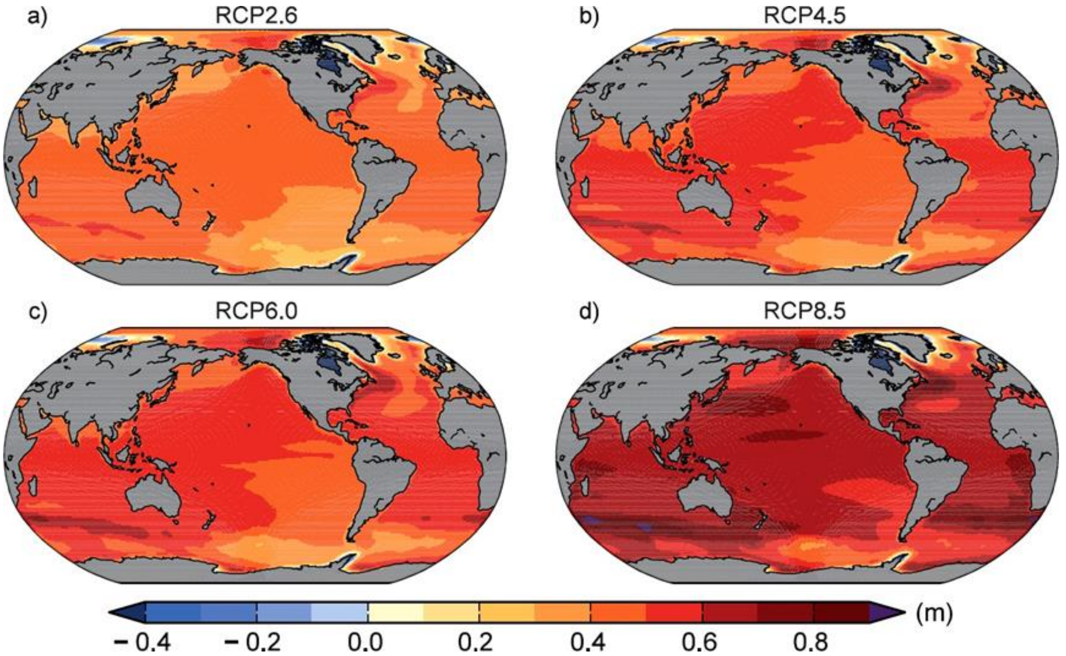


**Figure 2.1. Relative Sea Level Change 2081-2100 close to 1986-2005 (meters).**

**Source: Figure TS.23, IPCC, 2014a.**

Figure 2.1. shows sea level rise projections published by IPCC for different scenarios. For the period 2081-2100, concerning 1986-2005, the IPCC Fifth Assessment Report expects an increase in global mean sea level rise, likely to be from 0.37 to 0.69 m in the Special Report on Emission Scenarios (SRES) A1B scenario; 0.26 to 0.55 m in RCP2.6; 0.32 to 0.63 m in RCP4.5; 0.33 to 0.63 m in RCP6.0; and 0.45 to 0.82 m in RCP8.5 with medium confidence. According to this last scenario, the sea level will rise from 0.52 to 0.98 m in 2100, being the rate between 2081 and 2100 from 8 to 16 mm per annum, with medium confidence (IPCC, 2014a).

Despite being lower than in the RCP8.5, all other scenarios are higher for 2100 compared to the period between 2081 and 2100. In SRES A1B, the global rise in sea level is expected to be from 0.42 to 0.80; RCP2.6 from 0.28 to 0.61; RCP4.5 from 0.36 to 0.71; RCP6.0 from 0.38 to 0.73; and in RCP8.5 0.52 to 0.98 m (IPCC, 2014a).

Down here, as shown in Figure 2.2., a compilation of paleo sea level data (purple), tide gauge data (blue, orange and green), altimeter data (light blue) and central estimates and likely ranges for projections of global mean sea level rise from the combination of Coupled Model Inter-comparison Project Phase CMIP) 5 and process-based models for Representative Concentration Pathways (RCP) 2.6 (blue) and RCP8.5 (red) scenarios, all relative to pre-industrial values (IPCC, 2014a).

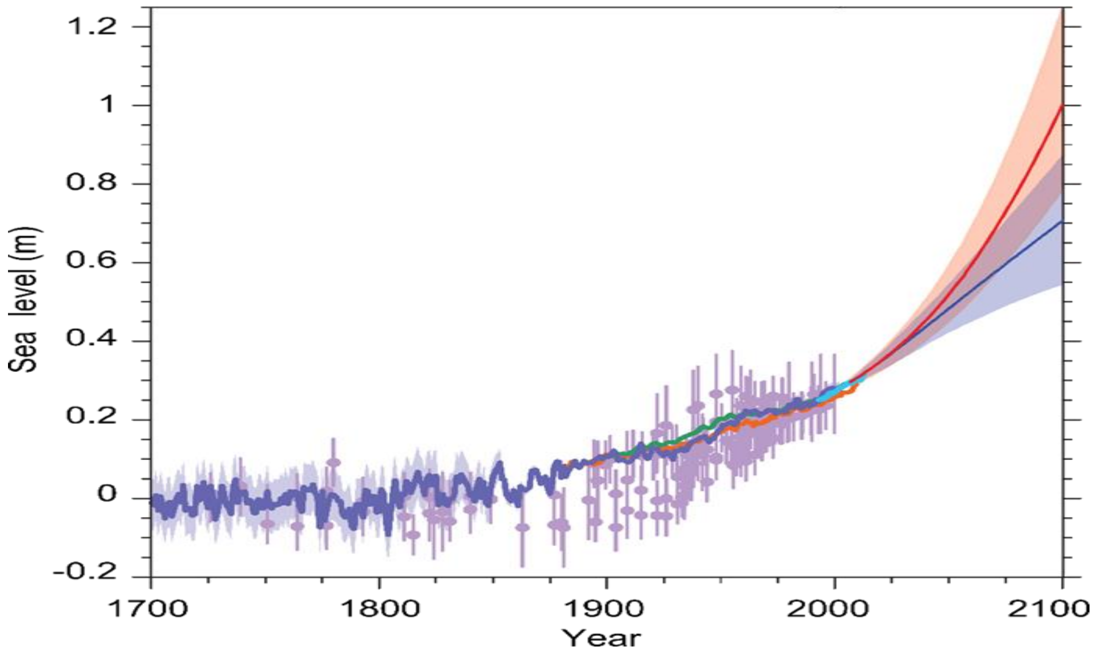


**Figure 2.2. Combination of CMIP 5 Model and (RCP) 2.6 (blue) and RCP8.5 (red) scenarios**

**Source: IPCC (2013)**

Increasing seawater temperature generally implies lower water density and a larger water volume. Increased salinity has the opposite effect, as water density increases with salinity. These two factors may balance each other out. However, uncertainty about the magnitude of this variation today makes it challenging to predict regional sea-level changes accurately. Moreover, the total mass of seawater in the Atlantic Ocean is likely to rise since the global water mass will increase as glaciers and ice sheets melt (IPCC, 2014). Vertical movements of landmasses and different sea level trends in other parts of the Mediterranean will further increase the uncertainty of regional sea level change. Scientific projections still offer a wide range of values, from hardly any difference to rises of many tens of centimetres (Antoniolli et al., 2017).

Europe's predominant summer tourist flows are from north to south to the coastal zone. However, coastal tourism is one of the most vulnerable to climate change, and the Mediterranean region is the world's most popular holiday region. These Mediterranean destinations, such as Spain, Portugal, Greece, Croatia and south of France, have a relatively high proportion of foreign tourists and an above-average economic reliance on tourism (IPCC, 2007).

Most recreational activities in coastal and marine environments depend on climate conditions (Scott et al., 2008). In some cases, weather even determines or limits tourists' involvement in certain activities, as it directly impacts on comfort or safety of participants. In other instances, climatic events could affect the natural resources essential for tourist activities, decreasing attractiveness and visitor numbers (Uyarra et al., 2005).

Coastal areas seem particularly vulnerable to climate change impacts as they are exposed to extreme climate events and sea-level rise (IPCC, 2007). This vulnerability is exacerbated by multiple stressors, increasing social pressures such as rising population and development (Nicholls et al., 2008). However, it can be said in a brief that towards the end of the 21st century, two scenarios indicate that July and August will probably be less suitable for coastal tourism, and possibly a change in the seasonality pattern of demand might occur (Paul E. Parham et al., 2007).

Climate change might result in a "doughnut" pattern of demand in the European Mediterranean region that there will be more tourists in the shoulder seasons (fall and spring) than in the summer. According to Perry, the increased erosion of the beaches caused by sea level rise will indirectly result in a reduction in demand and an increase in the need for planning restrictions in the coastal areas (Perry, 2007). Erosion of beaches and sea level rise will lead to a reduction of the usable beach area all over the world.

## 2.16. Impacts on Marine Life

There is much evidence found recently globally among scientific investigations showing that oceanographic and climate parameters, both individually and in combination, are affecting coastal and marine ecosystems in coastal tourism destinations. Climate change may affect the diversity, size and composition of marine species and communities through multiple pathways. (Badjeck et al., 2010). Marine and coastal communities will also respond differently to climate change impacts in combination with human pressures and local conditions. Despite these variations, some general trends of biodiversity impacts are already being observed and provide evidence for future scenarios (Kont et al., 2008; Lapinski, 2012). These negative changes will affect the world of coastal destinations and should be considered to reduce market loss in the coastal destinations.

## 2.17. Coastal Erosion and Sediment Deposition

Coastal erosion and Sediment deposition occur very frequently in most hotspot-vulnerable areas across Europe, from the Northern regions of the Baltic sea to the southern parts of the Mediterranean Sea coastal zones. Several studies reports that extreme erosion events caused by increased storminess in the eastern Baltic Sea and the decline in sea ice occurrence are observed more frequently (Ryabchuk et al., 2012; Žilinskas, 2008; Kont et al., 2008; Lapinski, 2012). BSR-wide projections for coastal erosion are not available (EEA, 2012). There is uncertainty about whether climate change is the cause of increasing cliff erosion in the southern BSR (Wenk and Jansen, 2011).

The local effects of erosion in the coastal destination should be studied in detail as several factors are affecting coastal erosion (IPCC, 2007): 1) sea level relative to land elevation; 2) wave conditions including; height, frequency, direction, extreme conditions; 3) wind and current conditions including; direction, intensity; 4) geology/soil types on land and seabed; 5) topography and morphology; heights of dunes and areas behind the beach as well as the form of the shoreline; and 6) bathymetry; seabed depth and gradient.

In the case of beach change, a survey of tourists to Barbados and Bonaire found that under a severe scenario where "beaches largely disappeared", 77% would be unwilling to return, though again, it is unclear how respondents interpreted such a scenario. Greater complexity was revealed in a study of beach erosion and restoration perceptions in Playa del Carmen in Mexico (Kerstetter and Redcliff, 2010; Buzinde, Manuel-Navarrete, Yoo, and Morais, 2010).

Coastal and beach erosion can be intensified by cleaning beaches of litter (and beach wrack) and dredging of marinas, which can cause the removal of sand, a precious touristic resource. The results of plant and animal species richness showed that even extensively used beaches suffer dramatically under tourist activities (Schierding et al., 2011; Grunewald, 2006). As such, beach-cleaning and armouring that might increase due to climate change impacts the status of the biological diversity and accelerates the deterioration of nature-tourism resources.

Most beaches have been eroded due to storms (Tonisson et al., 2008); in only a few places, accumulation processes have been observed, and thus recovery of beaches occurred (Kont et al., 2008). Beach and dune erosion, coastal damages and protection systems may lead to a less attractive shoreline negative impact on coastal destination image (Sherman et al., 2002; Jedrzejczak, 2004; Schlacher et al., 2008; Kont et al., 2008) and tourism sector as tourists do not prefer artificial coastlines or groins. Coastal erosion might affect roads, railways, water supply and sewage systems, tourist facilities, valuable land, valuable natural environments, and recreational areas (Hamilton, 2007; Meyer-Arendt, 2001).

## 2.18. Ocean Water Warming

Ocean warming will change the atmospheric and oceanic conditions, leading to an increased probability of storms and water evaporation, negatively affecting the wind speed on the coastlines. Ocean warming will be the main contributor to coral reef bleaching due to reefs' high vulnerability and sensitivity to water temperature. The mean maximum summer seawater temperature of the Mediterranean Sea has risen by around 1 °C during the last three decades (Marbà and Duarte, 2010), and there has been an increase in the frequency and intensity of marine heat waves (Coma et al., 2009). Seawater warming can kill organisms such as the mussel Mytilus galloprovincialis (Anestis et al., 2007; Gazeau et al., 2014). During summer and autumn, seawater temperature is above 26–27 °C. (Ramón et al., 2005).

## 2.19. Water Acidification in the Mediterranean Sea

The Mediterranean Sea is low in nutrients except where coasts are affected by eutrophication, such as the Adriatic Sea. There is a general eastward pattern of increasing sea surface water temperature (SST), salinity (S), oxygen concentration, total carbon and alkalinity. Seasonal pH amplitudes can be very large, particularly in the relatively shallow North Adriatic Sea, which also has an extensive seasonal temperature range. The SSTS patterns are mainly explained by evaporation coupled with highly alkaline freshwaters entering the basin from rivers and the Black Sea (Schneider et al., 2007; Cossarini et al., 2014; Álvarez et al., 2014).

The anthropogenic CO2 concentration for the Mediterranean Sea (Schneider et al., 2007; CIESM, 2008b; Touratier and Goyet, 2009) is higher than in the Atlantic Ocean and the Pacific Ocean (Lee et al., 2003; Sabine et al., 2002) at the same latitude, and higher than other marginal seas in the northern hemisphere (Lee et al., 2011). The increased uptake of anthropogenic CO2 in the Mediterranean Sea is related to its active overturning circulation (Pinardi and Masetti, 2000) and relatively high temperature (Palmiéri et al., 2014; Schneider et al., 2010).

A dataset from the Northwestern Mediterranean Sea indicates a pH reduction of approximately 0.0018 pH units per year (Meier et al., 2014; Howes et al., 2015) from 1994 to 2006. For the next fifty years, an extrapolation of data from this time series (Dyfamed, central Ligurian Sea) leads to an estimated pH decrease of 0.07–0.13 units corresponding to a decreasing rate of 0.002 ±0.001 pH units per year (Geri et al., 2014).

## 2.20. Increased Heat Wave Occurrence as Extreme Weather Phenomenon

There is no single concept of a heat wave, which explains why there are different definitions (Kalkstein and Valimont, 1986). Nevertheless, heat waves are characterised by specific common patterns. They are often defined as extreme high-temperature events that last for several days (UNWTO 1999). So, heat waves are restricted to the simultaneous fulfilment of two conditions: (1) temperatures above a certain threshold, which establishes whether a day is considered to be hot or not; and (2) a certain persistence in the number of consecutive hot days (Folland et al., 1999). From an atmospheric point of view, they are associated with mechanisms that operate at the synoptic scale, often related to stationary, or almost stationary, zones of high pressure that are of subtropical origin (Koffi and Koffi, 2008).

## 2.21. Marine Invasive Species Increase

Invasive warm water species of algae, invertebrates and fish increase their geographical ranges due to climate change (Bianchi, 2007; Lejeune et al., 2010). This tropical fauna and flora now form a significant portion of the biota in the Southern Mediterranean (Lasram and Mouillot, 2009), where nearly half of the trawl catches along the Levantine coast consist of fish originating from the Red Sea (Coll et al., 2010; Costello et al., 2010). Most of the 955 alien species recorded so far have been found in the Eastern Mediterranean (Zenetos et al., 2002), where many are detrimental to fisheries, although some are now targeted commercial.

## 2.22. Decrease in Available Domestic Water

Climate Change can also indirectly impact the quality of the services provided by the facilities, for instance, through the availability of water. This aspect receives plenty of attention from the literature, especially concerning countries that already suffer from water scarcity. As regards physical impacts, climate change is expected to cause wet tropical regions to get wetter (European Commission DG Environment, 2012). While dry subtropical regions become drier, reducing soil moisture and runoff (Seager et al., 2013), for northern regions, the water stress is projected to reduce (Koutroulis et al., 2019). Water availability is one of the most intrinsically complex factors, as it is determined by a considerable number of variables apart from most obvious temperatures and precipitation: plants vegetation response (Mankin et al., 2019), population growth, ageing and water supply infrastructure (Kristvik et al., 2019).

## 2.23. Impacts of Climate Change on Tourism and Tourism Impacts on Climate Change

The tourism sector is dependent on the weather and climate. Most outdoor tourism activities focus on the attraction of knowable biophysical resources such as beaches, lakes, and even forests, all of which are climate dependent. For example, critical ecosystems offering winter sports and beach holiday facilities will be directly threatened by global warming and sea level rise. Enhanced temperatures in the mid-latitudes may reduce the relative attraction of some Mediterranean, and longer-haul destinations, especially in areas like Portugal and Spain, become more prone to hurricanes (Amelung and Viner, 2006; Moreno and Amelung, 2009). It is also important to underline that the relationship between climate change and tourism is twofold: climate change impacts on tourism, and tourism influences climate change.

## 2.24. The Concept of Climate Change Impact Chains

Tourism's long-term sustainability depends on the preservation and enhancement of its environment. Climate change affects ecosystems' services to tourism (Cheer and Lew, 2017; Kaján et al., 2015). For example, more frequent and severe heatwaves or beach availability reduction due to rising sea levels influence the value of the recreational experience at the destination, affecting tourism demand and expenditure.

In general, the systematic assessment of the complex relationship between climate hazards, risks, tourism demand, and tourism experience value requires the accurate identification of a conceptual framework through which analysing the literature: The Impact Chains (IC). The concept of IC was introduced by Isoard et al. (2008) and Schneiderbauer et al. (2013), then 'catalysed' by the German cooperation (GIZ) in the Vulnerability Sourcebook (Fritzsche et al., 2014) and since then widely used as a climate risk assessment method at the global scale (UNDP, World Bank, Horizon 2020.), as well as at local, regional or national level.

Under this approach, the risk is defined as 'the potential, when the outcome is uncertain, for adverse consequences on lives, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure' (IPCC, 2014a). Thus, risk assessment concerns the interaction of climatic, environmental and human factors that can lead to impacts and disasters and how to manage the underlying risks (Birkmann, 2006; Turner et al., 2003).

The Impact Chain looks like a diagram (Schneiderbauer et al., 2013), which summarises the relationships between different climate shocks, ecosystem services and economic activities under study, taking into account exposure (to climate parameters), sensitivity (related to physical and socio-economic features of the destination), and adaptive capacity. According to the Glossary of the IPCC Fifth and Fourth Assessment Report (IPCC, 2014a; IPCC, 2007), the components of the Impact Chains can be defined, as shown in Figure 2.3.

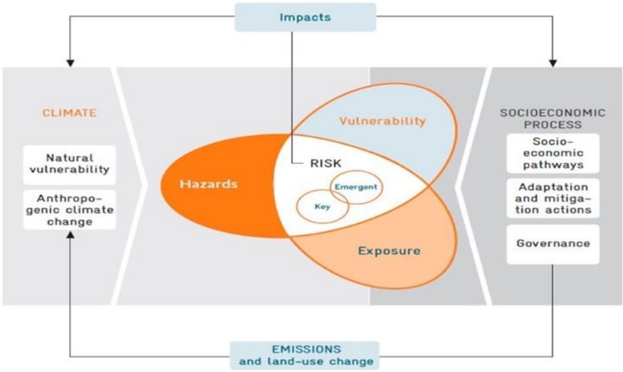


**Figure 2.3. Climate Change Impact Chain, Source: Schneiderbauer et al. (2013)**

The impact Chain can be both a technical tool integrating quantitative and qualitative results from different disciplines and a participatory tool, allowing a better understanding and dialogue with communities, policymakers and stakeholders. Impact Chain has been employed to analyse climate-related risks for agriculture, food production and consumption, terrestrial and marine biodiversity and tourism (Dickinson et al., 2014; Jacxsens et al., 2010; Mach et al., 2016). This Chain represents the main application to support the design of disaster risk management and adaptation strategies in urban and coastal cities (Abadie, 2018).

Some definitions used in climate change studies are defined below:

- Hazard is the potential occurrence of a climate-related physical event or trend with a physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (Brooks, 2003; Brooks et al., 2005);
- Exposure is the presence of people, livelihoods, species, ecosystems, environmental functions, services, infrastructures, and economic, social, or cultural assets in places and settings that could be adversely affected (Dickinson et al., 2014). Absolute numbers can express the degree of exposure, densities, or proportions of the elements at risk (e.g. population density in an area affected by drought);
- Vulnerability is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (Ford et al., 2010; Füssel, 2007).
- Sensitivity may include physical attributes of a system (e.g. building material of houses, type of soil in agriculture fields), social, economic, and cultural attributes (e.g. age distribution, income distribution). Adaptive capacity refers to the ability of societies and communities to prepare for and respond to current and future climate impacts.
- Risk is the potential climate-related consequence (climate impact) for something of socioeconomic value (assets, people, ecosystem, culture, among others) (Brooks, 2003; Dickinson et al., 2014; Tangney, 2019). Impacts are the effects on natural and human systems, on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of CC or hazardous climate events occurring within a specific period, given the level of vulnerability of an exposed society or system (Nguyen et al., 2016; Schneider Bauer et al., 2013).

In general, climate defines the length and quality of tourism seasons and plays a significant role in destination choice and tourist spending. Climate affects a wide range of environmental resources and critical attractions for tourism, such as snow conditions, wildlife productivity and biodiversity, water levels and quality. Climate also influences environmental conditions that can deter tourists, including infectious diseases, wildfires, insect or water-borne pests (e.g., jellyfish, algae blooms), and extreme events such as tropical cyclones (Di Franco et al., 2012).

The integrated effects of climate change will have far-reaching consequences for tourism businesses and destinations. Importantly, climate change will generate negative and positive impacts on tourism, which will vary substantially by market segment and geographic region. The implications of climate change for any tourism business or destination will also partially depend on the impacts on its competitors. (Di Franco et al., 2012).

A negative impact on one part of the tourism system may constitute an opportunity elsewhere. Consequently, there will be 'winners and losers at the business, destination, and national levels. Due to the minimal information available on the potential impacts of climate change in some tourism regions, this qualitative assessment must also be considered with caution. (Di Franco et al., 2012.).

The relationship between climate change and tourism is in two ways: climate change impacts tourism, and the tourism sector also influences climate change (Peeters, 2007). As a harsh environmental phenomenon, climate change will directly impact the tourism sector by shifting the distribution of climatic resources among different destinations worldwide. This shift could change the length and quality of tourism seasons and even tourism seasonality affecting both the temporal pattern and spatial distribution of coastal tourist flows and their spending timings (Amelung et al., 2009).

Climate change may lead to higher flood risk, increasing the threat of loss of life and property in coastal regions and damage to infrastructure, and finally, might lead to loss of coastal tourism (Watkiss et al., 2005). Warmer water temperatures and extreme precipitation will increase the risk of jellyfish in the coastal zone, which can also threaten tourists while surfing or swimming. Climate change is also likely to increase the risk of infectious diseases during the high season in hot weather due to favourable virus transmission conditions, which can threaten the coastal tourism market (Maddison, 2001).

It is recognised that tourism is subject to weather and climate, with sun, sand and sea travel decisions mainly being based on perceptions of warm, sunny environments. Hence, tourism depends on various climate variables such as temperature, precipitation, and humidity (Smith, 1993; De Freitas and Matzarakis, 2005). Accordingly, it is expected that climate change will affect travel behaviour because of altering conditions for holidaymaking at the destination level and climate variables perceived as less or more comfortable by the tourists (Agnew and Viner, 2001; Hamilton et al., 2004).

Most publications have warned that tourist destinations might lose part of their attractiveness due to their focus on tourists and their response to changing climatic variables. The effects of increasing temperatures and related parameters (such as rain) on the choice of a destination and time of departure have been focal points of research. For example, to identify 'optimal' temperatures, Maddison (2001) analysed travel patterns of British tourists and found that the maximum daytime temperature was 30.7 ◦C, with slight increases above this level leading to decreasing visits. Maddison also found that more significant rainfall would deter tourists.

The other probable impact of climate change can be heat waves in the coastal regions, which reduce Tourist's comfort and satisfaction. The research team's findings, led by Dr Sarah Perkins-Kirkpatrick from the Centre of Excellence for Climate System Science (ARC), divided the globe into 26 regions to examine how heat waves will change for every 1-degree Celsius rise in global temperature. They found that for every 1-degree Celsius rise during summer, there were an extra 14.8-28.2 heat waves. Heat waves would average 3.4 to 17.5 days longer. It is surprising to know about the alarmingly rapid increase in heat wave days in the tropics, where some regions transition to an almost constant heat wave state with just a 2°C rise. They found that even with just a 1.5°C increase in global temperatures, nearly all regions started to experience heatwave events every four years that once only occurred every 30 years. If global temperatures were to rise by 5°C, such events would occur annually.

It should be noted that, as 'temperature' is statistically significant in econometric studies of climate and tourism demand, it has been used as the proxy variable for the climate. The term 'Global Warming' in some tourism sectors, such as coastal tourism, can best describe the situation. However, as several studies have shown, 'climate' is more complex than just temperature as tourists consider a range of meteorological variables in their decision-making (Gössling et al., 2012).

Only systematic regional-level assessments are conducted a definitive statement on the net economic or social impacts in the tourism sector will be possible. Furthermore, the outcome will most likely depend on the extent of climate change. The impact on tourism may strongly parallel that of the global economy, where a 1°C temperature rise may result in a net benefit for the world economy. However, more significant increases increasingly show net declines (Di Franco et al., 2012). It is now widely acknowledged that, regardless of emissions reduction efforts, societies worldwide will be forced to adapt to inevitable climate change. It is critical to underline that, irrespective of the kind or magnitude of climate change impacts, all tourism companies and destinations will need to adapt to reduce risks and capitalise on new opportunities in a way that is economically, socially, and environmentally sustainable (Gössling et al., 2012).

## 2.25. Climate Change Impacts on Coastal tourism

Coastal tourism is impacted by climate change in various ways, and because these changes are all connected in a chain, the term "climate change" is used to describe them. Here, impact chains mainly describe how climate change has affected coastal tourism. Three primary types of IC, whose interactions travellers might have at tourist destinations, can be used to outline the developments that are taking place and which were significant for the coastal and maritime tourism sector: (i) The state of the natural environment; (ii) The state of the amenities and infrastructure; and (iii) The state of the comfort of tourists. The value of the tourist experience may decrease due to changes to these features brought about by climate change.

Climate Change related risks at destinations are presented as having a multi-hazard origin (Nguyen et al., 2016). For example, the risk of diminished destination competitiveness due to beach surface loss arises from sea level rise and higher erosion due to the increased energy of seawater beating the shoreline. In the case of ecosystem services, potential climate hazards affect different types of both marine and land environments. Regarding comfort and health, potential risks of thermal stress and changes in the likelihood of being affected by emergent diseases have been considered necessary. Concerning infrastructures and services, apart from damages to infrastructures and the cultural heritage, the availability of water supply has also been identified as an essential risk.

It was found that by adapting measurable risks, the areas and the possible climate changes chain impacts are as follows:

- Loss of the value of the tourist experience in coastal tourism due to environmental attribute changes.
- Loss of species, growth in exotic invasive species, or a decline in the landscape makes marine areas less attractive.
- Loss of attractiveness and Tourist comfort due to coastline availability reduction.
- Loss of attractiveness due to increased danger of forest fires in tourist areas.
- Loss of attractiveness of land environments due to loss of species, increase of exotic invasive species or degradation of the landscape.
- Loss of tourist experience value in the destination due to changes in human being comfort.

- Loss of comfort due to increased thermal stress and heat waves.
- Increase of health issues due to emergent diseases.
- Loss of tourist experience value in the destination due to the change in the quality of infrastructure and facilities.
- Increase of damages to infrastructures and facilities (accommodation, promenades, water treatment system, among others).
- Decrease of available domestic water for the tourism sector.
- Loss of attractiveness due to loss of cultural heritage

Impacts listed in Arabadzhyan et al. (2021).

The Figure 2.4. represents an integration of the climate change impact chains for coastal tourism. Due to the intrinsic complexity of tourism destinations, risks must be formulated as the combination of many hazards and, at the same time, a single hazard may be linked to more than one risk.

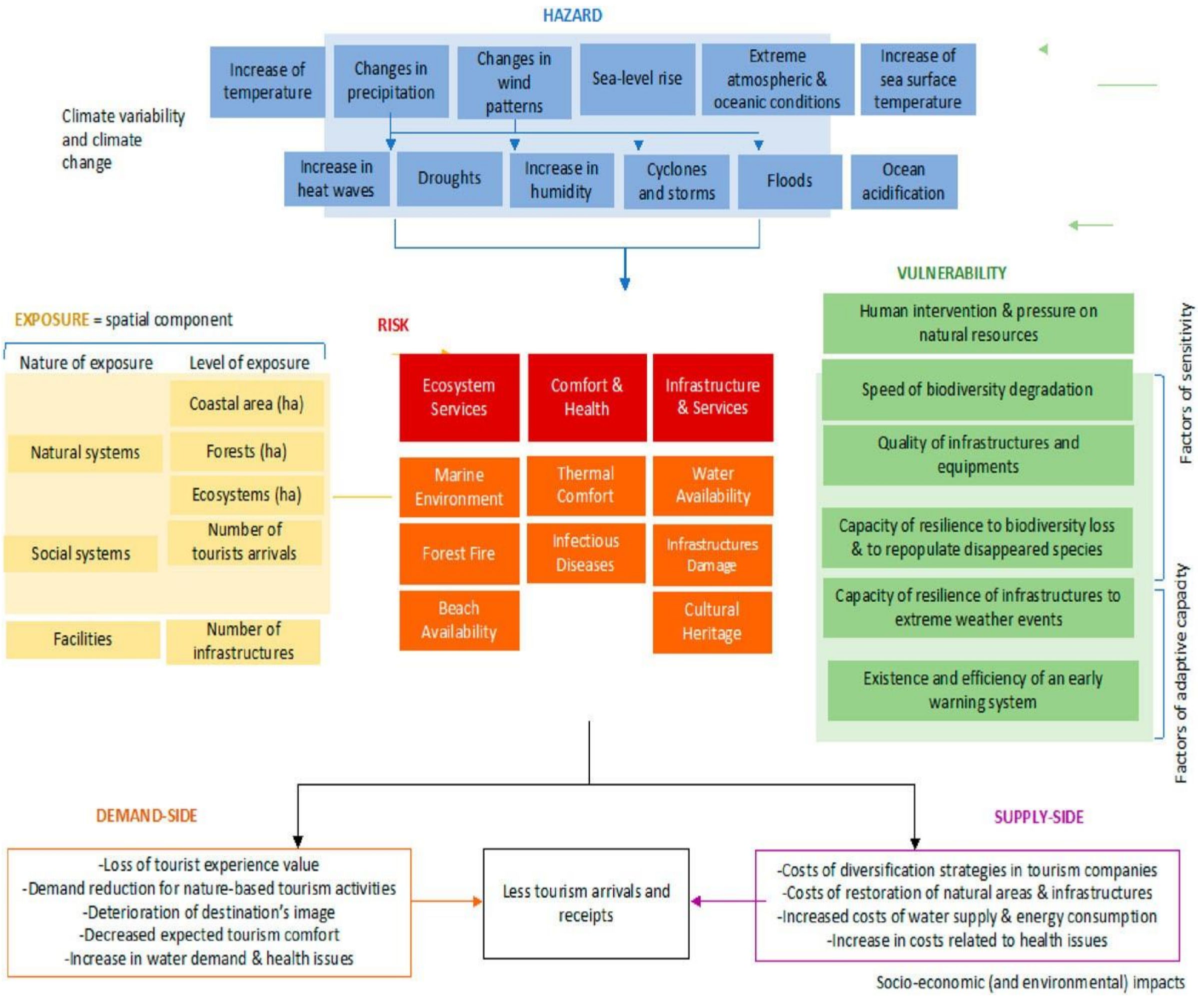


**Figure 2.4. Climate Chain Impact Chain on Coastal Tourism, Source: Arabadzhyan et al. (2021)**

The climatic hazards are shown in the Figure mentioned above (Figure 2.4. align with the existing literature and the IPCC reports. In particular, heat waves, droughts, floods, storms, and other extreme atmospheric events often have a substantial and essential instant impact on coastal tourism, biodiversity, society, and infrastructures due to their immediate destructive effects. Other climate hazards, such as the increase in average temperatures, changes in precipitation, wind patterns, sea level rise and ocean acidification, are less noticeable. Therefore, their impact is progressive but, at the same time, very relevant because of their influence on extreme hazards and their effect on ecosystems and habitats.

## 2.26. Direct Climate Change Impacts on Tourism

Climate change impacts also affect human health and lead to fatal illnesses: increasing temperatures cause heat stress and death rates from respiratory diseases. Young children and ageing populations are particularly vulnerable to heat waves, and the mortality rates from these extremes will likely increase. Climate change also has a detrimental impact on air quality, which has consequences for human health. Long-term exposure to reduced air quality increases premature mortality rates by causing more significant illnesses such as lung cancer and cardiopulmonary disease. Ozone (O3) is a harmful air pollutant sensitive to changes in weather conditions such as those caused by climate change; climate change will increase human exposure to ozone (Schleussner et al., 2019).

Climate change also increases the risk of the spread of vector-borne diseases, which have decreased over recent decades such as Malaria. Globally 88% of the existing burden of infections caused by climate change is carried by children under five. Also, these climatic changes may increase the risk of transmission of tropical infectious diseases, which can negatively impact the region's image in tourist destinations worldwide (Schleussner et al., 2019).

Among other main negative direct impacts of climate change on human beings, respectively tourism sector is related to the influence of climate on factors such as the thermal comfort of visitors, the risk of transmission of infectious diseases and increasing the risk of natural disasters. These changes might change and alter the temporal distribution of the leading tourism markets. The climatic parameters such as daily temperature, annual rain and snow precipitations, and the UV index substantially impact the tourist selection for a seaside resort region affected by climate change during the last decades. Climate change also may cause harsh coastal erosion and increase the coastal regions' average temperature and humidity percentage (DPPRI, 2009).

Changes such as sweet water availability, losing biodiversity, landscape aesthetic reduction, altered agricultural production (e.g., wine tourism), coastal line erosion, damage to coastal infrastructures and even the increasing incidence of infective diseases in coastal areas might all harm the tourism sector to varying degrees. Impacts of mitigation and adaptation policies about issues such as tourist mobility policies that seek to reduce CO2 emissions due to tourist activities will lead to increased transport prices. They may foster environmental attitudes that lead tourists to change travel patterns (DPPRI, 2009).

The Fifth Assessment Report (AR5) of the IPCC (2014) states that projected increases in temperature throughout Europe, the Middle East and North America and decreasing precipitation in southern Europe are to be expected with increasing global warming. Climate change may lead to global warming and respectively heat wave occurrences; therefore, rising air temperatures may create discomfort for tourists during the hottest months of outdoor activities. The coastal tourism high season in the northern hemisphere, which is from July to August, but otherwise prolongs tourist seasons and extends tourism opportunities to other coastal destinations.

## 2.27. Indirect Climate Changes Impacts on Tourism

The influence of climate and weather on human well-being and health was noticed long ago. First thoughts about the biological significance of the climate can be found in the works of the father of medicine, Hippocrates. There are several mechanisms by which climate can affect health (Haines and Patz, 2004). Extremes of air temperature and rainfall, such as heat waves, floods, and drought, have direct, immediate effects on mortality and longer-term effects (Ahern et al., 2005).

Climate change is also likely to affect biodiversity and the ecosystem goods and services it relieson for human health. Usually, the impact of climate and weather on human well-being and health reflects in the psych-emotional reactions to the weather, climate change, the abnormal changes of physiological processes in the body that lead to deterioration of health, the occurrence of clinical disorders, illness and even death. As a rule, healthy people do not notice weather changes (Haines et al., 2006).

If adaptive mechanisms in a body are not adequately coordinated, even a healthy person can experience metabotropic reactions in the form of lung ailment and a decline in health. Adaptive mechanisms do not compensate for physiological disorders in a patient and a weakened human (especially with age). Some health problems may occur because of travelling to climate-stressed locations (e.g., caused by heat stress, UV radiation, air pollution or heat stroke). Climate advisory service activity can be beneficial to prevent tourists and especially such risk groups as retirees, sick people and children from these threats. Bioclimatic information may be successfully applied in tourism planning, tourism industries and in reducing adverse effects of weather and climate on tourists and this branch of the economy (Matzarakis, 2010; Scott et al., 2009).

## 2.28. Socio-Economic Impacts of Climate Changes on Tourism

Tourism is a particularly climate-sensitive economic sector, considering that climate change affects several vital factors pertinent to the tourism sector. Climate plays an important role in destination choice and the timing of travel (e.g., Scott and Lemieux, 2009; Kozak, Uysal, and Birkan, 2008; Hamilton and Tol, 2007; Hamilton and Lau, 2005). In addition, it allows for an activity to be undertaken or inhibits participation; for instance, ski tourism depends on snow conditions (e.g. Scott, Jones, and Konopek, 2008; Scott and Jones, 2007). Several studies have examined the influence of climate change on tourists' demands and flow based on future scenarios suggested by the Intergovernmental Panel on Climate Change (Scott, Jones, and Konopek, 2007; Hamilton et al., 2005; Lise and Tol, 2002).

The scientific community has considered the impacts of climate change on tourism on (i) a Global scale (Amelung et al., 2007a; Hamilton et al., 2005), (ii) a Country scale (Hamilton and Tol, 2007) and (iii) Destination scale, such as on coastal areas (Moreno and Amelung, 2009; Moreno and Becken, 2009; Phillips and Jones, 2006), islands, ski areas and parks (Scott et al., 2007; Jones and Scott, 2006).

Furthermore, extreme weather events, sea level rise, snow decrease, wildfires, and infectious diseases are some of the climate change impacts that could affect tourists' comfort, activities and safety. Heatwaves (UNWTO-UNEP-WMO, 2008), fires and droughts (Scott and Lemieux, 2009), hurricanes, transportation accidents, delays, and cancellations (Koetse and Rietveld, 2009) have been reported, resulting in injuries and life losses, which induce insecurity to tourists. Therefore, cancellations of next season's bookings in affected areas.

For instance, the 2003 heatwave in France was responsible for 15,000 deaths and significant shifts in traditional tourist flow for this year away from the traditional resorts in the Mediterranean and towards Northern beach locations (UNWTO-UNEPWMO, 2008). On the contrary, regions in which climate change leads to moderate temperatures and does not incur extreme weather conditions, not traditional destinations, will experience a double positive effect. Considering that there will be an influx of tourists from the most popular destinations, locals will no longer travel to foreign holiday destinations (Hamilton et al., 2005).

The coastal tourism sector is essential to regional and national economies and employment; it is the most considerable single maritime economic activity in Europe; it employs more than 2 million Europeans. Coastal destinations are the most popular destinations for domestic and foreign tourists. Coastal areas are also crucial for the leisure and recreation of the local communities, and they are a part of regional identity, place image and branding. While climate change impacts on human life have well-defined and different origins, the interactions among the diverse influences still need to be fully understood. Their final effects, especially those involving social-economic responses, are likely to play an important role (ECORYS, 2012).

Sea level rise could substantially impact river deltas on coastal zones, which are often more densely populated, have more infrastructures, and may wipe out entire islands and island nations. Sea level rise is, therefore, one of the most prominent assessments of the impacts of climate change, and the costs of sea level rise are equally famous in the estimates of the costs of climate change (Nicholls et al., 2008).

In 1991 the IPCC had already proposed methodologies and estimates of the cost of sea level rise and the benefit of coastal protection (IPCC CZMS, 1991). Literature concentrates on the direct costs of sea level rise and possible adaptation options (Bosello et al., 2012). The main result of these studies is that the price of sea level rise (albeit in some cases a small fraction of GDP) can be considerably high in absolute terms. For example, US$0.06 billion is the estimated annualised cost of 50 cm. of sea level rise for the USA, according to Yohe et al. (1996). US$3.4 billion is Morisugi et al. (1995) estimate for Japan. A yearly cost ranging from euros 4.4 to 42.5 billion is the evaluation proposed for Europe by CEC (2007) for a sea level increase of 22 and 96 cm, respectively.

Against this background, coastal protection is practical and efficient in most cases. Coastal safety was confirmed for Europe as a whole (CEC, 2007), for the Netherlands, Germany (Nicholls et al., 2008), Poland (Zeider, 1997), Japan (Morisugi et al., 1995), Senegal (Dennis et al., 1995). Tol (2007) showed that high levels of coastal protection (>70% of the threatened coast) would be optimal for most of the world's regions.

According to Deke et al. (2001), the direct protection costs against the 13 cm. of sea level rise forecast for 2030 are a tiny percentage of GDP, ranging from 0.001% in Latin America to 0.035% in India. However, coastal protection investment reduces "productive" capital stock.

The input substitution processes triggered by capital scarcity imply a welfare loss ranging from 0.3% of India to 0.006% of Western Europe concerning the no protection case. The study also highlights the different results when countries are ranked according to direct costs or welfare losses. These results result from redistributing regional and international allocation effects of a slightly lower investment path.

Climate is by no means one of the most critical determinants of holiday destination choice (Witt and Witt, 1995; Gössling and Hall, 2006; Bigano et al., 2006; Rosselló et al., 2005). The "amenity of climate" is recognised as one of the significant determinants of tourism flows (Maddison, 2001; Lise and Tol, 2002; Bigano et al., 2006). The Mediterranean, in particular, benefits from this determinant, being close to the main holidaymakers of Europe's wealthy but cool and rainy Northwest. Tropical islands are another example, where in the recipe of a dream holiday, their "perfect" climate is a fundamental ingredient. Climate change would alter that, as tourists are particularly footloose. The currently popular holiday destinations may become too hot, and goals that are now too cool would be popular (Hamilton et al., 2005; Hamilton and Tol, 2007; Amelung et al., 2007b). This could have a significant impact on some economies. Just consider that about 10% of the world's GDP is now spent on tourism and that recent contributions highlight the importance of tourism in stimulating economic growth (Lee and Chang, 2008).

Bosello et al. (2004) and Berrittella et al. (2006) analyse the impact on the world economic system of climate-change-induced increase in sea level and change in tourism flows. Both studies are characterised as CGE models, which allow for assessing the "systemic" effects induced by changes in resources, technologies, and consumption patterns. These papers are the only ones that look at climate change's general equilibrium effects on tourism. Darwin and Tol (2001) and Deke et al. (2001) study the general equilibrium effects of sea level rise, but not as comprehensively as Bosello et al. (2004).

## 2.29. Impacts of the Tourism Sector on Climate Change

The first relation may ask for adaptation measures, while the second may ask for mitigation measures to reduce greenhouse gas emissions (Peeters, 2007). As one of the critical global economic sectors interconnected with many other sectors (aviation, accommodation), tourism is essential to climate change. Although tourism emissions of $CO_2$ were approximately 5% of the total global emissions in 2005, rapid growth is forecast for tourism, with an increase of 130% predicted from 2005 to 2035 (UNWTO-UNEP-WMO, 2008).

Tourism's role as a contributor to climate change needs to be addressed, with only a few studies investigating energy use and greenhouse gas emissions associated with tourist activities (Becken, 2002; Becken et al., 2010). The controversy about tourist travel and its impact on global climate has been publicised in newspapers and popular journals to inform the public. It also spreads a fair amount of scientific uncertainty (Zehr, 2000).

The composition of tourism-related emissions and energy consumption in different aspects, such as aviation (Cohen and Higham, 2011; Dubois and Ceron, 2006; Geossling and Peeters, 2007; Smith and Rodger, 2009), accommodation, and activity (Becken and Simmons, 2002), have been investigated to inform policymaking and management. Emissions from air travel are the main tourism contributor to global warming, which is responsible for 40% of the total carbon emissions caused by this sector (Geossling, 2009). Whether the worldwide tourism sector can deliver on its "aspirational" greenhouse gas emissions, its reduction targets are also largely dependent on emissions reductions related to air travel (Scott et al., 2010).

Compared to current trends of travelling longer distances, shorter stays, more frequent departures, and high flying (Ceron and Dubois, 2007), major modal shifts in tourism transport combined with holidaying in destinations closer to home are necessary for a lower carbon future (Dickinson, 2010). Unfortunately, the tourists' answers as to whether they would change their travel plans to reduce their impact on the global climate are ambiguous, although they are environmentally aware and educated tourists (Cohen, Higham, and Cavaliere, 2011; Hares et al., 2010; McKercher et al., 2010). In addition, academic research on tourism policy related to climate change is increasing gradually because tourism stakeholders are becoming more involved in responding to climate change (Gossling, Hall, Peeters, and Scott, 2010; Pentelow and Scott, 2011).

## 2.30. Conclusions

The chapter reviewed the literature on various issues related to climate change's impacts on tourism, specifically the coastal tourism sector and their relationship. It first discussed the critical points of this relationship before expanding the subject to various forms of tourism that exist while highlighting how the tourism sector is regarded as a highly climate-sensitive economic sector. As a result, the main effects of climate change are explored from a socioeconomic perspective while analysing the adaptation and mitigation measures put in place to deal with the impact of climate change.

The most significant future challenges to tourism growth include terrorism, pandemic, and climate change across the globe. All over the world, there are climatic issues at both the national and regional levels, which have a variety of implications for tourism. Environmental effects of climate change present a significant barrier to further tourism development, as natural landscapes serve as the primary tourist draw.

This chapter covered choosing a vacation spot, including the procedure for doing so and highlighting the impact of climate and weather. At the end of the chapter, knowledge gaps in this area are highlighted while discussing the potential consequences of climate change on tourists' choice of destinations and how they react to these changes. This chapter has offered a framework for the literature evaluation and the work plan around which this thesis will be developed.

The following steps include the collection and analysis of secondary data to define climatic change scenarios which might be happening in each of the case study regions. The results of these studies will be the primary input for subsequent studies in future.

# CHAPTER 3

# (Study site and Methodology)

## 3.1. Introduction

This chapter mainly details and accounts for the theoretical and practical applications of the research methods adopted. In this case, the advantages and challenges of the comparative case study approach are covered, exploring the benefits and challenges of using the system from a theoretical and practical point of view. Furthermore, the data analysis procedures and the data collection are explained.

As mentioned in Chapter 2 (Literature Review), the existing literature about tourism adaptation frameworks to climate change included are all under given conditions with the relatively high adaptive capacity of tourists, which can be different under extreme climate change scenarios. Therefore, it seems necessary to investigate how tourists will react to the proposed climate changes under IPCC (International Panel of Climate Change) scenarios. Due to the significant gap in the literature review mentioned in the second chapter, this chapter considers the various aspects of climate change and tourism under IPCC scenarios, specifically in case study regions of Kish Island, Iran and the Algarve region in Portugal.

This chapter describes the study site of the research and the methodology used. Accordingly, the chapter is divided into two parts. The first part provides detailed information about the study site's location and geography in Portugal and Iran. Further, the downscaling process is presented to select the most comparable regions in Portugal and Iran. The second part of this chapter provides a broad overview of the techniques and methodologies chosen as proper tools to analyse data under climatic change scenarios from different aspects in two case study regions.

The data analysing techniques, such as Mann-Kendall, Sheip-Sen, Lars-WG6, and RCPI, are explained. This study evaluates the climate change analysis trend of the last half century and the effects on the water resources of the case study regions. Moreover, the future directions of temperature and precipitation variables are predicted based on the past trends of climatic changes found in the secondary data resources.

The cluster zoning technique is used to downscale the case study in Iran due to its vast area, numerous climatic zones, and diversified tourism activities. Respectively same issue was applied to the case study of Portugal. It also tried to evaluate the climate change impacts of climate change on both case studies by assessing the observed data trends through the non-parametric Mann-Kendall and Sen's slope method.

As this study is concerned with detecting temperature and precipitation changes, changes in rainfall and flooding in case study regions, the past trend test in Man-Kendall was applied to estimate a model comprising the temperature and precipitation. Man-Kendall, accordingly, with the RCPI (Representative Concentration as Pass Way Modelling Index) scenarios to forecast the possible climatic changes that may have meaningful impacts on touristic activities in these two case study regions. The final assessment will be TCI (Tourism Climate Index) evaluation by using the results of the previously mentioned sections to see how tourists will react to climatic changes in future.

This chapter finishes with a discussion of climate change in the study site presenting observed and projected changes in the climate of the study area. The second part describes chosen methodology in all detail, explaining the sampling method for the respondents, a discussion of the research process and data collection methods, followed by a description of the design of the questionnaire.

## 3.2. The Comparative Study Approach

As Bryman (2013) states, comparative case studies involve the analysis and synthesis of the similarities, differences, and patterns across two or more cases that share a common focus or goal. They may be selected as an appropriate impact evaluation design when it is not feasible to undertake an experimental design and/or when there is a need to explain how the context influences the success of program or policy initiatives. The adaptation process to extreme environmental phenomena such as global warming resulting from climate change happens worldwide. This approach will benefit from different inputs of data and contexts that Portugal and Iran case studies can provide. Therefore, having two destinations in various phases of their life cycle and located on other continents will justify this comparative study approach. Research that follows the recommendation of diversifying the geographical contexts of the research is, for example, Correia and Kozak (2022).

## 3.3. The Quantitative Method Approach

A quantitative method was chosen for this research project due to its applicability to the research being undertaken. The quantitative approach provides several advantages in the research methodology's conceptual and practical framework. Namely, to get numerical measures of the impact of climate change and interpret the results of the analysed data. The studies about the impacts of climatic change on the tourism sector can be broadly divided into two main categories: qualitative approach studies and quantitative approach studies. Quantitative impact studies can be grouped into four subcategories: (1) Studies that predict changes in the supply of tourism services, (2) studies that predict changes in climatic attractiveness mainly by using tourism climate indices and using IPCC Climate scenarios (3) studies that estimate changes in demand by studying the statistical relationship between demand and weather or climate (4) studies that estimate tourism flows using simulation models (Bigano et al., 2008). This work mainly studies quantitative climate change impacts by the approach to subcategories 2 and 3.

## 3.4. The Case Study Approach

A case study approach is the premise for this study. This research methodology and the debate surrounding its use date back to the 1970s. It was used in the 1990s and is a widely used research methodology by postgraduate students (Susam-Sarajeva, 2009; Simons, 1996; Adelman et al., 1976).

Case studies associate the case study with a location, a local community, or a geographical area like a region or a country (Yin, 2013). Case studies are used more in social and economic contests. Usually, case studies are used in both quantitative and qualitative research (Bryman, 2012).

According to the map of Tourism Vulnerability Hotspots in Figure 3.1., which provides a summary assessment of the most at-risk tourism destinations across the globe for the mid-to late-21st century, there is still minimal information available on the potential impacts of climate change in some tourism regions, including Middle East region (UNWTO-UNEP-WMO 2008).

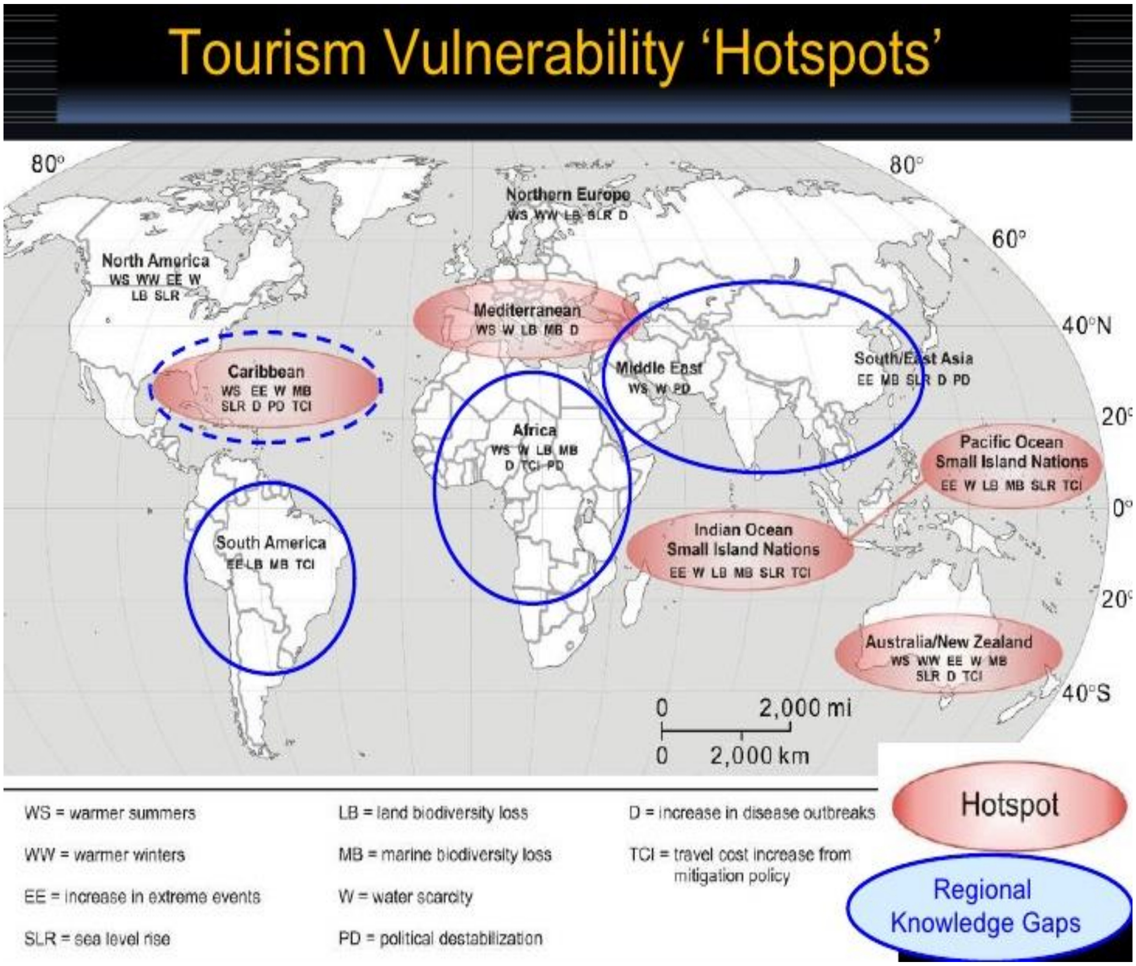


**Figure 3.1. Tourism Climate Change Vulnerability Hotspots, Geographic distribution of significant climate change impacts affecting tourism destinations Source: UNWTO.2008**

A systematic regional-level assessment was conducted using a definitive statement on the impacts of global warming on the coastal tourism sector. Therefore, this map suggests that Kish Island and the Algarve region are some of the regions that should be researched. Regarding tourism activities, these two places are mainly coastal and marine tourism destinations, so 3S tourism with other coastal outdoor activities is standard in these two regions. People living along the Algarve region coastline and Kish Island mainly depend on tourism, which is affected by the changes in weather and climate. It is consensual that these two regions are very climate-sensitive, and climate change is a significant threat to the coastal tourism sector.

As mentioned, due to climate change impacts, there will be a gradual shift in international tourism demand to higher latitudes. In general, the significant effects of climate change on coastal tourism competitiveness in these two regions can be briefly explained below:

(A) Tourism in Algarve (Portugal) is vulnerable to climatic changes because (1) the tourism sector is critical to Algarve's economy due to the contribution of tourism to the GDP and the employment in the region; (2) temperature increases in most other destinations in other Mediterranean countries are moderated to a more considerable extent by the sea, and (3) Tourist generator countries travel to Algarve (Portugal) may obtain a more attractive climate in the northern latitudes in future.

(B) The tourism sector in Kish Island (Iran) is also very vulnerable to climatic changes due to its dependence on tourism and climate vulnerability due to the contribution of tourism to the GDP and employment in the region. While these two locations are both in the northern hemisphere, they have the same timing calendar and tourism high season period starting from June and ending in September. Therefore, if a heat wave reaches these regions, many tourists will travel to other cooler or less warm destinations, mainly in the northern locations. For Portugal, the alternative for the Algarve is primarily located in the north or even on other northern European countries' coasts. The alternatives for Iran are in the Caspian Sea coastal region in the country's north.

The Algarve region is one of Portugal's most well-known and essential tourist destinations. It is in a mature stage regarding its tourism life cycle, with nearly fifty years of tourism activity. Generally, the steady repeat visitation patterns in the Algarve, where more than 60 out of 100 tourists (Correia and Pimpão, 2012) repeat visits to the destination for ages, justifies the Algarve maturity.

In the case of Portugal, some studies on the impacts of climate change on tourism have been done. Namely, Pintassilgo et al. (2016) highlight the impact of tourism, Calado et al. (2018) address vulnerable ecosystems as is the case of the Azores, an archipelago of islands in Portugal, Carvalho et al., 2014) that addresses climate policies in Portugal, or Surugiu, Breda, Surugiu, and Dinca, (2011) that compares the impact of climate change on the seaside in Portugal and Romania, among others. This contrasts with the case of Iran, where there need to be more studies about climate change impact assessments on the tourism sector. Therefore, it is necessary to carry out interdisciplinary and integrated research considering the climate change impacts on coastal tourism dimensions in these two countries.

## 3.5. Location and Geography of Case Study Regions by Cluster Zoning

The two countries of Portugal and Iran cannot be compared due to the vast area and numerous meteorological stations. A downscaling process is chosen to increase the validity and accuracy of data analyses and, respectively, a better reliable forecast of the future climatic scenarios for both case study regions. In general, downscaling climate change models for different case study regions is the procedure of using large-scale climate models. Climate predictions at finer temporal and spatial scales to fit the purpose of local-level analysis and planning. Downscaling is the process of relocating coarse resolution General Circulation Model (type of Climate Model) to fine spatial scale (ground station) data (Murphy, 1999; Fowler et al., 2007). A cluster zoning process was adapted based on defining touristic axes to downscale both countries.

The cluster zoning uses modified, well-known national touristic axes in both countries based on the locations' geographical similarities or the major touristic activities practised in the chosen regions.

## 3.6. Research Reliability, Validity and Sampling Method

The reliability and validity of the research are very significant from a theoretical point of view. There are several definitions for these two terms. Kumar (2014) postulates that reliability refers to whether the replicated data collection techniques and analytical procedures produce similar or near-similar findings. On the other hand, validity refers to whether the research measures what it seeks to measure. These two complementary aspects of research are essential in establishing the findings' trustworthiness, dependability, and worthiness.

A series of steps and procedures were initiated throughout the research process, from research design, data collection, analysis, and reporting of results, to ensure reliability and validity. The methodological design was carefully done by establishing the logical link between the research's central questions, hypothesis, and objectives.

Sampling is a fundamental issue in a comparative study because it should be peer-to-peer comparable with nearly the same characteristics in the main points. As comparing two countries need lots of data, time, and a considerable amount of data processing in this work, a downscaling method is applied to downscale two countries' sampling, especially for Iran, a vast country. Due to the high number of meteorology stations in Iran, it is decided to downscale all 31 provinces into some tourist zones with a common type of Tourism type as its axis.

In the case of Iran, besides a large number of meteorological stations and due to the diversified types of climate zones which are suitable for specific types of tourism activity it is tried to make the case study zone more concise and smaller after the downscaling process and as about seven Touristic axes are elaborated, and touristic zoning is also applied. With the help of downscaling technique, it will be easier to compare the impacts of the same phenomenon of climate change impacts on Tourism in a vast country such as Iran. The same pattern of downscaling case study samples using the touristic axis is applied to Portugal. In the case of Portugal also, 7 Touristic axes were designed to cover the whole country and its Islands in the Atlantic Ocean.


**Figure 3.2. Portugal 7 Touristic Axes Best Itinerary Routes Map (Source: https://www.kimkim.com/d/portugal/maps)**

## 3.7. Portugal Cluster Zoning and Sampling Case Study Region

International tourist flows are unevenly distributed between the different world regions. Europe is currently the world's leading destination, with a total of 648.9 million international arrivals (a market share of 48%) in 2018. The popularity of the Mediterranean is a predominant factor in Europe's leading position. Accounting for 209 million international arrivals in 2018, it is the single most crucial regional destination in the world (UNWTO, 2019). Most of the international arrivals in the Mediterranean originate from Europe itself, from northern Europe. Although recently, there has been a diversification in the spaces developed for tourism, coastal zones still play a crucial role as tourism destinations.

The European Union estimates that about 60% of trips within Europe with at least four overnight stays take place at the seaside: closeness to the sea remains a significant selection criterion despite the common opinion of the growing importance of cultural and nature-based tourism (Leidner, 2004). Multiple elements can explain the North to South flow of tourists that characterises the European tourism sector, including the accessibility, infrastructures, availability of attractions and cultural assets in the southern countries. The first factor in choosing a southern European holiday destination is the search for warm weather and sunshine by the seaside (Bramwell, 2004; Leidner, 2004; Mather et al., 2005).

Among the Mediterranean destinations, Portugal is one of the most popular and famous ones, which attracts many tourists during the year in Europe. Tourism is an important economic sector sector in Portugal, employing over 5% of the working population, and spending by foreign tourists contributes to about 4.5% of the national GDP (INE 2000). The central tourism destination regions are the southern coastal region of the Algarve, accounting for 41% of the Portuguese tourism market, followed by the main coastal metropolitan area of Lisbon and the Tagus Valley region, and thirdly by the islands of Madeira (INE, 2002).

Tourism's importance to the Portuguese economy and the unequivocal links of the sector with the atmosphere highlights the need to consider the climate in all its aspects. Weather and climate conditions are key elements in most tourism products provided by tourist destinations in Portugal. Thus, it is essential to consider the atmospheric factors now, but it is also important to consider any future changes in the atmospheric conditions (Gómez-Martín, 2005; Hall, 2008; Becken and Hay, 2007; Becken, 2010).

### 3.7.1. Algarve Region Case Study

Portugal has a long coastline with a wide variety of coastal destinations. Among them, the Algarve is the most famous one. In the middle 1960s, tourism resort areas started to appear in the Algarve region, polarising the attention and concentrating investment in these regions, leading the traditional tourist centres to lose their preponderance (Portugal Tourism Board Report, 2013).


**Figure 3.3. Algarve Region Location, Source (https://www.istockphoto.com/pt)**

Algarve Region is a coastal area located in the southern region of Portugal, covering an area of 77,55 km² and 280 km from the capital – Lisbon. It is located on the south coast of Portugal and the east coast of the Atlantic Ocean, Europe's westernmost area. The Coastal geomorphology in the Algarve region consists of diverse sandy beaches with different sand colours reeks, muddy tidal flats, cliffs, and rocky shores. The construction of the international airports of Faro (Algarve) allowed the establishment of air connections with the main inbound markets. By then, the accommodation capacity in Algarve started to increase significantly. There are many beautiful beaches in the Algarve region, picturesque fishing towns and a good climate, all of which combine to create the perfect holiday coastal and coastal 3S tourism destination (Algarve tourism board Report, 2013).

The Portuguese government announced the Algarve tourism plan in 2007 to position the Algarve region as a Top tourism destination in the whole country, promoting it as a modern and competitive coastal tourism. The high season in the Algarve region starts in June and ends in September (PENT by Turismo de Portugal, 2007).

On the other hand, the Algarve region could be negatively affected by climate change. In the Mediterranean areas, increasing average temperatures, respectively, with the increasing probability of heat waves, could result in temperatures exceeding the comfortable threshold more often and frequently in the future. It is estimated that, by the year 2030, the Algarve region will have a noticeable increase in the number of days with temperatures growing above 40°C. Many meteorologists are concerned that climate change is worsening with potentially catastrophic consequences in countries like Portugal. That could include the Algarve's coastal regions and towns. Thus, seaside resorts are becoming less popular and safe due to significant marine flooding (Len Port et al., 2015).

In the Algarve region, a sharp reduction in the number of days with comfortable levels is expected mainly because of heat stress (April, May, and October will concentrate 50% of these days). Further, an increase in the number of days with more intense heat waves; and a reduction in the number of days of cold stress. This means the Algarve region will be more attractive during spring and autumn.

In general, the impacts of climate change in the Algarve region are potentially significant but not necessarily negative. Under some scenarios, projections show that if global warming happens harshly in the summer season, tourist comfort in the Algarve region will deteriorate immensely, whereas, in the countries of the North of Europe and Portugal, conditions will improve. This will significantly reduce tourist flow and tourism revenues from Northern to Southern Europe in the summer to the Algarve region. On the other hand, in the spring and autumn, tourist comfort will improve in the Algarve region. However, since the summer season is the prevalent season for tourism in Europe, it is doubtful whether the deterioration in the summer conditions can be compensated by the improvements in the spring and autumn seasons unless institutional changes are taken simultaneously (Matzarakis et al., 2007).

The consequences of climate change in Portugal are expected to entail three significant geological effects in Portugal. First, due to the rise in sea levels, studies predict an increase in the erosion of Portugal's coastal areas. Second, scientists anticipate increased rain precipitation and floods carrying high social and economic costs. Finally, studies show that the tendency for increasingly hotter summers in Portugal has accelerated in the past few decades. Research and analysis based on data collected from 1931 to 2000 in Portugal demonstrate that the six hottest summers occurred in the last 12 years (SIAM, 2002).

### 3.7.2. Tourism and Climate Change in Portugal

Despite being one of the European countries most vulnerable to the effects of climate change, only recently Portugal started to design climate change policies to mitigate risks in coastal areas (Carvalho et al., 2014).

Regarding land use and occupation, the situation in Portugal reflects an imbalance in favour of coastal areas (Neves and Rodrigues, 2015; Veloso-Gomes et al., 2004). Currently, 2/3 of the population living in Portugal is distributed along the coastline (Craveiro, Antunes, et al., 2012). In the mainland region of Portugal, Lisbon and Porto's metropolitan areas concentrate most of the population. Although more dispersed throughout smaller agglomerations from North to South, the coastal zone has significantly more people than the inland regions (Craveiro et al., 2012a; Neves and Rodrigues, 2015). This trend reinforces the urgency and the necessity of effective adaptation measures for land management, especially those more directly related to coastal zones (Fernandes and Neves, 2017). The increasing exposure of populations in these territories (Domingues et al., 2018) to coastal climatic phenomena (IPCC, 2012, 2014a).

However, it was only in 2009, with the publication of the National Strategy for Integrated Coastal Zone Management (Estratégia Nacional para a Gestão Integrada da Zona Costeira – ENGIZC) (RCM no.82/2009, of September 8), that climate change starts to be part of the set of issues associated with coastal zones in Portugal. This national strategy emphasises the need to create measures to anticipate, prevent and manage situations of risk and environmental, social and economic impacts. These buffer zones should identify and contain the occupation in vulnerable territories based on precautionary measures (Fernandes and Neves, 2017; Carvalho et al., 2014).

More recently, the Strategic Framework for Climate Policy (Quadro Estratégico para a Política Climática – QEPiC), approved by RCM no.56/2015 of July 30, has framed the national climate policies. Further, it reiterates the need for articulation of land management instruments and institutions in integrating the climate mentioned above policies concerns within sectoral policies to reinforce these territories' resilience and adaptive capacities (Fernandes and Neves, 2017). Europe remains the most popular holiday destination in the world, hosting over half of the total tourist arrivals, having surpassed, for the first time, the one billion mark in 2012 – quadrupling the arrivals registered in 1950 (UNWTO, 2013). International tourism revenue grew along with the arrivals rate, totalling 837 billion € in 2012. Within Europe, the Mediterranean still holds a privileged position.

Climate change impacts could affect Mediterranean regions' environments in several other important ways. Warming temperatures (on both land and sea) are thought to increase the risk of droughts, wildfires, and desertification, particularly in the southern Mediterranean area. This could affect local water access, agriculture, and human health. Agriculture could also suffer from changes in precipitation (less frequent and/or more intense rainfall), reduced soil moisture and salt-water intrusion into freshwater aquifers. Sea level rise and coastal erosion can, in the longer run, reduce the effectiveness of coastal defences, resulting in flooding in low-lying coastal areas and disrupting transport activities and social services (roads, sewage systems).

Climate change is already altering the balance of the Mediterranean marine environment with severe and irreversible consequences for its ecosystems and the services they provide. The disruption of ecological functions and ecosystem services severely impacts human communities, especially in coastal areas where most touristic infrastructures are located, with high human dependencies on marine resources. Portugal is one of the southern European countries that has been outdoing the sub-region regarding demand share. Almost 7.7 million tourists entered Portugal in 2012 (UNWTO, 2013). It is the sixth country in terms of the number of international arrivals in the southern Europe/Mediterranean region, falling behind Spain, Italy, Turkey, Greece and Croatia and 5th in terms of tourism expenditures, with 11,056 million € accounted for in 2012 (UNWTO, 2013). Further, domestic tourism is not something to disregard (over 6 million people) (Turismo de Portugal, 2013).

The consequences of climate change for the tourism sector are unlikely to be uniform across European regions (Hall and Higham (2005), Rosselló and Santana (2014)). Current climate projections in the European case indicate that climatic conditions might become more favourable for tourism in the northern regions and less so in the southern regions (Ciscar et al., 2011). The net losses or gains induced by these changes will also depend on how tourists possibly alter their valuation of climatic-related amenities. For instance, one would expect that inhabitants of the northern regions of the European Union would value climatic conditions differently from people in southern regions who have easier access to sun-related amenities (Morris and Walls, 2009).

Portugal is a small country in Southwest Europe, with many Mediterranean physical and geographic features. The government is highly vulnerable to extreme weather events such as high temperatures and heat waves—the frequency and strength of these events increases due to global warming. (Beniston et al., 2007; Fischer and Schär, 2010; Nikulin et al., 2011). The primary motivation for 60% of the tourists coming to Portugal is to enjoy the sun and beaches (UNWTO, 2013).

Weather and climate conditions are key elements in most tourism products provided by tourist destinations in Portugal. Thus, it is crucial to consider the atmospheric aspects at the present moment, but it is also essential to consider any future changes in the atmospheric conditions (Smith, 1993; Wall and Badke, 1994; Gómez-Martín, 2005; Hall, 2008; Becken and Hay, 2007; Becken, 2010). Climate change and its impacts in Portugal were first addressed by Aguiar and Santos (1987), who projected a double increase in CO2 concentration, which will lead to a lower atmosphere global average temperature of 2.5°C.

The main contributions of Portuguese researchers to climate-related studies about Portugal started at the beginning of the XXI century. Their research relies on temperature changes (Wilbanks et al., 2007; Santos et al., 2001; Andrade et al., 2014; Ramos et al., 2011) and precipitation levels (Andrade and Santos, 2013; Costa et al., 2012) as these issues will potentially cause the significant impacts.

Although climate change and greenhouse gas emissions are a global phenomenon, the impacts of climate change are experienced locally. Scientific and local knowledge about place-based vulnerability is essential for developing adaptation strategies tailored to community needs (Hegarty, 1997; Keskitalo, 2004). In other words, adaptation strategies should be designed and implemented locally with input from the individuals and communities directly affected by climate change (Baker et al., 2012; Fatorić et al., 2014; Otto-Zimmermann, 2002).

Using different climate scenarios, studies on climate change in Portugal indicate that in the summer season, the temperature will increase from 3°C to 7°C in continental Portugal, especially in the Northern and Central regions of the country. Wilbanks et al. (2007) point out that by the mid-XXI century, the temperature will increase an average of 1.7°C (B2 scenario) and 2.5°C (A2 scenario) in Lisbon.

Santos et al. (2001) argues that temperature in Lisbon could increase up to 2°C and 4°C by the mid-XXI century and up to 5°C and 9°C by the end of the XXI century, according to B2 and A2 scenarios, respectively. Besides, Ramos et al. (2011) evaluated extreme temperatures over Portugal and found that both maximum and minimum temperatures are expected to increase under different climate scenarios during 2071-2100. For instance, the maximum temperature is expected to increase to 3.2°C and 4.7°C in summer under the B2 and A2 scenarios, respectively. In addition, an increase of 2.7°C (B2 scenario) and 4.1°C (A2 scenario) in the minimum temperature in summer is expected.

There are climate contrasts between northern and southern Portugal as the northern part is more influenced by the North Atlantic, while the south has a more typical Mediterranean climate. Considering these contrasts, Andrade et al. (2014) analysed projections for spatial-temporal distributions of temperatures in Portugal. They found that for the future period (2041-2070), significant warming trends of 2–4°C are expected in both seasonal and daily scales. Besides, an increase in the frequency of extreme events is projected over inland Portugal (Andrade et al., 2014). Andrade and Santos (2013) explored precipitation projections in Portugal for 2041-2070 and found that the winter means precipitation level is expected to decrease in total Portugal, except for the Northern region.

Besides, Costa et al. (2012) assessed precipitation extremes in Portugal. They found out that a significant decrease is expected in total precipitation in Portugal, especially in autumn over north western and southern Portugal during 2071-2100 under A1B and B1 SRES scenarios. In addition, the dry season is expected to extend from summer to spring and autumn due to the dry spell lengths in spring and autumn in Portugal (Costa et al., 2012).

Regarding the sea level rise in Portugal, Dias and Taborda (1988) project an increase of 0.14 and 0.57m in the mean sea level rise at the end of this century on the Portuguese coast. Moreover, 36% of continental Portugal is already affected by desertification, which could increase with less precipitation, higher temperatures and heat waves. (Santos et al., 2002) Another severe impact of climate change on Portugal is forest fires which are projected to increase in future in case of no adaptation measures (Carvalho et al., 2010).

### 3.7.3. Potential Impacts of Climate Change on Tourism in Portugal

European Environment Agency EEA (2012) predicts that the Mediterranean region, including Portugal, will be affected by the impacts of climate change. For instance, the temperature rise will be more significant than the European average; annual precipitation will decrease, biodiversity loss and desertification will increase, summer tourism will decrease, and shoulder season tourism will potentially increase. Moreover, researchers argue that climate change can significantly reduce comfort levels during part of the summer tourist season in the Mediterranean. (Amelung and Moreno, 2012).

All these projected changes in climate will have direct and indirect effects on the tourism sector of Portugal. Changes in climate patterns will significantly affect the present climate tourism potential of the area, which can lead to a decrease in peak seasons and a potential increase in shoulder seasons. Accordingly, occupancy rates are expected to be distributed through spring, summer, and autumn. (Amelung and Viner, 2006; Moreno and Amelung, 2009).

Portugal's coastline is approximately 2.830km, with sandy beaches, dunes, cliffs, and rocky shores. Because of changes in climatic patterns such as temperature and precipitation, which substantially affect tourist destination choice for coastal areas, they are one of Portugal’s most vulnerable tourism types. Among the most significant effects of climate change, coastal erosion is likely the first place for Portugal's coastal tourism. According to Coelho et al. (2009) and Lopes et al. (2011), beach erosion is of the most common impacts of climate change on coasts, as 67% of the Portuguese coast is estimated to be at risk of erosion during the subsequent decades, and the Algarve coast is one of the most vulnerable areas. It is also estimated that coastal erosion will increase Portugal's risk of inundation and land loss. (Coelho et al., 2009; Lopes et al., 2011)

Algarve shallow waters have warmed by almost 2°C since the 1980s, and sea surface temperatures are expected to be approximately 2.5 °C warmer by 2100. By the end of the 21st century, the combined effects of declining precipitation and increased evaporation are likely to cause an increase in the sea's freshwater deficit (by approximately 15cm per year), which in turn will contribute to progressively higher seawater salinity (SSS) in the order of 0.5 units over the next 100 years. These changes in temperature and salinity may affect other oceanographic processes and be reflected in thermohaline circulation (density-driven water circulation caused by temperature and salinity), lower intensity of upwelling and reduced formation of deep-water masses (Schleussner et al., 2019).

Portugal is projected to be exposed to a more than 0.4m projected change in relative sea level in the period 2081-2100 compared with 1986-2005 under a scenario where global warming reaches about 2.5°C by 2100 (RCP4.5). This will result in flooding and coastal erosion. Severe heatwaves, storms and droughts have already affected Portugal and will continue to do so, with increasing frequency and intensity. Increases in extreme precipitation are expected mainly over north-eastern Portugal in winter and spring. Wildfires are occurring more frequently and on a larger scale than initially expected. Relative to other Mediterranean countries, Portugal is the country which has suffered by far the most from forest fires. During the last 30 years, 35% of the region's fire incidents and 39% of the area affected yearly were in Portugal (Schleussner et al., 2019).

Portugal's Mediterranean climate is characterised by warm and dry summers and cool and wet winters (Carvalho et al., 2014). The vulnerability of Portugal to climate variability is well established. Portugal has experienced a rise in mean temperatures accompanied by intensifying highly high temperatures (Cardoso et al., 2019). Furthermore, eight of Portugal's 10 warmest years have been recorded in the last 20 years (Carvalho et al., 2014).

According to Aguiar, 2010, in the short term, climate change can positively impact tourism in Cascais, in the Lisbon area, such as an increase in the number of favourable months for beach tourism. However, towards the end of the century, seasonal demand pattern is expected to change as July and August will probably be less suitable for beach tourism. (Aguiar, 2010) point out that a reduction of beaches is also expected in Cascais due to rising sea levels and beach erosion. Besides, tourism in Algarve is a risk of climate change impacts such as the negative impact on the thermal comfort of visitors, the risk of natural disasters and infectious diseases, among others (Santos et al., 2001).

Portugal is one of the countries with the most significant spatial precipitation gradients, from the north-western region, which is directly affected by the passage of Atlantic storms, to the drier southern regions (Soares et al., 2015). Migratory batteries are responsible for most of the annual precipitation between November and April. According to Carvalho et al., "In the period 1902–2010, the region has experienced 10 of the 12 driest winter seasons in the last 20 years "(Carvalho et al., 2014). Portugal's annual precipitation has decreased by 90 mm per decade (Füssel et al., 2017). The observations show a tendency towards more frequent and intense extreme weather events, particularly heat waves, droughts, and extreme precipitation (Carvalho et al., 2014). The Mediterranean region, and specifically Portugal, is regarded as a climate hotspot, which is, among other impacts, projected to experience the most remarkable drying among 26 regions across the globe (Carvalho et al., 2014).

Portugal and the wider Mediterranean region have experienced an increase in the frequency of heat waves (Hov et al., 2013). Between 1981-2010 a total of 130 heat waves occurred in mainland Portugal during the dryer and hotter periods (between May and October) (Parente et al., 2018). 60% of these heat waves occurred in July and August (Parente et al., 2018). The areas with the most heatwaves were the northeast quarter and the southernmost region of Portugal. Also affected, but to a lesser extent and magnitude, were the central western coastal region and the metropolitan areas of Porto and Lisbon (Parente et al., 2018). In Portugal, extensive forest fires have already taken a very high toll (European Commission, 2019).

Between 1966 and 2017, around 160 significant wildfires and heat waves occurred in Europe, which together caused 140,000 deaths (Vitolo et al., 2019). Wildfires are also extremely financially costly. The six largest wildfires in Europe (Spain, Portugal, Croatia, and Montenegro) resulted in damage costing up to 732 million US Dollars (Vitolo et al., 2019). Portugal is the Mediterranean country that has suffered the most from forest fires. During the last 30 years, 35% of the region's fire incidents and 39% of the area affected yearly were in Portugal. On average, 3% of Portugal's forests burn annually (Hernández, 2019).

The mainland of Portugal has experienced severe droughts over the past 30 years, especially in the years 2004-2005, 2011-2012 and 2017-2019 (Carvalho et al., 2014; Sousa et al., 2019). 2005 was the driest year in the last 78 years, followed by 2007 and 2004 (Carvalho et al., 2014). The 2005 droughts affected 100% of mainland Portugal and substantially impacted different socioeconomic and environmental sectors (Dias et al., 2018). By the end of the hydrological year of 2005, 97% of Portugal was still in severe or extreme drought (Dias et al., 2018). Already 36% of the Portuguese continental territory is affected by desertification (Carvalho et al., 2014).

The Atlantic coast of Portugal is exposed to very energetic waves generated along the north Atlantic, which also constitute the dominant coastal hazard component (Vousdoukas et al., 2016). Extreme short-term events like coastal storms have become more intense and frequent and threaten coastal environments in Portugal, mainly during winter (Gomes et al., 2018).

### 3.7.4. Vulnerability of the Tourism Sector to Climate Change in Portugal

Portugal's vulnerability to climate change is becoming more widely recognised. "Portugal is one of the countries most hit by climate change," President von der Leyen said during the European Council meeting in December 2019. Southern Europe has seen temperature rises and precipitation declines because of climate change, according to the Intergovernmental Panel on Climate Change (IPCC). Furthermore, increases in drought frequency and magnitude in the Mediterranean region are expected to be significantly greater at 2°C than at 1.5°C of global warming. Rising sea levels exacerbate coastal hazards, and land pressures worsen existing risks to livelihoods, biodiversity, human and ecological health, infrastructure, and food systems (Schleussner et al.,2019).

In Portugal, mean and extreme temperatures have increased in the past decades and are projected to continue. Under a scenario where global warming reaches about 4.3°C by 2100 (RCP8.5), maximum summer and autumn temperatures in Portugal increase by up to 8°C and ultimate spring and winter temperatures increase between 2°C and 4°C. Annual precipitation has decreased, and climate models project that this decrease will continue. Under a scenario where global warming reaches about 3°C by 2100 (RCP6.0), precipitation will decrease by about 30% in the southern part and 15% in the northern part of the country (Schleussner et al.,2019).

Despite the potentially high-risk scenario for the tourism sector and the global environment, relatively little research has been undertaken concerning tourism and climate change (Becken, 2007; Hunter and Shaw, 2007). Studies about climate change in Portugal (using different climate scenarios) indicate that temperature will tend to increase from 3ºC to 7ºC for the summer season in mainland Portugal, particularly affecting the Northern and Central regions. In the Algarve region in the South, the temperature will increase on average 1.7 ºC and 2.5ºC (B2 and A2 scenarios) (Wilbanks et al., 2007) by mid-XXI century, while that change could reach 2 to 4ºC by mid-XXI century and 5 to 9ºC by the end of the century, for the maximum summer temperatures (Santos et al., 2001). Different scenarios forecast a reduction in annual rainfall in mainland Portugal by 20% to 40% of current levels, primarily due to a reduced rainy season which is expected to be more concentrated in spring and autumn. Most of the models predict a moderate rainfall increase in the North during the winter season for the period 2070-2099 in comparison to the baseline period of 1961-1990. Model projections are less consistent in the Centre than in the South in the winter season for the same period (Santos et al., 2001).

According to the second report of the SIAM project (Climate Change in Portugal - Scenarios, Impacts and Adaptation Measures), a reduction of 150 mm in median annual rainfall is estimated until 2050 within the four different scenarios. Further, Santos et al. (2001) argue that the decline would be especially accentuated in the autumn. Global climate models, such as coupled atmosphere–ocean general circulation model ECHAM4/OPYC3 (Semenov and Bengtsson, 2002) and the Hadley Centre model (Allen and Ingram, 2002; Allan and Soden, 2008) suggest that, in the future, precipitation will occur predominantly as short-term heavy rainfall events.

Nevertheless, there is no evidence of increased severe rainfall events in the past three decades in the Algarve region (Aguiar, 2010).

The projected changes in the study area could have direct and indirect impacts that may affect the tourist sector in opposing ways. Changes in climate parameters will cause significant changes in the present climate-tourism potential of the area. These could materialise in a favourable expansion of the tourist season, spreading occupancy rates more evenly through spring, autumn and summer. However, part of the summer tourist season may suffer an essential decrease in comfort levels (Amelung and Viner, 2006; Moreno and Amelung, 2009).

Rutty and Scott (2015) provide some new insights on thermal tourist preferences for beach tourism and the number of ideal or unacceptable months of Mediterranean beach and urban tourist destinations by early, mid and end of the XXI century.

The future climate scenario could represent an opportunity to reduce the seasonality that has traditionally characterised the tourist sector in the study region (Hein et al., 2009). According to Hadwen et al. (2011), where a marked variation in climate (differences in winter and summer temperatures or pronounced wet or dry seasons) exists, seasonality is mainly driven by these differences. In contrast, the reduction in precipitation could lead to a reduction in the availability of water supplies and an increase in water quality problems risks.

Another significant negative Impact of climate change in Portugal is forest fires. In contrast, in many areas, the physical impacts of climate change are likely to drive a higher probability of forest fires and a substantial increase in fire-vulnerable areas (Abrha and Adhana, 2019). The analysis of publications investigating socioeconomic impacts highlights the negligible effect of wildfires on the destination's attractiveness. A notable exception is a study by Otrachshenko and Nunes (2019), which reveals that burned areas harm the number of tourist arrivals. The authors estimate that projected costs to the Portuguese economy due to the impact of burned areas in 2030 will reach € 17–24 million for domestic and € 18–38 million for inbound tourism, while in 2050, costs may increase at least fourfold.

### 3.7.5. Air Pollution in Portugal by Dust of African Origin

Natural contributions to air pollution in Europe have been debated in the EU Report (IES–JRC, 2007). Accordingly, the contribution of natural sources to the PM levels at the European level may range from 5% to 50%. Mineral dust outbreaks are among Southern Europe's leading causes of high PM10 particle mass concentrations (Rodriguez et al., 2001; Borges et al., 2007; Wagner et al., 2009). Reis et al. (2002), Fialho et al. (2006) and Freitas et al. (2007) stress the importance of mineral dulong–ranging transport from North African deserts to specific Mediterranean Southern European countries like Portugal.

Last year the frequency of dust transferring into Portuguese air territory of African origin was a growing concern on the national scale. The Portuguese Environment Agency has warned of more frequent situations of poor air quality due to high levels of inhalable particles due to clouds of dust from North Africa, which are somehow out of control in Portugal. "A phenomenon that occurs when the air mass containing high concentrations of dust is transported over large distances from arid and semi-arid regions, reaching lower altitudes, and ground level, as is the case in the situation that is taking place during last years both in the interior North and South region of the country" (Agência Portuguesa do Ambiente, March 2022).

The Portuguese Environment Agency also indicates that "*this pollutant has effects on human health, mainly on the most sensitive population, children and the elderly, whose health care must be redoubled during the occurrence of these situations, and the specific recommendations of the Directorate-General must be followed*" (Agência Portuguesa do Ambiente, March 2022).

## 3.7.6. Sea Level Rise in Portugal

Portugal is predicted to see more than 0.4 change in relative sea level in 2081-2100 compared to 1986-2005 under scenario RCP4. 5, where global warming will reach 2.5°C by 2100. This will lead to flooding and coastal erosion. Estuaries and coastal lagoons will be the most affected by sea level rise in Portugal.

Based on Diário de Notícias has published the more alarming screenshots of the map, stressing that thanks to its long coast, "Portugal has several areas of risk". The bottom line, the paper admits, is that "it appears too late for whatever it is done  today to change what is coming in 31 years". According to this study which reveals flooded areas are as below: Starting at the border with Spain, areas underwater are those around Cacela Velha, Tavira, Santa Luzia, Praia do Barril, Fuzeta, Olhão, the islands of Ria Formosa, large parts of Faro, areas around Vilamoura, Armação de Pêra, Praia da Rocha, Alvor, Lagos (principally around Meia Praia and running inland), and Boca does Rio. On the west coast, some areas like the valley running up to the back of Aljezur – clearly once filled by seawater – appears set to return to the days of yesteryear. Elsewhere in the country, danger areas include the Tejo and Sado estuaries, parts of Aveiro and Figueira da Foz. (https://coastal.climatecentral.org/)

### 3.7.7. Droughts and Wild Forest Fires in Portugal

In the last three decades, Portugal has been the European country with the highest number of wildfires and the third-largest burnt area (BA) (Carvalho et al., 2010; Tonini et al., 2018). These events are associated with the type of climate, extreme weather and/or climatic conditions, type of vegetation and human activities (Flannigan et al., 2009; Khabarov et al., 2014; Turco et al., 2017). Several studies have correlated fire occurrence or / and BA with drought periods around the world, including Portugal (Aragão et al., 2018; Dimitrakopoulos et al., 2011; Margolis et al., 2017; Nogueira et al., 2017; Ruffault et al., 2018; Russo et al., 2017; Scasta et al., 2016; Urbieta et al., 2015).

The fire incidence in Portugal is determined (Pereira et al., 2005; Trigo et al., 2006) by: (i) the Mediterranean type of climate, which, with mild and humid winters and hot and dry summers, defines the type and life cycle of the vegetation, and explains the prominent summer fire season peak and the secondary fire season in the late winter-spring; and, (ii) extreme weather (heat waves) and climate (droughts) conditions, which determines the vegetation physiological state (Mateus and Fernandes, 2014). The combined effect of precipitation scarcity over relatively long periods, along with other climatic anomalies, such as high temperature and low relative humidity, may contribute to the increase in tree mortality (Gouveia et al., 2009), which plays an essential role in fuel dynamics and availability (Stephens et al., 2018). As a disturbance agent, drought is linked to the fire regime triangle, which defines the linkages between vegetation, which is a determinant of broad-scale fuel characteristics, climate conditions that support fire weather, and ignition sources, either human or natural (Moritz et al., 2005; Parisien and Moritz, 2009). In the fire regime triangle, vegetation is considered the fuel of wildfires encompassing live vegetation individuals (e.g. grass, shrub, trees), aboveground vegetation residues (e.g. leaf litter, fallen branches), and below ground partially decayed biomass (e.g. peats). Weather and climate, the second element of the fire regime triangle, have, in turn, a profound influence on fire ignition, fire behaviour, and fire severity. For instance, at the regional scale and at the seasonal or inter-annual time scales, severe droughts at the beginning of the fire season (late spring and early summer) inevitably lead to high levels of vegetation stress, increasing the flammability of live and dead fuels (Pausas and Paula, 2012).

The spring fire season is particularly evident in the Northern region of Portugal. It is mainly driven by drought and low air humidity, associated with anomalous atmospheric anticyclonic circulation associated with blocking activity (Amraoui et al., 2015). Summer fire incidence depends on the occurrence of very intense dry spells during days of extreme synoptic situations (Amraoui et al., 2015; Parente et al., 2018) and relatively long dry periods with an absence of precipitation in late spring and early summer, which was one of the objectives of this study. The atmospheric circulation drivers lead to the establishment of a surrounding circulation over the Iberian Peninsula, characterised by easterly winds on the north facade of Portugal, northwest winds on the western facade and southwest winds on the Algarve coast, which generally inhibits the occurrence of forest fires because it brings on the continent an atmospheric current with moderate temperatures and high moisture content (Durão and Corte-Real, 2006). The disruption of this surrounding circulation with warm and dry easterly winds over Iberia increases the fire incidence and the LWs occurrence (Costa, 1994; DaCamara et al., 1997).

### 3.7.8. Water shortage in Portugal

The major rivers in Portugal are the Tagus, the Douro, the Guadiana and the Minho, with which hydrological basins are shared with Spain, as is that of the Lima. The seasonal distribution of river discharge will change due to climate change as it had dramatic changes recently: discharge will concentrate in winter months and reduce in spring, summer and autumn. The relative magnitude of the impact of climate change on river discharge increases from the North to the South of the country. A reduction of low flow volumes up to −50 % was shown for the Tagus River in the period 2070-2099 compared with the reference period 1981-2010, in an assessment based on five climates (GCMs) and five hydrological models and four different scenarios of climate change ranging from a low- to a high-end scenario of global warming (the so-called RCPs 2.6, 4.5, 6.0 and 8.5). (https://www.climatechangepost.com/portugal)

The magnitude and frequency of floods will increase, particularly in the North, due to the precipitation concentration in the winter and a predicted increase in the frequency of heavy rainfall. Water quality will deteriorate, particularly in the south region, due to a rise in temperature and a reduction in river flows in the summer. Groundwater tables will sink, especially in near-subsurface aquifers, due to the expected replenishing rate reduction and evaporation increase. There will also be an increase in saline contamination of coastal aquifers due to saline intrusion as a result of sea level rise. (https://www.climatechangepost.com/portugal).

The combined effect of changes in recharge, crop water demand and sea level rise on groundwater levels and flow into coastal wetlands was studied for three Mediterranean areas: The Central Algarve (Portugal), the Ebre Delta (Spain), and the Atlantic Sahel (Morocco) (16). This was done for combinations of a Regional Climate Model (RCM) and a driving Global Circulation Model (GCM) under the IPCC A1b climate scenario for the periods 2020–2050 and 2069–2099 and compared with 1980–2010 (for the Portuguese and Moroccan sites) and 1960–1990 (for the Spanish site), (https://www.climatechangepost.com/portugal).

According to the results:

- Crop water demand will increase steadily, causing 15–20 % additional evapotranspiration until 2100. For the Portuguese site, crop groundwater demand is expected to increase by 32 %.
- Groundwater recharge will decrease toward the end of the century (mean >25 %) in all three areas.
- The response of groundwater flow to the projected decreases in recharge and increases in pumping rates will be a strongly reduced outflow into the coastal wetlands.
- In the long term, water availability in the three regions is projected to decrease substantially and, together with increasing water demands, may seriously affect the well-being of humans and ecosystems that depend on groundwater for their subsistence.

### 3.7.9. Coastal Erosion and Coastal Rock Fall in Portugal

The Portuguese coastline is about 1187 km, of which approximately 44% are beaches. The coast is diverse in its geomorphologic features, including sandy beaches and dunes, high cliffs and low-lying rocky shores, coastal lagoons and barrier islands. High energy waves and the intense longshore sediment drift make the continental Atlantic coast naturally vulnerable to erosion and flooding, with Lisbon and Algarve being the most exposed regions (Martins et al., 2013).

According to the Portuguese Environment Agency, about 75 beaches in the Algarve are at risk of rock falls (Ambiente Portugal, 2014).

The Ria Formosa coastal lagoon is located in a Natural Park on the south coast of the Algarve, Portugal. It is formed by two peninsulas (Ancão and Cacela) and five barrier islands (Barreta, Culatra, Armona, Tavira and Cabanas). This area represents a significant and biologically rich reserve with highly diversified fauna and is a popular tourist destination because of its extensive sandy beaches. Additionally, it is one of the most valuable and essential wetland areas worldwide, protected by the Ramsar and Bern conventions (Ceia et al., 2010).

The Ria Formosa, a barrier island system, is highly vulnerable to erosion and storm exposure, especially its fragile dune fields and beaches with narrow barriers and gentle slopes (Ceia et al., 2010). The main reasons for progressing erosion were the construction of marine jetties in the 1950s, seawalls and greyness in the early 1980s to protect settlements and infrastructure, and illegal buildings on the dunes (Ferreira and Matias, 2013), exacerbated by massive tourism development (Ceia et al., 2010). Thus, the coastal protection structures interrupted the longshore drift and caused sediment starvation, and buildings destructed the dune system. The below-mentioned Figure 3.4. map of Portuguese Coastal Erosion is illustrated with distinguished red lines showing the most vulnerable zones.


**Figure 3.4. Map of Coastal Erosion in Portugal, Source: APA, 2021**

## 3.7.10. Impact of Climate Change on the Vector Born disease in Portugal

Climate change also increases the risk of the spread of vector-borne diseases, which has decreased over recent decades. For example, climate change stands to significantly increase the number of days in Portugal with temperatures suitable for the survival of malaria vectors. Mosquito-borne diseases such as malaria were a significant public health concern in Portugal until the 1950s. Diseases transmitted by other vectors, such as Mediterranean spotted fever (MSF) and leishmaniosis, remain endemic to Portugal. Although human cases of vector-borne diseases have generally decreased over recent decades, many competent vectors are present in Portugal, posing a disease risk. Vectors and some vector-borne diseases often exhibit distinct seasonal patterns that suggest that they are weather-sensitive (Caeiro, 1999; Pires, 2000; Sousa et al., 2003).

Diseases identified as the most probable and dangerous possible in case of climate change in Portugal include malaria, West Nile virus (WNV) fever, leishmaniosis, Lyme disease, MSF, and schistosomiasis. Information on current and historical disease prevalence, vector presence, appropriate hosts, and parasites. The current Portuguese climate is conducive to malaria transmission, and competent vectors (Anopheles Astroparvus Mosquitoes) are abundant and widespread (Galão et al., 2002).

The fact that no local malaria cases are reported indicates that the local mosquito population is not infected with parasites. Although survival of both vector and parasite is possible under current climate conditions, the current transmission risk of Plasmodium Vivax malaria is shallow (parasite and vector both present but no infected vector present), whereas that of P. falciparum malaria is negligible because no suitable vectors are present in Portugal. However, suppose a (new) population of mosquitoes infected with P. Vivax or P. falciparum were to be introduced into Portugal, and current environmental conditions were assumed. In that case, transmission risk might change to a low-risk level, taking no additional vector control (Aguiar, 2010).

The climate change scenarios of IPCC under RCP projected significant increases in the number of days with mean temperatures suitable for Anopheles, P. Vivax, and P. falciparum survival. However, if no infected vectors are present, the risk of contracting P. Vivax malaria should remain very low and negligible for P. falciparum malaria. The risk might increase to a medium level if a new population of mosquitoes infected with P. Vivax (or P. falciparum) were introduced (Aguiar, 2010).

## 3.8. Iran's Cluster Zoning and Sampling to Case Study Region

This section presents an overview of the tourism sector in Iran to help recognise the tourism situation in the development of the mainland and its islands. Among the Middle Eastern destinations, Iran is among the most popular ones, attracting many tourists during the year.

Almost all the developing countries in the Middle East, such as Iran, are vulnerable to the impacts of global climate change primarily because of their limited adaptive capacities in dealing with extreme events such as climate change (Pouliotte et al., 2009). The impacts of climate change can be detected in many areas, from hydrological implications to desertification. Among all the vulnerable zones, Iran's coastline is an extreme example of a Middle Eastern Tourism destination. An investigation done by the Iranian national meteorology organisation (IRIMO, 2012) shows that geophysical observation (e.g., temperature, precipitation, and sea level rise) changed during the last ten years, showing a clear and meaningful message about climate change which is a hazardous sign for the tourism activities in future.

Iran is a vast country with a huge, diversified area, including nearly thousands of Metrological stations. As such, this study evaluates the classification of climatic indexes of Iran by selecting the central weather station of 31 provinces based on cluster analysis and all regimes of tourism climate indexes classified into six different categories. These six categories are based on the six Iranian Tourism Axes, so Iran's weather cluster zoning is also based on the Iran Tourism axes categorisation. It should be noted that the significance of tourism for the Iranian economy is less than Portugal's. However, weather and climate conditions are critical elements in choosing Iran as a destination for domestic and international tourists.

### 3.8.1. Tourism and Climate Change in Iran

Due to a rich historical heritage of over 5000 years, numerous environmental attractions, and a varied climate, Iran receives a small number but a broad spectrum of tourists who visit widely distributed locations (Farajzadeh and Matzarakis, 2009; Morakabati, 2011). Iran has eight World Heritage sites, including four ancient historical sites and four historical towns and religious sites (Baum and O'Gorman, 2010; Mohammadi et al., 2010).

The coastal area of the Caspian Sea in the North and the coastlines of the Persian Gulf and Oman sea attract leisure tourists predominantly. With the warm waters of the Caspian Sea in summer and the favourable climate of the southern coastline in the winter, these two areas serve as critical coastal tourism locations in the country and attract both local and international visitors (Eshiki and Kaboudi, 2012). The diversified climate of Iran in its 31 provinces attracts tourists, with a range of available activities, including mineral hot springs, mountain climbing, hiking, skiing, white water rafting, and so many other activities (Zamani-Farahani, 2012).

In addition to cultural and leisure tourism, Iran has a long history of business tourism, particularly from its citizens and residents of adjacent regions (Baum and O'Gorman, 2010). Despite the significant number and range of tourist attractions in Iran, the country currently attracts less than two million arrivals annually and receives only 5 % of the Islamic tourism market (Morakabati, 2011). To sustainably improve and maintain tourism in Iran, adaptation to future climate change is essential (Ahmadi, 2012).

In some parts of southern and southeastern Iran, more than half of the total precipitation occurs in the winter. Moving away from the mentioned regions to the North and the Caspian Sea coast, the contribution of autumn precipitation to total one becomes higher than winter precipitation. The precipitation regime of northwestern parts of Iran is classified in the spring season. The contribution of summer precipitation to total precipitation is noticeable in the southern parts of the Caspian Sea and Southeastern areas (Durand and Mansouri, 2014).

Spatial and temporal trend analysis of temperature extremes in Iran revealed that about 66% of the country has a significant positive trend in the frequency of hot days and nights. In comparison, about 40.9% and 68.5% have a substantial decrease in the frequency of cold days and nights, respectively. Besides, a significant increasing trend (~30%) of hot extremes was revealed in central and southern regions of Iran, which are comprised of the Great Kavir and Lut deserts out of mountainous zones (Darand et al., 2015). Therefore, other researchers indicated significant decreasing trends in snow cover in Iran based on the models under projection scenarios (Zarenistanak et al., 2015).

The results of the local Moran's index and hotspot analysis revealed that the precipitation along the Caspian Sea's coast, western and southwestern parts of Iran had a positive spatial autocorrelation. In contrast, the precipitation variation in central Iran and along the country's southern coastline showed a negative spatial autocorrelation (Ghalhari et al. 2016).

The most mentioned studies have considered climatic and synoptic stations throughout the country by different periods. Over a long-term period, the spatial distribution for annual precipitation showed a downward trend in northwestern and southeastern Iran (Raziei et al., 2012). Researchers have indicated significant anomalies in precipitation extremes in the northwest and southeast regions of Iran along the Zagros Mountains (Tabari et al., 2014). Under climate change effects, all meteorological characteristics of Iran have been altered. For instance, the role of the Siberian high-pressure extension in Iran's climate has changed spatially and temporally from temperature fluctuating to drought controlling (Ghanghermeh et al., 2015).

Hence, one of the climate change facts in Iran is the increasing trend of drought severity and the decreasing trend of rainfall and food magnitude (Modarres et al., 2016). However, climate changes and global warming affect precipitation and extreme events such as floods and droughts in Iran (Eslamian et al., 2011). During the past 40 years, the average decreasing precipitation rate in the study area was 2.56 mm/year (Zohrabi et al., 2014). Moreover, climate change can affect water resources, agriculture, the environment, public hygiene, sector, and the economy (Samadi et al., 2009; Gohari et al., 2013).

Iran's tourism sector has excellent potential for development. According to the WTO, Iran is ranked 10th in terms of archaeology and historical attraction and ranked 5th in terms of natural attractions (Ghanian et al., 2014; Yazdanpanah et al., 2016). However, tourism has yet to be able to play an influential role in Iran's economy. Due to the country's economic dependence on oil, attention and investment are required to develop tourism and abandon its single-product economy. Some of Iran's potential tourism developments are in rural areas due to major cultural, historical, natural, and structural attractions, not to mention the various patterns of tourism seen within the country (Rezvani, 2008).

Despite the economic and social importance of the tourism sector in Iran, the development and expansion of the sector need to be better managed. Most recent development programs have focused on diversifying the economy and reducing the reliance on a single-product economy comprising oil exports. The growth of the tourism sector, and the national focus on economic diversification, have resulted in an expansion of local tourism research, with a particular emphasis on the significance of climate (Farajzadeh and Matzarakis, 2009; Roshan et al., 2016).

Despite the poorly coordinated expansion of the sector, tourism development in Iran has been particularly successful. According to the World Tourism Organization, Iran is ranked among the top ten archaeological and historical attractions globally and fifth among natural attractions (Ghanian et al., 2014; Yazdanpanah et al., 2016; Roshan et al., 2016). The Arab uprising in 2011 witnessed a significant drop of 10–40% in tourist arrivals to Syria, Egypt, and Lebanon. In contrast, Iran experienced an increase in the number of international tourists. In 2010, a total of 2.9 million tourist arrivals were recorded, followed by a rise of 3.3 million tourists by 2011 (United Nations World Tourism Organization (UNWTO) 2013). Although only 154,000 tourists visited Iran in 1990, travel to Iran steadily increased during the 1990s, and 1.342 million tourists visited Iran in

2000. The Iranian tourism sector has more than doubled since 2000, and 2.7 million tourists visited Iran in 2006 (Salavati and Hashim, 2015).

The World Tourism Organization's latest reports in 2014 and 2015, the World Tourism and Travel Council in 2014, as well as the statistics of Iran's Statistics Center for 2013–2008 have tried to determine the tourism status of the Iranian macroeconomic system as well as the tourism situation internally, externally, and domestically. The report shows that tourism has created a total of 1,184,000 jobs. According to the World Tourism and Travel Council, based on the growth index of tourism's share in GDP, Iran was in fourth place in 2014, with a growth of 10% compared with 2013 (The World Economy Newspaper, 2017).

In Iran, during the past years, severe effects of climate changes, such as the drying of a large part of Lake Urmia, dust storms in the South, west, and centre of the country, and drying of wetlands (Mardi et al., 2018), a sharp rise in temperature in summer (Daneshvar et al., 2019), decrease in precipitation (Rahimi et al., 2020) and drought (Keshavarz et al., 2013) have been observed. A significant part of the Caspian Sea's low-elevation coastal zone, fundamental to tourism in this area, has been submerged during the past years. Impeded drainage seriously affects tourists, residents, and agricultural production, and submerged houses and wastewater wells are hazardous for swimmers (Mirzaei, 2013).

Khorani and Monjazeb Marvdashti (2014) examine the effects of climate change on the number of Hengam island visitors. The general circulation model results show that Hengam Island will face warmer temperatures in winter and spring and lower temperatures in autumn and summer in the next 30 years. As a result, the number of visitors will increase relatively in autumn and summer and decrease in winter and spring. Yazdanpanah et al. (2016) used the HadCM3 model for two A1B and B1 emission scenarios by PET climate comfort index to examine the climate comfort of the Zayande-Roud river route. The results show that some tourism destinations in the western part of the river are at risk of reducing the number of climate comfort days because of the higher warming in western areas with colder climates.

Although some other studies examined the potential impacts of climate change on Iran's agriculture and environment, the climate change impacts on tourism still need to be better understood and remain a knowledge gap. Indeed, possible climatic effects and consequences on Iran's tourism are unknown and have not received much attention (Roshan et al., 2016; Karimi et al., 2016; Mansouri et al., 2017; Sayari et al., 2011).

### 3.8.2. Potential Impacts of Climate Change on Tourism in Iran

Mountain areas are sensitive to climate change, and implications of climate change can be seen, for example, in less snow, receding glaciers, melting permafrost and more extreme events like landslides. Furthermore, climate change will shift mountain flora and fauna. Second-order impacts will occur in mountain agriculture, hydropower and tourism (Bürki, 2003).

Skiing is only feasible at elevations greater than 750 meters. Except for the Caspian regions, this layer shows that most western and northern provinces are suitable for skiing. The final map, which shows locations ideal for the construction of ski resorts, was produced by projecting these three layers. Mountainous regions of Chaharmahal, Kohgeeloye, Isfahan, and Fars are the best places for this activity, in addition to the Alborz range between Tehran provinces. Skiing-related climatic factors include the daily temperature, maximum, minimum, and mean; the daily precipitation, including snowfall and rain; and the daily snow depth. Snow cover is necessary for winter activities to be economically sustainable.

One of the most significant effects of the increase in air temperature in the future will be the change in the spectrum of thermal bioclimatic niches for humans. The bioclimatic conditions will change to a warm and hot range as the temperature rises by the end of this century. Due to rising temperatures in the future, favourable bioclimatic conditions will change from early spring to mid-winter. The period with warm bioclimatic conditions will also increase by mid-autumn. The expansion and spatial range of warm and unfavourable bio climates are essential in the spring and summer seasons. Under climate change, Iran's human thermal bioclimate will change in terms of temporal and spatial aspects (Hamzeh, 2021).

The IPCC estimates an increase in temperature in the Middle East up to 2 °C in the next 15–20 years and over 4 °C by the end of the century. This fact is combined with a decline in precipitation by 20% (IPCC, 2007; Elasha, 2010). Hence, Middle East countries are very vulnerable to face climate change effects. Among the Middle East countries, Iran will experience an increase of 2.6 °C in mean temperatures and a 35% decline in precipitation in the following decades (NCCOI 2014). Hence, the climate change fact of Iran is more severe than in the Middle East region. Several researchers have reported that heat waves will be increased (30%) by the end of the century in Iran and West Asia (Zhang et al., 2005; Rahimzadeh et al., 2009; IPCC, 2012).

Therefore, many reports observe a steady decline in annual rainfall (~30%) (Narasimhan and Srinivasan, 2005). Several researchers have widely studied the spatial and temporal precipitation trends in Iran. The literature review revealed that the two high mountain ranges of Zagros and Alborz in the west and north, respectively, strikingly affect the temporal and spatial patterns of rainfall and temperature (Zarenistanak et al., 2015; Ghalhari et al., 2016; Roushangar et al., 2018).

For instance, Rainfall trends analysis of Iran using the Mann–Kendall test indicated a decreasing trend in annual and seasonal precipitation at stations mostly occurring in the northwest of Iran (Modarres and Sarhadi, 2009). Similar research using the Mann–Kendall test showed a significant negative trend in Iran's annual precipitation, especially in the winter series (Tabari, 2011).

Another research found a relatively regular year-round distribution of precipitation in the north of Iran. However, an extreme concentration of rainfall in a few months of the year was detected in the southern country (Raziei et al., 2012). A noticeable decrease in precipitation of rains has been indicated in northern Iran, which has temperate weather affected by Alborz Mountains and the Caspian Sea (Somee et al., 2012).

Regionalisation of precipitation regimes in Iran using principal component analysis and hierarchical clustering analysis revealed that the central precipitation regime is in the winter season. In some parts of southern and south-eastern Iran, more than half of the total precipitation occurs in the winter. Moving away from the mentioned regions to the north and the Caspian Sea coast, the contribution of autumn precipitation to total one becomes higher than winter precipitation. The precipitation regime of north-western parts of Iran is classified in the spring season. The contribution of summer precipitation to total precipitation is noticeable in the southern parts of the Caspian Sea and South-eastern areas (Darand and Daneshvar, 2014).

Spatial and temporal trend analysis of temperature extremes in Iran revealed that about 66% of the country has a significant positive trend in the frequency of hot days and nights. In comparison, about 40.9% and 68.5% have a substantial decrease in the frequency of cold days and nights, respectively. Besides, a significant increasing trend (~30%) of hot extremes was revealed in central and southern regions of Iran, which are comprised of the Great Kavir and Lut deserts out of mountainous zones (Darand et al., 2015). Therefore, other researchers indicated significant decreasing trends in snow cover in Iran based on all the models under projection scenarios (Zarenistanak et al., 2015).

The results of the local Moran's index and hotspot analysis revealed that the precipitation along the Caspian Sea's coast, western and southwestern parts of Iran had a positive spatial autocorrelation. In contrast, the precipitation variation in central Iran and along the southern coastline showed a negative spatial autocorrelation (Ghalhari et al. 2016). The most mentioned studies have considered climatic and synoptic stations throughout the country by different periods. Over a long-term period, the spatial distribution for annual precipitation showed a downward trend in northwestern and southeastern Iran (Raziei et al., 2014).

Researchers have indicated significant anomalies in precipitation extremes in the northwest and southeast regions of Iran along the Zagros Mountains (Tabari et al., 2014). Under climate change effects, all meteorological characteristics of Iran have been altered. The role of the Siberian high-pressure extension in Iran's climate has changed spatially and temporally from temperature fluctuation to drought control (Ghanghermeh et al., 2015). Hence, one of the climate change facts in Iran is the increasing trend of drought severity and the decreasing trend of rainfall and food magnitude (Modarres et al., 2016).

### 3.8.3. Vulnerability of Iran's Tourism Sector to Climate Change

With a total area of 1.648 million km2, Iran locates between 45° and 63° East and 25°–40° North in the Middle East Fig (1). The general climate of Iran represents an arid and semiarid character in the mid-latitude position. Iran's climate is mainly dry and semiarid (Sodoudi et al., 2010; Fallah et al., 2017), and rainfall depends on geographical latitude and topographical altitude (Ramzi et al., 2017). Most of the precipitation in Iran has been influenced by the pressure centre of the western Mediterranean oscillation (Ghasemian, 2008). Albeit significant influences of El Niño southern oscillation on other meteorological parameters, such as air temperature in Iran, were also reported by Choobari et al. (2017).

Climate change fact is intensive among Middle East countries and especially Iran. Among the Middle East countries, Iran will experience an increase of 2.6 °C in mean temperatures and a 35% decline in precipitation in the following decades. The IPCC special report on the impacts of global warming of 1.5°C (Ove Hoegh-Guldberg et al., 2018) emphasises that limiting global warming to 1.5°C is expected to reduce the probability of extreme drought, precipitation deficits substantially, and risks associated with water availability (i.e., water stress) in some regions (medium confidence).

The climate change fact of Iran is more severe than in the Middle East. Most of the research indicates a dryer regime for the future in addition to lesser precipitation events, which is more evident in the warm season (Shamami et al., 2018), indicating the changes inconsistent with global warming/climate change (Abolverdi et al., 2014). Based on recent scientific reports, the frequency of extreme precipitation will be decreased in Iran (Choobari and Najaf, 2018). Then an increased risk of droughts will threaten water and food security, especially for people living in the highly populated cities of Iran (Karandish and Mousavi, 2018).

Risks associated with increases in drought frequency and magnitude are projected to be substantially more significant at 2°C than at 1.5°C in the Mediterranean region (including southern Europe, northern Africa, and the Middle East) and southern Africa (medium confidence). Investigating climate change facts is essential in arid regions such as Iran, where the dry condition may increase under global warming (Karandish et al., 2017).

Madani (2014) highlights Iran's water crises, including depleting groundwater levels, drying lakes, water supply, and extreme events. With nearly 85% of the country being in semiarid and arid climates, the country faces both prolonged droughts and food. In the past two decades, foods have affected 11 million people in Iran and caused over 2600 fatal casualties (Madani, 2014).

Furthermore, many studies point to the rising temperature in Iran and the Middle East and notably warmer summers in recent years (Pal and Eltahir, 2015; Delju, Ceylan, Piguet, and Rebetez, 2013; Medany, 2008). Although the effect of hot heatwaves on migration in this area is not fully understood, Pal and Eltahir (2015) underscore that the upward trend in temperature is so alarming that it can eventually make the Persian Gulf countries virtually uninhabitable and could force people to migrate. The global average annual precipitation is more than 830 mm, classifying Iran as an arid and semiarid country. In recent years, climatic anomalies such as storms, long-term droughts and the trend of temperature and precipitation changes in Iran show the depth of the effects of climate change on our land, while our lives are gradually and increasingly affected by climate change and global warming. The thermal map of Iran is shown in Figure 3.5. shows the drastic differences between different regions in Iran, from the North, which is cold, to the South, which is warm or hot all year.

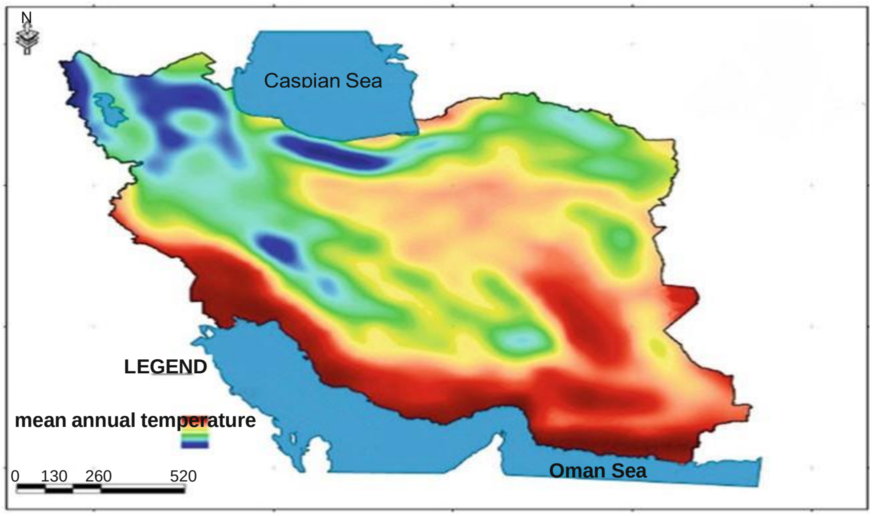


**Figure 3.5. Iran Mean Annual Temperature Map, Source: Iran Meteorology Organization (2019)**

Other climate change impacts in Iran are the socioeconomic impacts on its tourist destinations. Climate change could also become a high risk for future economic growth and political stability, especially in areas highly dependent on Tourism revenue, like the Northern region at the coast of the Caspian Sea and cities such as Isfahan, Yazd, Shiraz, Kashan, and Tabriz Islands in the Persian Gulf such as Kish and Qeshm. Climate change will be considered on both national and regional scales as a security risk which might steadily intensify, especially under higher warming degrees scenarios in Iran also.

### 3.8.4. Air Quality Decrease and Dust Storm

While the health effects caused by air pollution are broad, it mainly impacts the respiratory and cardiovascular systems (Monteiro et al., 2016). According to The State of Global Air 2019 report, tropospheric ozone pollution exposure increases the likelihood of dying from respiratory diseases, specifically chronic obstructive pulmonary diseases. It is, therefore, responsible for many premature deaths worldwide (Health Effect Institute, 2019). Both ozone and PM are very sensitive to changes in weather conditions (Monteiro et al., 2016). It has been noted that "changes in temperature, humidity, wind, and precipitation that may accompany future climate change can deeply impact air quality because of induced changes in the transport, dispersion, and transformation of air pollutants at multiple scales" (Dias et al., 2012).

Dust pollution has become a severe environmental problem, especially in recent decades. The present study's aim was the investigation the levels of PM10 concentration in the southwestern part of Iran and measure five important heavy metals (Pb, Cd, As, Hg and Cr) in some samples from 2005 to 2011. According to National Ambient Air Quality of USEPA guidelines, most days with non-standard, warning, emergency and critical conditions were related to 2009 (120 days), while the least polluted days were recorded in 2006 (16 days).

There are concerns about the increasing frequency and intensity trend of dust storms in recent years because of exceptional conditions in neighbouring Western countries, which could endanger public health and the environment. All measured heavy metals except mercury were higher than the standard level of WHO and USEPA. The increased dust storm and intensification of warning, emergency, and critical days in western provinces, particularly Kermanshah, Khuzestan and Ilam, have made living conditions difficult. These dust storms caused an increase in migration from Kermanshah to the central regions and neighbouring provinces that subsequently caused other social and economic problems and negatively impacted Tourism Sector in these regions. Another type of air pollution is also common in urban areas of metropolitan cities such as Isfahan, Mashad, Tabriz, and Tehran, especially during the winter due to cold air mass inversion. This type of pollution is manageable because all these cities mentioned above are among Iranian most critical touristic destinations (National Library of Medicine, 2011).

### 3.8.5. Sea Level Rise in North and South of Iran

The Caspian coast of Iran is about 740 km long, around the southern side of the Caspian Sea. The land descends from the lower slopes of the Alborz Mountains to the Caspian Sea, now about 26 m below the global mean sea level (Meehl et al., 2005; Nerem et al., 2006). The surface of the Caspian Sea has shown long-term oscillations and fell about 3 m between 1930 and 1977 when it rose about 2.5 m.

Coastal sensitivity to the Caspian Sea level rise has become a significant issue in the north of Iran. The overview published by the Geological Survey by Caspian Environment Program (CEP) in 2002-4 demonstrates that there are low, moderate, and high sensitivity regions. Some of Iran's most severely threatened coastal areas are parts of the Anzali Lagoon district in the north of Iran (UNOPS, 2003; Lowe, 2004).

One of the essential features of the Caspian Sea is its changing water level. This factor significantly affects biodiversity and coastal management in extensive shallow areas. These water level fluctuations considerably change the usual succession in water plants along beachfront properties along the coast (UNOPS, 2003). The Anzali lagoon Adaptive Management Pilot Initiative Project, as part of the Caspian Environment Program (CEP), was undertaken over two years (2005-7) activity related to Caspian Sea level fluctuations and their impact on both the natural and human activities.

### 3.8.6. Melting of Natural Glaciers and Sweet Water Shortage

The climate change fact of Iran is more severe than in the Middle East region. Most of the research indicates a dryer regime for the future in addition to lesser precipitation events, which is more evident in the warm season (Shamami et al., 2018), indicating the changes inconsistent with global warming/climate change (Abolverdi et al., 2014). Based on recent scientific reports, the frequency of extreme precipitation will be decreased in Iran (Choobari and Najaf, 2018). Then an increased risk of droughts will threaten water and food security, especially for people living in the highly populated cities of Iran (Karandish and Mousavi, 2018).

Large ice formations, like glaciers and polar ice caps, naturally melt back a bit each summer. In the winter, snows, primarily from evaporated seawater, are generally sufficient to balance the melting. Recently, though, persistently higher temperatures caused by global warming in Iran have led to greater-than-average summer melting and diminished snowfall in the Zagros and Alborz Mountains, both north and south of Iran, due to later winters and earlier springs.

This imbalance results in a significant net gain in the ratio of runoff to ocean evaporation, causing rivers such as Zayande-Roud and Karoon to either dry out or to have less water, also many lakes and lagoons such as Maharloo in central Iran, Urmia Lake in the northwest, Hamoun in the southeast and many other wetlands to get totally or partially dried out. Mountain glaciers' meltdowns are not only a severe loss of mountain aesthetic but also a problem for ski slopes on glaciers in winter and summer skiing which is also a big issue for winter and summer ecotourism (Abolverdi et al., 2014).

### 3.8.7. Coastal Erosion in Iranian Coast Lines

Coastal landscapes worldwide are experiencing drastic and rapid morphological changes, which have resulted in severe beach erosion (Phillips and Jones, 2006). Approximately 70% of the world's sandy beaches are receding (Bird, 1985; UNWTO, 2007). Along the coastline, widespread beach erosion has been reported in numerous touristic locations, such as the Islands in the south, including Kish, Qeshm, Hormuz, and Hengam. Also, the situation is difficult in some areas, such as the north of Iran, due to the Caspian Sea drops. Many where only a tiny strip of sandy shoreline is evident during low tide, and no beach is visible during high tide (Afshar, 2008).

As beaches erode, nearby built facilities are exposed to direct impacts of storm waves, and in instances wherein protective measures are not taken, fixed structures undergo grave damage (Zhang, Douglas, and Leatherman, 2004). Erosion has been occurring over geological time without intervention (Phillips and House, 2009). However, over the last decade, officials have implemented various beach replenishment measures to prevent further beach erosion, recuperate shorelines, and protect infrastructure (Phillips and Jones, 2006).

The northern part of Iran is a centre of agricultural production. The southern region is home to the energy sector, oil installations, and energy exports. The nation's largest ports for the export of goods are also located in the south. Both North and South characteristics define Iran as vulnerable to climate change. According to the 10-year hourly recorded data in three sites (Chabahar, Bandar Abbas and Bushehr), the mean sea level in the Persian Gulf and Sea of Oman has been rising at an average value of 4.5 mm/yr, which agrees with the IPCC 1995 scenario (Afshar,2008).

The impact of temperature and sea level rise, namely:

1) coastal erosion in the north and south;
2) inundation of lowlands such as the Miankaleh peninsula and Gorgan Bay.

Mass bleaching of the coral reef and saltwater intrusion caused by flooding and inundation are all notable instances of the vulnerability of Iran's northern and southern coastal zones.

From a socioeconomic point of view, climate change has a tremendous adverse impact on the availability of fresh water in these regions. Saltwater intrusion into surface water and groundwater is the most critical issue, particularly in the Karun River system, the primary drinking water source for more than one million population centres.

### 3.8.8. Vector-Borne Diseases Growth in Iran

Climate change will cause direct adverse health effects. Global warming is expected to lead to more cardiovascular, respiratory, and other diseases. One of the significant vectors born tropical diseases is Malaria, which is prevalent in different provinces of Iran. The research on the exposure rate to Malaria from 1982 to 1998 indicates that the trend cases of those infected are on the rise. Risks from vector-borne diseases are projected to increase with warming from 1.5°C to 2°C (Ove Hoegh-Guldberg et al., 2018).

In general, 88% of the disease burden due to climate change is carried by children under five (Ahdoot and Pacheco, 2015). Children are highly vulnerable to vector-borne diseases such as dengue fever and Malaria (UNICEF, 2015). Two-thirds of the deaths by Malaria happened to children, of which two-thirds are below the age of five (UNICEF, 2015).

### 3.8.9. Iran's Tourism Axis: Kish Island Case Study

In a globalised world, it is normal to find competition among nations and regions in their desire to gain an increasing number of tourists. As tourism industries grow in relevance in national contexts, the competition is becoming more intense between nations, regions, and cities to be more attractive destinations for domestic and foreign tourists (Barreira et al., 2016).

Regional tourism development, led by some regional tourism planning bodies, can best be defined as those projects involving multiple independent sites, with individual decision-makers who have agreed to work on common marketing strategies for the benefit of all (Shields and Schibik, 1995). Therefore, a regional tourism planning body may be associated with any location from a downtown historic district to a 26-county area (Shields and Schibik, 1995). Economically, this topic, called the third-millennium trade, is one of the most profitable economic areas as it is believed that international tourism flows create the most dynamic economic exchanges that may occur between countries (Vellas and Lionel, 2005).

A total of 1,326 million international tourist arrivals were recorded in worldwide destinations. Some 86 million more than in 2016. Global tourism receipts increased by 4.9 per cent in real terms (adjusted for exchange rate fluctuations and inflation) to reach US$1,340bn in 2017 (WTO, 2018). In Asia, the significance of regional tourism as a development tool at the regional and local levels has been on the rise in recent decades (Mazumder et al., 2013). Many developing countries in Asia, which are successfully exploiting their natural resources for tourism purposes, have been able to increase their international receipts due to tourism development, and it is not surprising that tourism has become an important export sector in these economies.

This belief that tourism development causes long-term economic growth is known in the literature as the tourism-led growth hypothesis (Chingarande and Saayman, 2018). Meanwhile, according to the WTO report, by attracting 4.7 million foreign tourists, Iran ranked 48th in 2013 for the first time since 1977 (WTO, 2014). The tourism sector in Iran could have an average annual income of US$10bn (equal to the income from oil), but this is different. Nowadays, with a yearly income of less than US$ 6bn, Iran is not even among the 50 top-rated tourist destinations in the world (WTO, 2018; Heidari et al., 2013).

While the Middle East depicted signs of recovery in 2017 with a substantial 13 per cent increase in income generated by international tourism (WTO, 2018), Iran's share has been insignificant. In 2017, the total contribution of travel and tourism to employment, including jobs indirectly supported by the sector, was 6.1 per cent. Visitor exports generated only 3.9 per cent of the total exports in 2017 (World Travel and Tourism Council, 2018). Therefore, despite enormous potential, the Iranian tourism sector has faced several challenges, including broad-ranging nuclear-related sanctions, negative imagery in the west and a need for more effective management of resources (Khodadadi, 2016). One of the obstacles to effective resource management is the need for equipped tourism axes in potential regions and the relevant planning and management for their development. Some of the attractive attributes of Kish Island in Iran as tourist destinations include the availability of beautiful beaches and landscapes associated with warm weather and sunshine. At the same time, coastal and marine tourism has also become one of the fastest-growing types of tourism (Barreira et al., 2016).

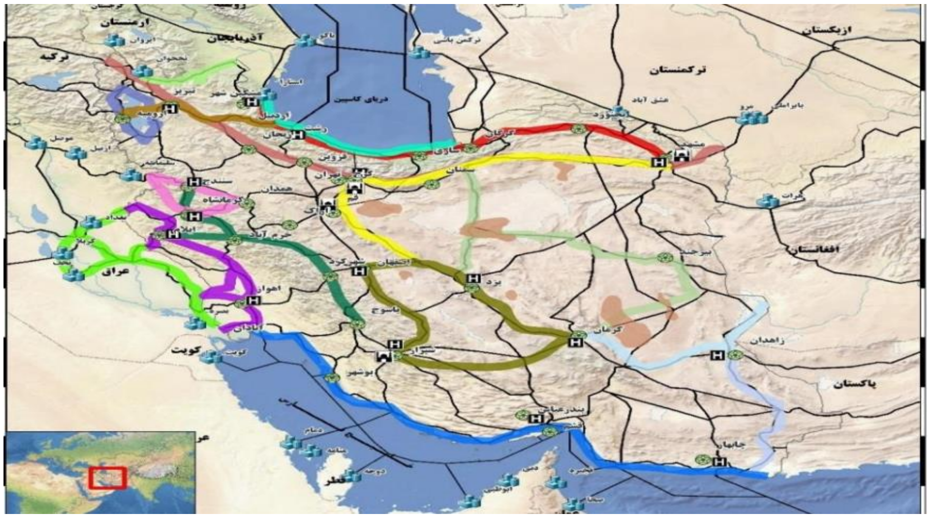

**Figure 3.6. Tourists Axis Map Cluster Zoned in Colors, Source: Iran National Heritage and Tourism Organization 2018**

Kish Island has a long tourism history in the Persian Gulf region, more than 130 years (Nasr et al., 1971). The modernisation of Kish was established in 1968 when American experts selected Kish Island as a tourism-free zone due to its natural geographical features (Zalzadeh, 1977).

Tourism is the main economic engine in many countries, such as Iran. This is especially relevant for less developed countries and vital for small Islands such as Kish. To a certain extent, this element has shaped the arguments and position of some stakeholders in the tourism sector. Although acknowledging the role of tourism as a source of greenhouse gases, these actors commonly use the role of tourism in developing countries as an argument to respond to the critics that tourism as a sector should do more to combat climate change, i.e., reduce its emissions.

In the coming years, the tourism sector on an Island such as Kish Island must choose between lagging behind the impacts of climate change and positioning itself as a pioneer, leading the path towards sustainability. The tourism sector, particularly the coastal and marine segment of Kish Island, which is analysed in this research, shows the first signs of awareness and concern about the possible impacts of climate change on the sector's activities.

However, the full recognition of the magnitude of this natural disaster still needs to be acknowledged. Reduced numbers of visitors to the Island due to intolerable temperatures during the summer high season are only part of our problems. Other problems are rising sea levels and associated flooding and loss of shoreline and coral reef ecosystems extinction in a coral reef island such as Kish.

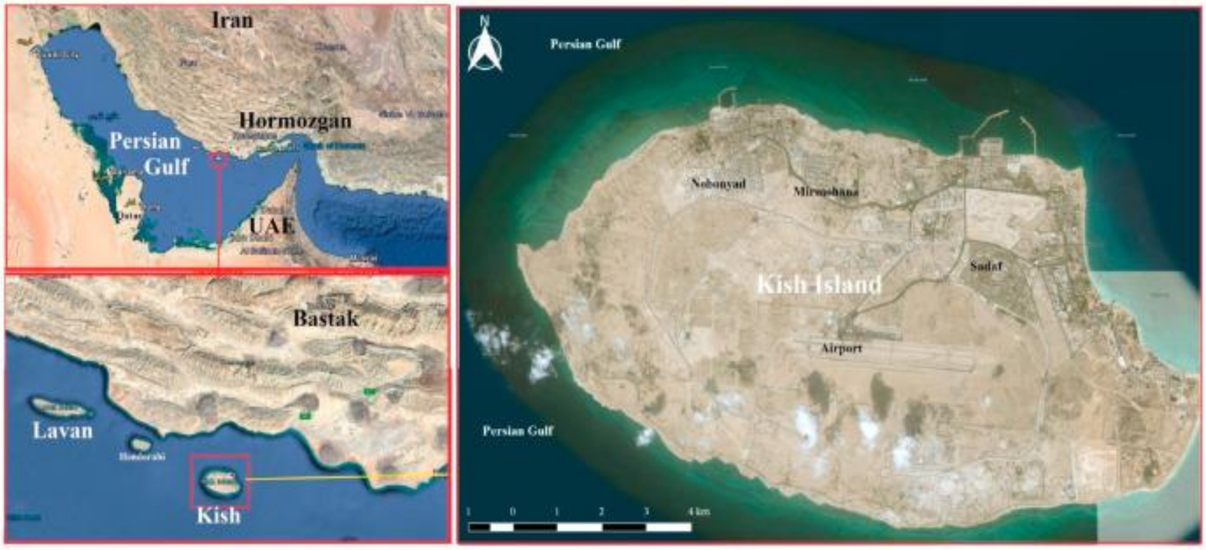


**Figure 3.7. Kish Island Location, Source:( https://earth.google.com)**

Two reasons contribute to this limited awareness about climate change impacts on Kish Island. First, understanding of climate change impacts on coastal tourism is limited, and significant knowledge gaps require more attention and profound scientific studies. The second reason relates to the science-practitioners divide; even though tourism is becoming aware of what is at stake, the short-term benefit still dominates over long-term planning. In this sense, science needs to play a more dominant role and provide the tools to facilitate the sector's risk assessment and adaptation options.

According to the tourism master plan of Iran (2001), Kish Island is one of the leading tourism destinations of the country and the tourism centre of the Persian Islands in the Persian Gulf. Besides the Caspian Sea shore, Kish Island is the only sea and recreational holiday beach and tourist destination in Iran. Kish Island's Coast is surrounded by various resources that support livelihoods and economic development in the Persian Gulf region. The resources include mangroves and other coastal forests; estuaries; coral reefs; marine species.

Since 2000, however, the tourism development of Kish has concentrated on the environmental and recreational aspects, mainly coastal and marine tourism. It follows the government's national strategies towards the tourism sector and ecological tourism.

The impacts of global climate change on the coastal tourism sector in Kish Island, which depends heavily on climate conditions, have increasingly gained concern in Iran. During the last decades, the semitropical climate in Kish is becoming tropical, with temperature and humidity rising in a way that exceeds the comfort threshold that tourists prefer.

In this context, the studies conducted by Tayebiyan et al. (2016) adopted different methods in assessing the impacts of the changes in the hydro-systems of Iranian basins. They all have reported that the present climate change would lead to an increase in temperature, a decrease in rainfall, an increase in the 24-h rain, and an increase in drought. The IPCC's Fifth Assessment Report adopted four climate scenarios (representative concentration pathway (RCP) 2.6, RCP 4.5, RCP 6.0, and RCP 8.5) based on the possible range of radiative forcing values, the equivalent CO2 concentrations, and the scenarios for climate modelling (Van Vuuren et al., 2011).

The findings revealed that between 2015 and 2050, precipitation ranges from 1.2 to 8.7%, temperatures range from 0.6 to 1.2 °C, and runoff is 27.2%. In this context, changes in the temporal-spatial distribution of rainfall, the form of rain (solid or liquid), surface runoff, evaporation, groundwater recharge, and water quality which generally can be considered as a new trend in the global climate, are due to this phenomenon (IPCC, 2008).

## 3.9. Research Design and Organization

In general, the term "research design" refers to the overall strategy that is chosen to integrate the different components of the study coherently and logically, thereby ensuring researcher will effectively address the research problem; it constitutes the blueprint for the collection, measurement, and analysis of data (Bryman, 2012).

Here in Figure 3.8., this thesis work's research design and organisation are illustrated and shown. In general, this figure shows the plan for what will be done to answer the research question. It offers the framework for choosing specific methods of data collection and analysis, which in this work, the secondary data collection is chosen. This work is an exploratory and applied descriptive work using quantitative methods to analyse the secondary data to forecast the future climatic changes possibly happening in both case study regions of Kish Island in Iran and the Algarve Region in Portugal.

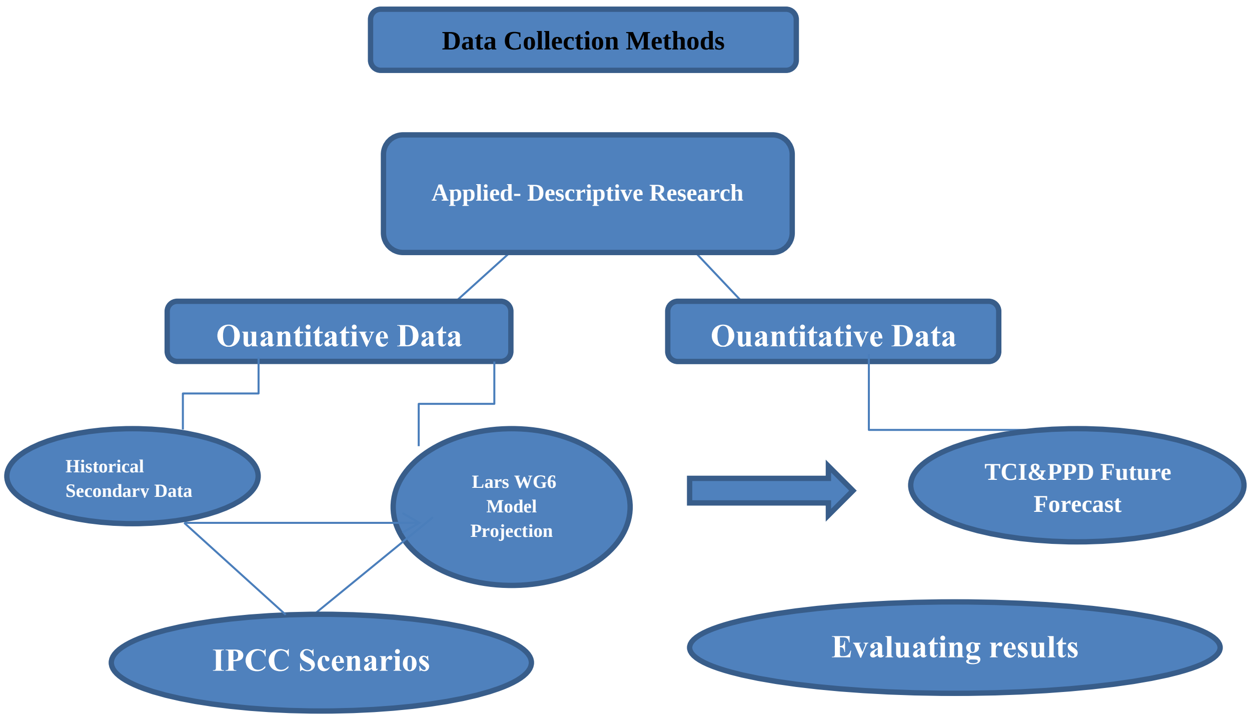


**Figure 3.8. Data Collection and Evaluation Methods**

### 3.9.1. Data Collection Methods

This work will be cross-sectional regarding data collection due to its descriptive nature. There will be only one type of data collected for this work: quantitative data. The data sources in this study will be only secondary data. Secondary data here will be based on meteorological datasets, statistics, reports, and scenarios, mainly from online resources, which will be mentioned and discussed in the forthcoming section below.

The data collection method will be applied to qualitative data using these techniques.

### 3.9.2. Setting Scenarios

Scenarios are internally consistent verbal futuristic pictures of a phenomenon, sequence of events, or situation, based on certain assumptions and factors (variables) chosen by its creator. Scenarios are used in estimating the probable effects of one or more variables and are an integral part of a situation analysis and long-range planning. In general, as there are no long-range scenarios for global tourism beyond the year 2030 (cf. UNWTO, 2011), there has yet to be the possibility of examining the implications of climate change impacts on coastal tourism on long-range tourism scenarios.

The possible scenarios in IPCC Scenarios are published in its most recent report. AR6 is applied to predicting potential changes in both case study regions to forecast possible responses of tourists based on the future Tourism Climate index changes, which may have essential instant impacts on tourists visiting Kish Island and the Algarve region. Representative Concentration Pathway (RCP) index was used in the fifth IPCC report in 2014 as a basis for probable futuristic climate scenarios that refer to concentrations up to the year 2100 and captures the IPCC trends for the future will also be applied in this work to enhance the accuracy of predictions.

## 3.10. Data Analysis Techniques

Here in this work, a quantitative method is used in data analysis. The secondary data will be analysed using Root Mean Square Error (RMSE) which is the standard deviation of the residuals (prediction errors). Residuals measure how far from the regression line data points are; RMSE measures how spread out these residuals are. In other words, it informs of how robust the data is around the line of best fit. Root mean square error is commonly used in climatology, forecasting, and regression analysis to verify experimental results. Mann-Kendall and Sens's Slope Estimator Test and Minitab16 software for analysis will be applied.

The quantitative part of the research study, mainly extracted from climatic data collected from different stations, will be undertaken using the LARS WG6 software. This will include descriptive statistics, hypothesis testing, factor analysis and Binary Sensitive Assessment Model in climate change will be applied.

The CIT (the thermal sensation) and TCI indices will be applied to determine the final impacts of the climate change scenarios on tourism behaviours. The two Indices mentioned above will be explained further in the section below.

These factors provide a systematic basis for assessing the climatic elements that most affect the quality of the coastal tourism experience by using a proper weighting of climatic variables in the survey questionnaires. This includes the TCI and CIT index formulas. Here there is a brief explanation of the indices mentioned above.

### 3.10.1. TCI, CIT and RCP Index

The impact of climate change on the climatic attractiveness of touristic destinations is usually assessed using the index approach (Bigano et al., 2008). The most used index is the Tourism Climatic Index (TCI), devised by Mieczkowski in 1985. The TCI is based on five variables: daytime thermal comfort index, daily thermal comfort index, precipitation, hours of sunshine, and wind speed (Matzarakis et al., 2007). Following a scheme, all the variables are transformed into ratings. How the scores are mapped to index values depends on the type and level of touristic activity. The TCI scale is divided into ten categories ranging from “ideal” to “impossible”.

Nowadays, one of the most globally applied systematic indices for quantifying climatic resources is the “Tourism Climate Index” (TCI). The TCI index was first developed by a meteorologist called Mieczkowski. It was initially designed to facilitate the numerical calculation of main climatic variables relevant to tourism studies into a single index format. According to the evidence and reports recorded in the IPCC, the TCI has been widely used for future climate calculations for many global destinations, especially in Europe. The TCI index can objectively compare different destinations simultaneously to assess their climatic suitability for general international tourism study purposes.

The TCI developed by Mieczkowski (1985) was based on previous research related to climate classifications for tourism and recreation (Heurtier,1968; Crowe, 1976) and theoretical considerations from the biometeorological literature related to human comfort, particularly concerning tourism activities (Burnet, 1963; Dammann, 1964; Hofer, 1967; Heurtier, 1968; Danilova 1973, and Kandror et al. 1974). Initially, 12 monthly climate variables were identified from the literature as pertinent to the TCI. Meteorological data limitations reduced the number of climate variables integrated into the TCI. The seven variables included are: monthly means for maximum daily temperature, mean daily temperature, minimum daily relative humidity, mean daily relative humidity, total precipitation, total hours of sunshine, and average wind speed. These seven climate variables were combined into five sub-indices that comprised the TCI.

A standardised rating system, ranging from 5 (optional) to -3 (extremely unfavourable), was devised to provide an everyday measurement basis for each sub-index. Although created based on available biometeorological literature, the rating systems of the five sub-indices and their relative weightings within the TCI are ultimately subjective.

In this research, TCI is computed for synoptic weather stations of Kish Island in Iran and the Algarve region in Portugal with a standard period recorded (1990-2021). Data for calculating the tourism climatic index are maximum daily temperature, mean daily temperature, minimum daily relative humidity, mean daily relative humidity, total precipitation, total hours of sunshine and average wind speed. Secondary data was collected from meteorological websites of Iran and Portugal. Computations took place based on Mieczkowski methods and RCPI model analysis per each cluster zone area within the country. TCI is chosen index to be applied in this thesis to facilitate the evaluation of the impacts of climatic changes in the two case study countries of Iran and Portugal on tourist behaviour and their level of comfort, satisfaction, and loyalty.

The CIT is an index based on TCI, which rates the climate resource for activities that are highly climate/weather sensitive, specifically, beach “sun, sea and sand” (3S) holidays (De Freitas et al., 2008). The CIT index mainly rates the weather resource for 3S tourism resorts. In general CIT index integrates thermal (T), aesthetic (A) and physical (P) facets of weather conditions, which are combined in a weather typology matrix to determine a climate satisfaction rating that ranges from very poor (1 = unacceptable) to very good (7 = optimal).

The CIT index measures thermal sensation using the standard nine-point ASHRAE scale (“very hot” to “very cold”). The perception of the weather resource does not exclusively rely on an optimal range of daily temperatures but also on the effects of relative humidity, wind speed, short- and long-wave radiation and cloudiness. Thus, it assesses the weather asset by merging all the aspects relevant to this tourism trend daily rather than monthly. Thermal (T), aesthetic (A) and physical (P) facets are combined in a weather typology matrix that ranks tourist comfort (De Freitas et al., 2008).

In these methods, all considered indices compute the specific value to display comfortable or uncomfortable situations, and then all computed indices are combined in a final formula:

$$TCI = 2 \times (CID + CIA + 2 \times P + 2 \times S + W) \quad (3.1.)$$

In this formula, CID indicates the comfortable daily index, CIA: 24 hours comfortable index, P: precipitation, S: sunshine hours and W: wind characteristics. In TCI, monthly averages of seven climate variables relevant to tourism are integrated into five sub-indices, listed in Table 3.1.

**Table 3.1. Summary of the sub-indices, their impact, and weighting in TCI (based on *Scott* and McBoyle, 2001)**

| Sub-index | Monthly averages | Influence on TCI | Weighting |
|---|---|---|---|
| daytime comfort index (CId) | daily maximum temperature (°C) and minimum relative humidity (%) | represents thermal comfort when total tourist activity occurs (usually between 12 a.m. and 4 p.m.) | 40% |
| daily comfort index (CIa) | daily mean temperature (°C) and mean relative humidity (%) | represents thermal comfort over the full 24-hour period | 10% |
| precipitation (R) | total precipitation (mm) | negative impact on outdoor activities and climatic well-being | 20% |
| sunshine (S) | sunshine duration (hour) | positive impact | 20% |
| wind (W) | wind speed ($ms^{-1}$) | variable impacts depending on its value and the maximum temperature | 10% |

As all sub-indices have a maximum score of 5, Mieczkowski (1985) proposed a rating system of TCI with an overall top score of 100, where acceptable scores are above 40, good climatic conditions are above 60, and excellent scores are above 80 (Table 3.2.).

**Table 3.2. Tourism Climatic Index rating system (Mieczkowski, 1985)**

| TCI scores | Descriptive categories |
|---|---|
| 90 – 100 | Ideal |
| 80 – 89 | Excellent |
| 70 – 79 | very good |
| 60 – 69 | Good |
| 50 – 59 | Acceptable |
| 40 – 49 | Marginal |
| 30 – 39 | Unfavourable |
| 20 – 29 | very unfavourable |
| 10 – 19 | extremely unfavourable |
| < 10 | Impossible |

Scott and McBoyle (2001) presented a conceptual framework of six possible types of annual TCI distributions; the tourism resource of all destinations can be classified into one. This framework is used to characterise the climatic tourism conditions in the world so far.

The sub-indices of TCI expressing thermal comfort conditions (CId, CIa) are based on the effective temperature (ET), which is a simple empirical index of air temperature/relative humidity combinations (Houghten and Yaglou, 1923). The optimal comfort zone of ET is between 20 and 27 °C according to ASHRAE (1972), rated with a maximum point of 5. The rating scale decreases on both sides of the optimal zone with 1 or 0.5 points. However, the rating points of the zones are based on the author's subjective opinion. They are not empirically tested against the preferences of tourists (De Freitas, 2003; De Freitas et al., 2008).

A further significant shortcoming of ET is that it needs to include the effects of such thermal parameters as wind speed and short and longwave radiation fluxes. In addition, it does not consider such physiological; thus, bioclimatic ally relevant personal data such as age, gender, height, weight, metabolic rate, and clothing. Therefore, it cannot evaluate the thermal conditions of the human body in a physiologically significant manner.

The PET value categories were initially defined according to thermal sensations and physiological stress levels of Western and Central European people. The thermally neutral heat sensation and stress are indicated by the PET value range of 18–23 °C (Figure 3.9.) (Matzarakis and Mayer, 1996).

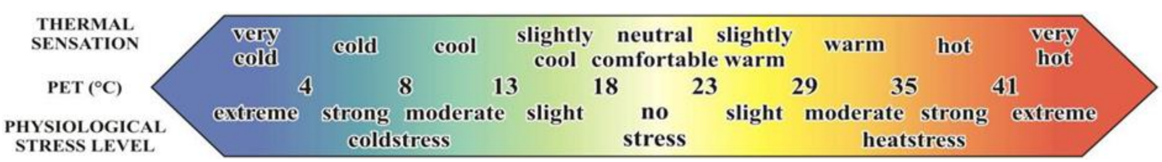


**Figure 3.9. The PET values (°C) categories for different thermal sensation grades and physiological stress levels of Western and Central European people (based on Matzarakis and Mayer, 1996).**

Recently to facilitate the calculation of the TCI, a mini portable software was designed in Iran by Hassan Oruji. Mohammad Alizadeh, in 2011, student of geography and tourism planning at Tehran University, which can be installed. This program runs efficiently by double-clicking on its calculation options after inserting climatic parameters, including CID, CIA, precipitation, sunny hour and wind. Where CID = index of thermal comfort during the day (° C), CIA = daily thermal comfort index (° C), P = total monthly rainfall (mm), S = sunshine (h/day) and W = wind speed (km/h).

In this part of this thesis, to calculate the TCI for both cases study regions, those mentioned above mini portable software will be utilised, and results will be presented in chapter IV for each case study. In general, the reliability and usability of the TCI index are still among the highest available indices, which rely on thresholds and classification that determine a range and quantitative scale for each index component.

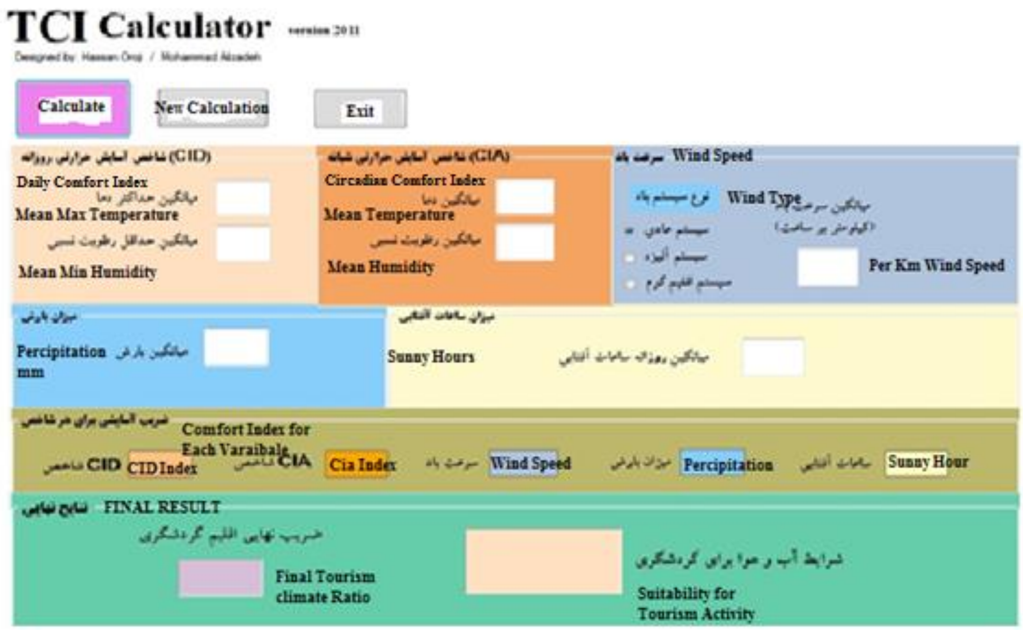


**Figure 3.10. TCI Calculator Semi Software**

As Coastal activities are daily activities and there is no night activity under this type of tourism, Maximum Temperature is the most critical factor in the selection of a coastal destination. Minimum temperature is given a relatively small weight even though among climate factors for Tourists in destination selection, with this presumption that during summer time the probability of precipitation in both case study regions of Kish Island and Algarve region is less than a per cent, so the factor of Sunshine hours and blue sky is eliminated from the scoring.

Socioeconomic and emission scenarios are used in climate research to provide plausible descriptions of how the future may evolve concerning various variables, including socioeconomic change, technological change, energy and land use, and emissions of greenhouse gases and air pollutants. They are used as input for climate model runs and as a basis for assessment of possible climate impacts and mitigation options and associated costs. For better comparisons between various studies and more accessible communication of model results, it is preferable to use a standard set of scenarios across the scientific community. Several scenarios methods formed such a role in the past, including the IS92 scenarios and, more recently, the scenarios from the Special Report on Emission Scenarios (Nakicenovic et al., 2000).

Moss et al. (2010) point out that the research community needs new scenarios. First, more detailed information is required for the current generation of climate models than that provided by any previous scenario sets. Second, there is an increasing interest in scenarios that explicitly explore the impact of different climate policies in addition to the no-climate-policy scenarios explored so far.

Such scenarios would allow evaluation of the "costs" and "benefits" of long-term climate goals. Finally, there is also an increasing interest in exploring the role of adaptation in more detail. This requires further integration of information for scenario development across the different disciplines involved in climate research. The need for new scenarios prompted the Intergovernmental Panel on Climate Change (IPCC) to request the scientific communities to develop a new set of scenarios to facilitate the future assessment of climate change (IPCC, 2007). The IPCC also decided such scenarios would not be developed as part of the IPCC process, leaving new scenario development to the research community.

The community subsequently designed a process of three phases (Moss et al., 2010):

1) Development of a scenario set containing emission, concentration, and land-use trajectories referred to as the "representative concentration pathways Index" (RCPI).
2) A parallel development phase with climate model runs and the development of socioeconomic scenarios.
3) A final integration and dissemination phase.

The primary purpose of the first phase (development of the RCPI) is to provide information on possible development trajectories for the main forcing agents of climate change, consistent with current scenario literature, allowing subsequent analysis by both Climate models and Integrated Assessment Models.

A careful selection process was used to identify the RCPI, using criteria that reflected the needs of both climate scenario developers and users. Two essential characteristics of RCPI are reflected in their names. The word "representative" signifies that each RCPI represents a more extensive set of scenarios in the literature. As a set, the RCPI should be compatible with the full range of emissions scenarios available in the current scientific literature, with and without climate policy. The words "concentration pathway" are meant to emphasise that these RCPIs are not the final new, fully integrated scenarios but instead are internally consistent sets of projections of the components of radiative forcing that are used in subsequent phases (Hibbard et al., 2007).

### 3.10.2. Mann-Kendall Trend Model Test

The Mann-Kendall test was first presented in (1945) and later expanded and developed by Kendall (1975) (Serrano, 1999). This method is commonly and widely used in trend analysis of hydrological and meteorological series. It is considered one of the essential methods for testing the trend of time series. One of the strengths of this method is its suitability for time series that do not follow a specific statistical distribution.

There are two advantages of using this test. First, it is a non-parametric test and does not require the data to be normally distributed. Second, the test has low sensitivity to abrupt breaks due to inhomogeneous time series. Any data reported as non-detects are included by assigning them a standard value smaller than the smallest measured value in the data set.

The Mann-Kendall test is run to detect trends in a long time series. This test is based on the idea that what has happened in the past gives a hint of what will happen in the future. A trend can be considered the general movement over time of a statistically detectable change (Gary and Philippe, 2011).

To calculate this test, the data was first ranked, the ti statistic (ratio of rank I to our previous rank) was calculated, and then the cumulative frequency of the ti statistic ($\sum t_i$) was obtained. Mathematical expectation $E_i$, variance $V_i$ and Mann-Kendall index $U_i$ are calculated based on relations 3.2. to 3.4..

$$E_i = \frac{n_i(n_i-1)}{4}, \quad (3.2.)$$

$$V_i = \frac{n_i(n_i-1)(2n_i+5)}{72}, \quad (3.3.)$$

$$U_i = \frac{\sum(t_i-E_i)}{\sqrt{V_i}}, \quad (3.4.)$$

The time order of the data and the statistic Ti is the ratio of rank i to the previous ranks. This index has a normal distribution. Therefore, to identify the significance, the standard curve table is used. To examine the changes, an index must also be determined, and the steps for calculating this index are as follows:

The data is ranked and the statistic (the ratio of the rank to our ranks) is specified and then the cumulative frequency ($\sum t'_i$) is calculated. Mathematical expectation $E'_i$, variance $V'_i$ and Mann-Kendall index $U'_i$ are as follows:

$$E'_i = \frac{[N-(n_i-1)](N-n_i)}{4}, \quad (3.5.)$$

$$V'_i = \frac{[N-(n_i-1)](N-n_i)\left[2\left(N-(n_i-1)\right)\right]+5}{72}, \quad (3.6.)$$

$$U'_i = \frac{-\sum(t'_i - E'_i)}{\sqrt{V'_i}}. \quad (3.7.)$$

N is the statistical sample size under study when it is -1.96 < U < 1.96, it is a random series and does not have a specific trend. But if U < +1.96 indicates an increasing trend and U > -1.96 indicates a decreasing trend in the data series (Ozbar, 2007).

### 3.10.3. Sen´s Slope Estimator Test

Simple linear regression is one of the most frequently used models for linear trend identification (Sen, 1968). This method requires, however, the assumption of residual normality (McBean and Motiee, 2008). Viessman et al. (1989) stated that, due to the influence of natural phenomena, many hydrological variables show a pronounced right skewness and do not adopt a normal distribution. Thus, the Sen (1968) slope estimator is a powerful tool for developing linear relationships. Sen's slope has the advantage over the slope of regression because gross data series errors and outliers do not affect much. The slope of the Sen was determined as the mean of all pair-wise slopes for dataset points.

Sen's method uses a linear model to estimate the slope of the trend, and the variance of the residuals should be constant in time calculated with this regression model as shown below:

$$Y_i = mx_i + c, \quad (3.8.)$$

Where Y is the dependent variable (for example, rainfall) and X is the independent variable (time in months or years), respectively, *m* is the line slope (mm/year), and c is the intercept constant coefficient. The coefficients (*m*) of the modal are determined using the Least-Squares method, the most commonly used method. The slope sign defines the variable trend direction; it increases if characterise is positive and decreases if it is negative and is calculated by:

$$m = Median\left(\frac{x_j - x_i}{j - i}\right), j > i. \quad (3.9.)$$

In this work, Minitab 19.1, commercial software for data analysis, graphing, and statistics, has been used to detect the meaningful changes in the historical climatic data series of both case study regions. There are many advantages to using this interactive and menu-driven software, and users are guided through the data analysis process according to "assistant" dialogue boxes. The software runs basic statistics, including parametric regression and analysis of variance, survival analysis, and a limited number of multivariate analyses. Some of the graph data and statistical models in this work were drawn with the help of Minitab 19.1.

### 3.10.4. Lars-WG6 Climate Model

The Long Ashton Research Station Weather Generator (LARS-WG) is a stochastic weather generator used for the simulation of weather data at a single site under both current and future climate conditions using General Circulation Models (GCM) (Racsko et al., 1991; Semenov and Brooks, 1999). These data are in the form of daily time series for a suite of climate variables, namely, precipitation (mm), maximum and minimum temperature (°C) and solar radiation (MJm-2day-1).

Stochastic weather generators were initially developed for two primary purposes: 1. To provide a means of simulating synthetic weather time-series with statistical characteristics corresponding to the observed statistics at a site, but which were long enough to be used in an assessment of risk in hydrological or agricultural applications. 2. To provide a means of extending the simulation of weather time series to unobserved locations through the interpolation of the weather generator parameters obtained from running the models at neighbouring sites.

It is worth noting that a stochastic weather generator is not a predictive tool that can be used in weather forecasting but is simply a means of generating time series of synthetic weather statistically 'identical' to the observations. Climate change studies have generated new interest in local stochastic weather simulation. Currently, global climate models (GCMs) output needs more spatial and temporal resolution and reliability to be used directly in impact models. A stochastic weather generator, however, can serve as a computationally inexpensive tool to produce multiple-year climate change scenarios at the daily time scale, which incorporate changes in both mean climate and climate variability (Semenov et al., 1998).

In 2005, Coulibaly and Dibike used three models, ANN (Artificial Neural Network), SDSM (Statistical Downscaling Model), and LARS-WG (Short for Long Ashton Research Station Weather Generator, to scale the climatic variables in Canada. The results showed that the SDSM (Statistical Downscaling Model) model has higher accuracy in micro-scale variation of climatic variables. Vezzoli et al. (2015) evaluated the SDSM model in Kermanshah. The results indicate the high accuracy of this model in the micro-scale scale of climatic variables—Xu and Luo (2015) compared the two statistical models of SDSM and LARS-WG. The results showed that in the period 1999–2071, the temperature increased in most scenarios compared to the base period. Norouzi and Fani (2020) Investigated the uncertainty of two small-scale LARS-WG and SDSM scaling models in Chadegan Wetland in Iran. The results showed that the LARS-WG model performed better in modelling climate data.

Based on the above studies, the LARS-WG model has high accuracy in both micro-scaling and macro-scaling climatic data. Most studies use the LARS-WG model in periods during the present century.

### 3.10.5. PPD Index

PPD, which stands for Predicted Percentage of Dissatisfaction, which is developed by Danish comfort researcher Fanger, who developed the PMV (predicted mean vote) first and then the PPD comfort model. He hypothesised that human thermal comfort was based on skin temperature and sweat secretion and that one could only be considered 'comfortable' if these factors were balanced within a narrow range of acceptability (Sebastian Guenther, 2022). PPD is primarily an index that makes a quantitative prediction of the proportion of thermally displeased residents (i.e., too hot or too cold). PPD indicates the proportion of people who are expected to feel localised discomfort. Unwanted bodily cooling or heating of a person is the leading cause of local pain. Drafts, unusually high vertical temperature changes between the ankles and the head, and/or floor temperature are common causes.

Fanger (1973) began his studies of thermal comfort in the 1960s proposed that a person's sense of thermal comfort was influenced by both the temperature of their skin and the amount of perspiration they were producing. One could only be considered "comfortable" if these two aspects were balanced within a specified acceptable range. Thermoregulatory systems in humans cause involuntary reactions that change body temperature. For instance, It may sweat in hot temperatures or shiver in cold weather to maintain our thermal balance and prevent local pain. Until a certain point, the human body can adapt to its environment, but once that point is reached, its reactions are perceived as uncomfortable. Finger's theory, which claimed that a person's level of thermal comfort could be calculated by considering their metabolic rate, garment insulation, and environment, was established through climate chamber studies.

Today's widely accepted ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) 55, published in 1966, was initially created as a criterion for assessing indoor environments and defines thermal comfort as a state of mind that conveys contentment with the thermal environment. Even in outdoor settings, such as coastal regions, the PPD indices can express these comfort levels.

According to ASHRAE 55, thermal comfort can be attained based on an occupant satisfaction rate of 80% or above using both indices. The remainder of the population may feel 10% dissatisfaction due to whole-body discomfort (based on all of the PMV-affecting factors) and 10% dissatisfaction due to local or partial-body pain (includes fewer factors than whole-body). Depending on the determined PPD, the PPD might range from 5% to 100%. These comfort levels will change depending on where the activity will be performed in tourist places. The standard satisfaction in an environment must be lower than 20% for comfort ranges to meet with standards.

## 3.11. Data Analysis

Secondary data analysis use is growing, given the broad access to archived records in today's digital age (Bulmer et al., 2009; Middleton et al., 2014). The use of this methodology is attributed to the advantages that it offers to the researcher. Secondary data on the impact of climate change are collected. Data sources are through online resources and official government institutions and parastatals mandated to work in the field of concern, such as IPCC (International Panel on Climate change) or WMO (World Meteorological Organization), which is a specialised agency of the United Nations. Respectively climate data records were obtained from the Islamic Republic of Iran National Meteorological Organization and the website of the World Meteorology Organization metadata (https://community.wmo.int/activity-areas/climate), which has close collaboration with Portuguese's National Meteorological Department, which is the official meteorological and climatology service provider for Portugal.

It is affiliated with the International Panel on Climate Change (IPCC) and World Meteorological Organization. As such, their data is considered highly reliable and valid. Climate parameter data was collected from both case study countries monthly for the period from 1980 to the current year 2021 for observation and analysis.

## 3.12. Conclusion

Earth's surface temperature has been increasing since the mid-19th century. During this period, the last three decades have been the hottest years. Recorded data show that from 1901 to 2011, land and ocean temperatures rose by an average of 0.89 Celsius. This rising trend in global warming, as well as changes in the physical properties of the atmosphere, indicate climate change. Suppose proper measures should be taken to reduce the effects of climate change and adapt. In that case, this phenomenon could affect a significant part of the world, including agriculture, water resources, and tourism. Today, atmospheric general circulation models are the most reliable for producing climatic scenarios. The outputs of these models have low spatial accuracy. Therefore, if the production of these models is placed directly as the input of meteorological models, it will increase the uncertainty. Meteorologists mostly use statistical modelling methods for microscale data mining. One of the reasons for using these models is their fast and easy operation compared to other methods.

The chapter presented the necessary steps to collect data from both primary and secondary sources, providing a step-by-step process. It emerged from the chapter that a case study mixed method approach was used in this research with the Pragmatism theoretical framework being used.

Cluster zone sampling through defining touristic axes was used to identify ideal locations for the research. Data analysis techniques were performed using tools best fit for the generated data, such as Mann-Kendall and Sen's slope Trend Analysis, Excel, Minitab16 and Lars WG6 analysis and TCI calculator. Various methods and techniques were used to respond to the research questions. The chapter paves the way for the next chapter on results presentation.

With climate change shifting the main weather parameters relevant to tourism and putting pressure on the environments where tourism activities occur, assessing climate change impacts on tourism has become a primary necessity. Existing studies on climate change impacts on tourism have commonly used composite indices such as the Tourism Climate Index to assess destinations' climate suitability for recreation.

However, this study was not explicitly designed for coastal tourism and therefore overemphasised the negative role of high temperature compared to other weather aspects. The findings presented in this thesis confirm the importance of climate for coastal tourism. Still, they reveal that the function of high temperature is less critical than other forms of tourism. Another limitation of the TCI is that the weighting of the weather parameters is rooted in theoretical knowledge rather than empirical evidence.

# CHAPTER 4

# (Results and Findings)

## 4.1. Introduction

This chapter discusses the results and findings adopted to address the research aims given in Chapter III. This study chapter mainly focuses on detecting trends in annual temperature and precipitation for the two case study regions. For this work, trend analysis was done using the Mann-Kendall test and Sen's slope estimator. The Mann-Kendall (MK) statistical test (Mann, 1945; Kendall, 1975), a rank-based non-parametric method, has been widely used for detecting trends in hydrometeorological time series such as groundwater (Helsel and Hirsch, 1992), water quality, temperature, and precipitation (Lettenmaier et al., 1994; Sang et al., 2014; Wang et al., 2019).

Sen's slope estimator, introduced and named after Henri Theil and Pranab K. Sen in 1950 and 1968, is a non-parametric estimator method used to predict the magnitude (proper slope) of hydro-metrological time series data worldwide. The widely used modified Mann-Kendall trend test was run at a 5% significance level for the series data for each case study region from 1980 to 2021. The resultant Mann- Kendall test statistic (S) indicates how strong the trend in temperature and precipitation is and whether it is increasing or decreasing. Here in this chapter, analysis of climatic parameter trends is done using Mann-Kendall (MK) Test and Sen's Slope Estimator are crucial in studying the impacts of climate change on coastal tourism in case study regions.

This chapter analyses the collected secondary data from two case study regions that underpin this study, including Kish Island in Iran and Algarve Region in Portugal. This includes finding trends among the historical meteorological data in a time series which exists up to the current time and forecasting future data based on the possible scenarios with the standpoint of the IPCC scenarios for the future under the paradigms of RCPI 4.5 and RCPI 8.5 in which the work is grounded. Then, the three research phases are performed: first by calculating future climate data of two case study regions, then validating data and finally putting extracted data from Mann-Kendall tests into test by use of the TCI Index to elaborate possible changes in the climatic variables, which may have a direct impact on tourists' perception and satisfaction from climate changes during coastal high season periods in the Algarve Region and Kish Island.

This thesis aims to assess the impacts of climate change on coastal or beach tourism using an adapted index known as TCI, which is used widely among Tourism researchers. The index in research will be carried out by broad historical climatic data, including Minimum Temperature, Maximum Temperature, Mean Annual Temperature and Annual precipitation collected from two case study regions of the Algarve region in Portugal and Kish Island in Iran in the form of time series as secondary data resources. The resulting index offered a view of the main changes in beach tourism climate comfort in the case study region, mainly in the summer high season for the Algarve region and Kish Island, besides other possible high seasons for both, which may vary from each other.

Climate conditions are changing in recent years for the two case study regions. For instance, in the Algarve region, the lack of precipitation, abundant sunny hours, moderate wind breeze and comfortable temperature contributed to this high climatic comfort in the past but more in future. The condition has already changed for the other case study region. It is not comfortable anymore during summer for Kish Island due to exceeding Maximum daily temperature from the tourist's comfort temperatures, so new seasonality and new high season may appear, and there will be a tourism calendar shift for sure happening in Kish Island and some shoulder season will be appearing. The Algarve region is not an exception in this case.

The moderate RCPI 4.5 and the more extreme RCPI 8.5 general Models were used to calculate index values for two case study regions under two potential scenario models of climate change in the period 2020-2050 as a near-future scenario and 2050 to 2100 as a far future. The climate scenarios are chosen from IPCC scenarios adapted to the tourism sector. They are primarily high emissions scenarios that present the quickest emission growth and the most significant potential changes for tourism in both the Middle East and European territory.

Recent analyses have identified these scenarios as the course that current emissions are taking place quite earlier than predicted. The results of this analysis indicated a meaningful trend, although the magnitude and speed of changes will be significantly different in the future. Future conditions reflected by all models show deteriorating comfort in all areas of the two case study regions, mainly in the South of Iran and Portugal. The rate of changes is accelerating in lower latitudes and locations in the south of the Middle East and Europe, mainly in the Mediterranean zone. Therefore, with these dramatic changes in the south of both countries, natural climatic comfort extends towards northern latitudes, and the beach climate index improves in the North of Iran and northwest of Portugal.

In brief, this chapter highlights findings on tracking evidence of climate variability and change in the Algarve region and Kish Island. As indicated in chapter 3 (methodology), various climatic variables were used to respond to research objectives that focused on determining the evidence of climate variability and change in two case study regions. Temperature patterns, including

Maximum daily temperature, Minimum daily temperature, mean daily Temperature, Precipitation, and daily sunny Hour from historical field data, were analysed for this purpose over 40 years.

The issues of climate change and regional tourism adaptation are investigated using a 'single case study approach. Yin (1993,) states that "the distinctive need for case studies arises out of the desire to understand social phenomena", specifically defining this approach as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not evident" (1993).

The case study approach is appropriate for this research, as climate change and adaptation can be regarded as a 'contemporary phenomenon, and by placing this within the 'real-life context' of the Algarve region and Kish Island, a greater understanding of these phenomena can be gained. A vital aim of this study is to develop a framework to assist regional tourism destinations in adapting to climate change. This model is then applied, as a dual case study, to explore the possibility of various adaptation options and their potential impact on tourist behaviour and demand for the future.

## 4.2. Methodology

This study incorporated three research analysis phases. The first phase involved the development of the Regional Tourism assessment and case study analysis applied. This phase includes two initial stages feed with secondary data sets of climatic time series collection and data validation analyses using LARS-WG 6 (Long Ashton Research Station Weather Generator) and Mann-Kendal Trend Test, Sen's Slop estimation. The second phase includes presenting the results of the first two phases in the TCI calculator to find the final predictive results about the suitability of climatic variables in the near and far future for coastal tourism activities in both study regions.

A standard statistical test for analysing and identifying trends in climatological and hydrologic time series in which the Mann-Kendall test and Sen's slope estimator for magnitude estimation will be applied for both case study regions. Finally, trend results were compared with regression analysis. Also LARS –WG6 model is a computationally downscaling tool to generate local scale climate scenarios based on global or regional climate models for impact assessments of climate change in such a way that all collected data were analysed by using incorporation of climate projections from the CMIP5 ensemble used in the IPCC Fifth Assessment Report. LARS-WG trend modelling has been well-validated in diverse climates worldwide, so its results have high validity and reliability.

A template was created using Microsoft Excel to run the Mann-Kendall Trend Test and LARS-WG6 model. Long-term historical secondary daily data of the climatic variables from (1986-2020) including temperature, precipitation of synoptic and climatological stations of Kish Island (Represented by Kish International airport station) and Algarve station (Represented by Faro International Airport Station) from (1982-2021) were collected. It should be noted that the climate information in the territory of the Algarve region's stations was homogenous, and weather condition in the area is close to each other, so long-term statistics has immediate distribution and the Faro station represents the whole region.

### 4.2.1. Data Collection and Data Processing

The secondary collected data from time series of historical available called predict ants which, for the case of Kish Island, were acquired from the office of the Iran Meteorology Organization also backed up by their online resources from (https://irimo.ir) for the period of 38 years (1982-2018). The data used in this thesis include data recorded by the Iranian Meteorological Organization at the Kish station. Kish weather station is managed under the supervision of the Hormozgan Province General Department of Meteorology (in the south of Iran and the Persian Gulf). Kish Island weather station is of synoptic type. In synoptic weather stations, air temperature data (minimum and maximum), wet and dry temperature, soil temperature in the depths (5, 10, 20, 30, 50 and 100 cm), air humidity, wind speed and direction (height 2 and 10 meters), sunny hours, air pressure at the station, evaporation from the basin surface according to the international standard WMO) and based on Greenwich time in 3-hour time intervals and recorded in the computer system. The Iran Meteorological Organization provides the database to users daily.

In this thesis, the hourly data of the Kish meteorological station is prepared daily in the statistical period (1982-2018). Data entered into the Excel environment by changing the format from TEXT to EXL.

The same type of climatic data was collected for the case of Algarve from the World Meteorological Organization website (https://community.wmo.int/climate-metadata) for the same period of 40 years (1980-2020) are downloaded. All these data were entered in Excel files and then entered into the Annual data worksheet in excel. In the second step, using Excel and Minitab 19 statistical software, the data were divided into monthly and yearly intervals according to the research objectives. In addition, statistical indicators such as average, total, standard deviation, etc., were calculated, and time series graphs of each climate variable were drawn, as shown below.

### 4.2.1.1. Calculation of Statistical Variables

The non-parametric Mann-Kendall test revealed climatic elements' changes in the next step. For the Mann-Kendall non-parametric test, which shows the difference in different ends and their significance, a statistical program was written in the Mintab19 software environment, which was done by transferring the data from the Excel software environment to the Minitab software.

Then, by calling the data in the Minitab environment and running the following program, the time series of the data is drawn, and a report is presented from the test of null hypotheses (significance of the trend) and hypothesis one (significance of the trend) at the 95% confidence level.

The IPCC database and the sixth report and its scenarios and Larswg6 environment for Kish Island and Algarve (Faro) station were used to investigate the future climate conditions. In this software, the data in (*.TXT) format is first entered into the Lars-WG software, and then by selecting the appropriate scenarios and converters is prepared for the sixth report. It should be noted that in this software, the data is in joules and daily. It is arranged for each year, and the output of four variables of maximum, minimum, sunny hours and precipitation for future periods are presented.

### 4.2.1.2. Data Description

The projected climate changes are highly uncertain and rely on technological innovations and socioeconomic development to adopt clean technology against greenhouse gas emissions in the atmosphere. The Coupled Model Inter-comparison Project Phase 5 (CMIP5), by the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), used RCPs that provide a more comprehensive picture of future climate change, including a mitigation scenario (RCP-2.6), two medium stabilisation scenarios (RCP-4.5 and RCP-6.0) and an extreme scenario (RCP 8.5). There are five GCMs of CMIP5 for one medium stabilisation scenario (RCP-4.5) and an extreme scenario (RCP-8.5).

These collected data were initially in the form of daily time series for a suite of climate variables, namely, precipitation (mm), maximum and minimum temperature (°C) and solar radiation (omitted because it was not measurable in both cases study regions also does not weight TCI calculation equation) to run in the format of data which can be run by LARS-WG6 data set modelling format and Mann-Kendall trend detection test time series. In this study, the entire daily gridded climatic time series have been converted into monthly time series during the historical period.

A few numbers of data in both stations have missing values that were replaced by using the interpolation technique by being replaced by 0. The 40 years of available historical data for both stations from the decade 80's to the current time were used as the baseline data for statistical downscaling and bias correction of the daily time series for the near and far future periods.

Generally, statistical tests such as LARS-WG6, which show the trend and point of a sudden change in time series, are divided into parametric and non-parametric. There are no theoretical non-parametric methods for data distribution, and this direction of process detection is not affected by a sudden change in time series. Therefore, they are more suitable for studying climatic variables with abnormal and heterogeneous distributions.

### 4.2.1.3. Data Downscaling Technique

As the data set in this study covers only a small area and we are using scenarios of a global scale from the Intergovernmental Panel on Climate Change (IPCC), downscaling approaches have been utilised to assess local-scale climate simulations. IPCC offers various climate change scenarios and attempts to forecast the result of that variation on related natural phenomena. These scenarios are based on pollution and land use dynamics, population and the influence of climate change on these activities.

IPCC scenarios depict a very heterogeneous world, a continuously growing global population, and economic development oriented regionally. To downscale global climate scenarios resulting from different emissions scenarios for evaluating climate influences on a small area such as Kish Island and Algarve Region, which are the case study region of this study.

Data downscaling will help us to provide highly accurate information at a scale of 100-500 kilometres for one grid size and temporal scales of monthly means and longer to project the influences of emissions on climate in the future. Accordingly, it is considered too coarse for planning and assessment of impact for almost all decision makers. It is utilized partially, with a resolution of 20 kilometres, or even a specific location, and temporally (e.g., daily temperature sequences from monthly or seasonal temperature amounts).

Accordingly, this study will apply the statistical downscaling method and, more precisely, the Long Ashton Research Station Weather Generator (LARS-WG) version6. To downscale the historical climatic data, daily maximum temperature variable data from Kish Island and Algarve region for 1980-2020 (40 years) was employed to calibrate and validate the LARS-WG6 model.

The LARS-WG6 model is adequate in replicating the observed maximum temperature in this study for both case study regions, emphasizing that the emphasis is appropriated for selected case study regions. Similar reliable performances in generating maximum temperature have been found for the LARS-WG6 model in various locations worldwide. Therefore, confidence was increased to employ the downscaling model in this study. The developed and calibrated LARS-WG6 model for two case study regions was then used to forecast maximum temperature for three periods, 2022-2050 and 2050-2100, dependent on the IPCC scenarios generated from global models.

### 4.2.2. Mann-Kendall Test in Time Series Data

To run and interpret a Mann-Kendall trend test on a time series in Excel, XLSTAT were used. As the climatic time series data in this study are from two different case station regions with nonstationary seasonal time series, with XLSTAT option since the goal is to test whether there is a trend in the time series or not. By using the demo file, select column B (Maximum Temp) in the Time series field and column A (Month) in the Date data field. After selecting the column headers, the option Series labels are activated.

XLSTAT offers two tests: the classical Mann-Kendall test to test if there is a trend in the time series; the seasonal Mann-Kendall test. The seasonal Mann-Kendall test is used to assess the trend and directionality in the time series.

The Seasonal Mann-Kendall option is also applied by entering 12, which is (=months) in the Period field. To calculate the p-value of this test, XLSTAT uses a normal approximation to estimate the distribution of the average Kendall tau. A continuity correction was also applied to increase the accuracy level for seasonal Mann-Kendall. As time series is dependent, the option Serial dependence was activates. In the Options tab, we select tau $\neq 0$ as an alternative hypothesis.

### 4.2.3. Mann-Kendall Trend Test Model Calculation and Result Interpretation

A statistical trend is a significant change over time that may be identified using both parametric and non-parametric techniques, and a time series' trend analysis measures the statistical significance and amplitude of the trend. Statistical significance trend analysis was performed in this study. In this part of the data analysis, Mann-Kendall Trend Test is used to analyse the difference in signs between earlier and later data points in both Kish International airport and Faro International airport. Respectively, according to the theory, if a trend is present, the sign values will tend to increase or decrease continuously. The use of this test has two benefits. Its non-parametric nature means that it is not dependent on regularly distributed data. Second, because of the inhomogeneity of the time series, the test has a low sensitivity to abrupt interruptions.

The data are included by giving any data reported as non-detects a standard value less than the smallest measured value in the data set. According to this test, the null hypothesis H0 assumes no trend (the data is independent and randomly ordered). This is tested against the alternative hypothesis H1, which takes a direction.

The Mann-Kendall test algorithm considers the time series of n data points and Ti and Tj as two subsets of data with i = 1, 2, 3..., n-1 and j = i+1, i+2, i+3..., n. The values of the data are assessed as an ordered time series. All following data values are compared to each data value. The statistic S is increased by one if a data value from a later period is higher than a data value from an earlier period. In contrast, S is reduced by one if a data value sampled from the last period is lower than that collected earlier. The final value of S is the sum of all such increments and decrements.

### 4.2.4. Test of Sen's Slope Estimator

Sen's slope estimator and Mann-Kendall were used in Minitab version 19 to analyse the trend for the monthly Minimum and Maximum temperature, annual precipitation data, and annual mean temperature for the two case study regions. The results of the observed climatic variables were established by linear regression using regression analysis.

Once the slope m of the regression model stated in Chapter 3 has been determined, a line may be generated from the sample points by setting the y-intercept C as the median value of the yi mxi. The line $Y_i = mx_i + c$ with coefficients m and c in slope-intercept form is then the fit line. Sen observed that when the values of xi are compared to their corresponding residuals, $Y_i - mx_i - c = \varepsilon_i$, the Kendall tau rank correlation coefficient becomes roughly zero. This implies that a data point's position on the left or right side of the data set is not correlated with how far the fit line passes above or below it.

The Kendall coefficient is unaffected by the choice of C, but it makes the median residual close to zero, meaning that the fit line passes above and below the same number of points. The interval comprising the middle 95% of the slopes of lines given by pairs of points can be used to calculate a confidence interval for the slope estimate. This can be done rapidly by sampling pairs of points and determining the 95% interval of the sampled slopes.

One of the most popular ways to find a pattern in a data series is using linear regression analysis, which is a parametric model. This model establishes a link between two variables by fitting a linear equation to the observed data (dependent and independent). The information is next evaluated to determine whether or not there is a relationship between the interest-related variables. The scatter plot makes it possible for this. The linear regression model is ineffective if there is no association between the two variables. The correlation coefficient quantifies this correlation between the variables, ranging from -1 to +1. A good match is indicated by a correlation coefficient value of less than 1. A value close to zero implies that the two variables have a random, non-linear relation.

## 4.2.5. LARS-WG Model Projection

As seen in those mentioned above, historical synthetic daily maximum temperature data and IPCC scenario were employed in the LARS-WG model to validate and calibrate the model by downscaling maximum temperature from 1980 to 2020 to forecast the timelines of 2022-2050 and 2050-2100.

After model calibration (1980–2020), the daily observed series data for Tmax, Tmin and precipitation were applied to examine parameters for a probability distribution. The experimental weather data (Tmax, Tmin and precipitation) were used in LARS-WG to generate time series of varying lengths by selecting random values from the stations' distributions.

LARS-WG was based on the semi-empirical distribution that used a cumulative probability distribution function to approximate the probability of dry and wet series for Tmax and Tmin and dry and wet days for the precipitation. The future climate scenarios were generated for the period (2022–2100) for selected RCPs based on the LARS-WG baseline parameters (1980–2020).

In LARS-WG, the differences in current and future climatic changes were incorporated using bias correction, which is the difference of the mean monthly changes of Tmax, Tmin and precipitation. The following equations are used for $\Delta T_i$ and $\Delta P_i$:

$$\Delta T_i = [T_{2022-2100} - T_{1980-2020}], \quad (4.1.)$$

with $\Delta P = (P_{2022-2100})$ and $i = P_{1980-2020}$.

The $\Delta T_i$ and $\Delta P_i$ are to represent long term changes of each month (1: s i: s 12), for temperature and precipitation, respectively.

To interpret the results of a Mann-Kendall test, it should be considered that the seasonal Mann-Kendall test will tell us whether there is a trend not due to seasonality. The p-value (<0,0001) shows that the null hypothesis is rejected. Thus, it may be suggested that there is a significant trend in our time series when it takes into account the 12-month seasonality.

The results of the yearly maximum temperature forecasting data for both case study regions and their ensemble mean for the two timeline periods are done, which are explained in the below sections. This historical figure shows that all the projected data over the period 2022-2050, in general, have considerable variation. In addition, the results exhibit anomalous behaviour in both case study regions in future.

The second timeline period, 2050-2100, shows that the variation will also be increased, compared with the previous two periods of 1980 to 2020 and 2022 to 2050. Models for both case study regions have a different pattern and offer the highest temperature predictions degree in the Algarve region compared with the Kish Island, demonstrating other trends in each one, which will be explained in the sections below in detail.

## 4.3. Climatic Variables Change Trend Detection in Case Study Regions

In this part of the work, historical data of the climatic variables of the two-case study region were first collected and analysed to find meaningful trends in their annual pattern changes during the recorded history. Finding and detecting the movements of changes will help us forecast the future climatic variables under some globally well-known scenarios introduced by IPCC, referred to in this work by RCPI 4.5 and RCPI 8.5.

RCPI, which stands for Representative Concentration pathways, as explained in chapter three, represents potential future scenarios for emissions of greenhouse gases and aerosols. RCPI scenarios are determined by total solar radiative forcing by 2100 rather than specific political, social, or economic outcomes. Data made available through Cal-Adapt combines two RCPIs: RCPI 4.5 and RCPI 8.5, to address uncertainty in future concentrations of greenhouse gases and aerosol emissions.

The Intergovernmental Panel on Climate Change (IPCC) characterises RCPI 4.5 as a moderate scenario in which emissions peaked about 2040 and then began to drop. The scenario with the highest baseline emissions is RCPI 8.5, which assumes that emissions would increase throughout the 21st century. As a result, the expected effects of climate change under RCPI 8.5 will often be worse than those under RCPI 4.5.

Using these two scenarios, it will be easy to compare a moderate and worst-case scenario while viewing both RCPI 4.5 and RCPI 8.5 scenarios. In short, RCPI 4.5 is a moderate scenario about climatic changes in the future period, which can be called the optimistic scenario for the future, and RCPI 8.5 is the pessimistic or worst possible scenario about the possible climatic changes for the future in each region.

**Table 4.1. RCPI Description and Citation (Van Vuurenet al., 2011)**

| Scenario | Description | IA Model | Publication – IA Model |
|---|---|---|---|
| RCP8.5 | Rising radiative forcing pathway leading to 8.5 W/m2 in 2100 | MESSAGE | Riahi et al. (2007) |
| RCP6 | Stabilisation without overshoot pathway to 6 W/m2 at stabilisation after 2100 | AIM | Hijioka et al. (2008) |
| RCP4.5 | Stabilisation without overshoot pathway to 4.5 W/m2 at stabilisation after 2100 | GCAM (Mini CAM) | Wise et al. (2009) |
| RCP2.6 | Peak in radiative forcing at ~ 3 W/m2 before 2100 and decline | IMAGE | van Vuuren et al. (2006; 2007) |

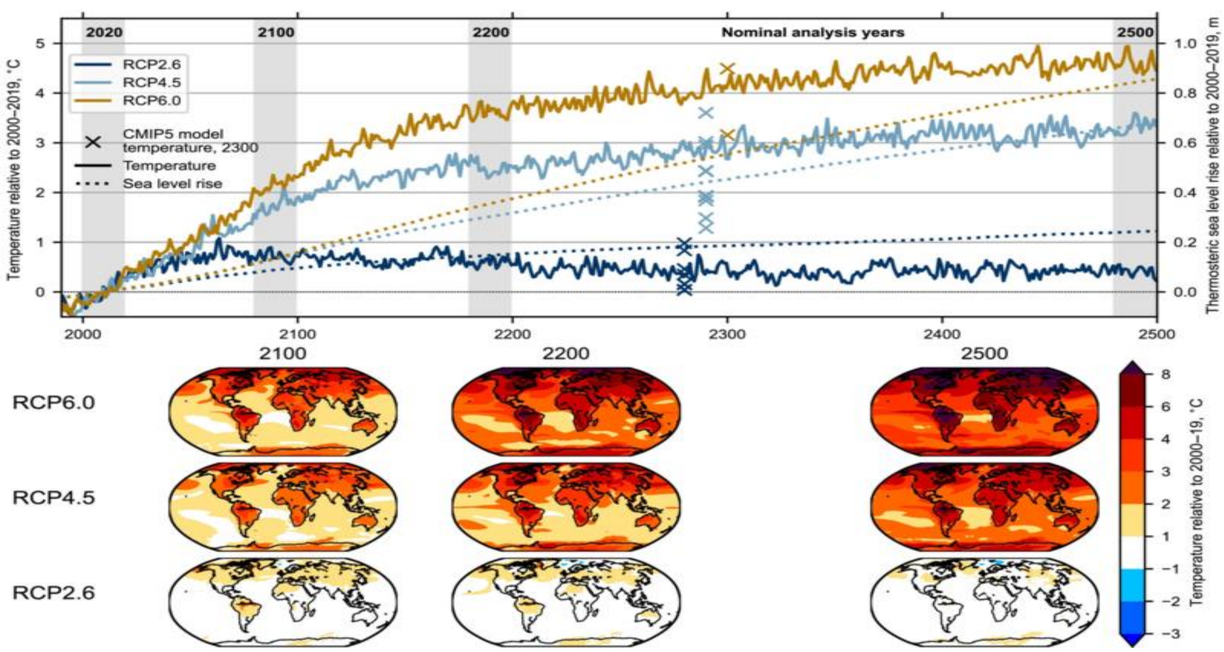


**Figure 4.1. Global mean temperature and sea-level rise anomalies relative to 2000–2019 mean for RCP climate change scenarios up to 2100. Source: (http:WorlHTTPmetereology Organization 2009).**

### 4.3.1. Kish Island Station Weather Specifications

It was decided to adopt an appropriate observation and model based on our study, which initially identified the Mediterranean region as one of the most notable climate change "hot spots" to prepare the possible prediction of the potential climatic changes in different parts of the world. Kish island is in a hot spot in vulnerable locations in case of climate change impacts. A portion of this unique region is included in several CORDEX domains, including those for Europe, Africa, the Mediterranean, and the Middle East/North Africa. In this study, it gathers and evaluate monthly temperature and precipitation fields obtained from simulations of regional climate models carried out throughout various CORDEX domains.

Based on the CORDEX domain, which covers Kish Island as a Middle Eastern location, the CMIP5 series models were applied. These models use the new scenarios of RCPIs, including RCPIs 2.6, 4.5, 6 and 8.5, which were created in 2010 by a scientific committee under the supervision of the International Panel on Climate Change(IPCC) to provide a set of information from the results of which the main factors of climate change can be identified. Its effects can be applied to climate models.

The CMIP5 scenarios are based on the different specifications of the technological level, social and economic situation, and policies in the future, which can lead to varying levels of greenhouse gas emissions and climate change. In each ver,sion of this scenario, the effect of greenhouse gas emission is divided into four categories based on its role in the level of radiative forcing; They have been classified until the end of the 21st century. Also, the results of these scenarios cover from 1850 to the end of the 21st century and have been formulated until 2300. According to all possible future model assessments, the change threshold is between 0.7 and 2 in Celsius in the historical data.

In general, the simulated output found in this study based on the RCP8.5 scenarios also shows an increase in temperature by 2100. The minimum temperature change threshold, according to the pessimistic situation, the RCPI 8.5 model will be 1/1 to 2.2 ° C. The threshold of temperature changes during the near future, according to RCP 4.5 scenarios, will fall between 0.6 to 1.4 ° C, and according to RCP 8.5 scenarios, between 0.8 to 1.6 ° C and in the distant future, according to the two scenarios, respectively. It will be even 1.7 to 2.6 during heat waves.

According to figures 4.2 and 4.3 eac,h RCP areisscribed. These four pathways were used for climate modelling and research for the IPCC fifth Assessment Report (AR5) in 2014. These pathways represent different climate futures, all possible depending on the volume of greenhouse gases (GHG) emitted in the years to come.

The average minimum temperature of this region increases from 23.2 ° C in the observation period based on the highest rate of change according to the two scenarios RCP4.5 and RCP8.5, respectively, 24.8 and 25.5 ° C. Intensity of incremental temperature changes according to two scenarios in all evaluation models during March; Then February will occur.

The RCPIs initially RCP2.6, RCP4.5, RCP6, and RCP8.5 are labelled after a possible range of radiative forcing values in the year 2100 (2.6, 4.5, 6, and 8.5 W/m2, respectively) therefore based on the CMPI 5 model the average minimum temperature changes for future for each of the RCPIs including RCPI 2.6, RCPI4.5, RCP6 and RCPI8.5 have been estimated in Figures as shown below:

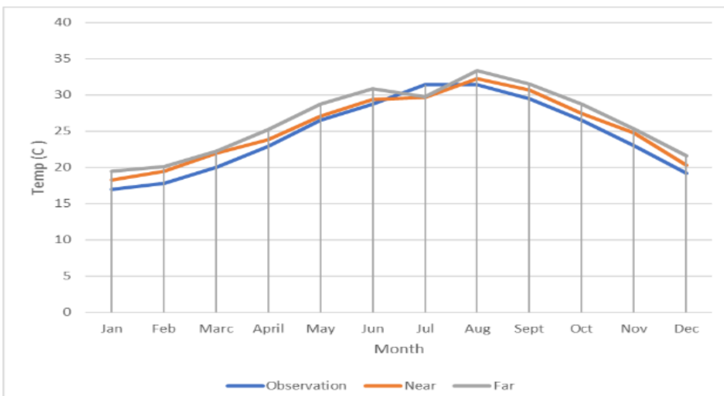


**Figure 4.2. Kish Station Prediction of average minimum temperature changes based on CMIP5 output based on RCPI2.6 Scenarios**

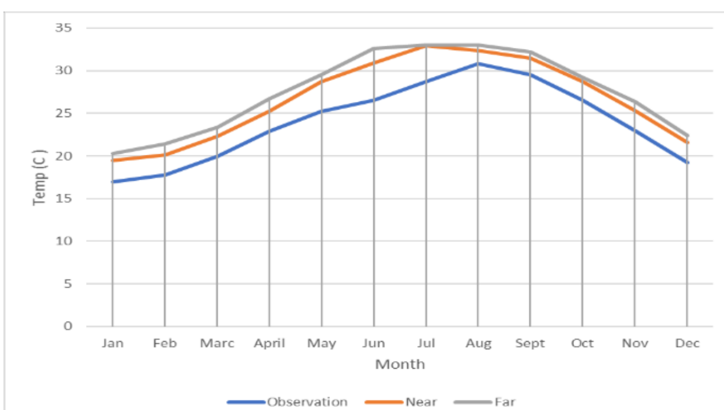


**Figure 4.3. Kish station Prediction of average minimum temperature changes based on CMIP5 output based on RCPI4.5**

**Scenarios**

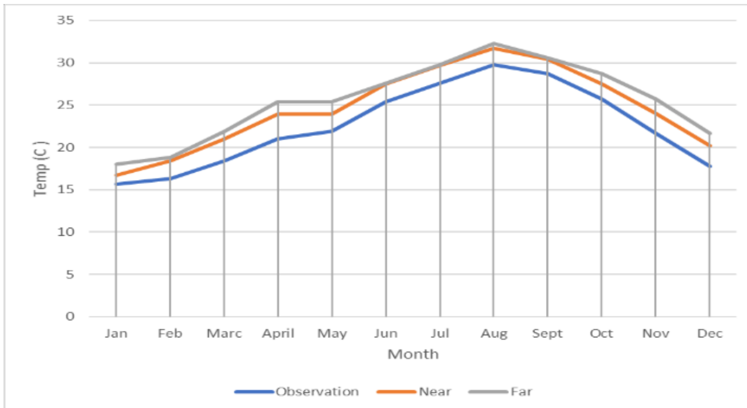


**Figure 4.4. Kish station Prediction of average minimum temperature changes based on CMIP5 output based on RCPI6 Scenarios**

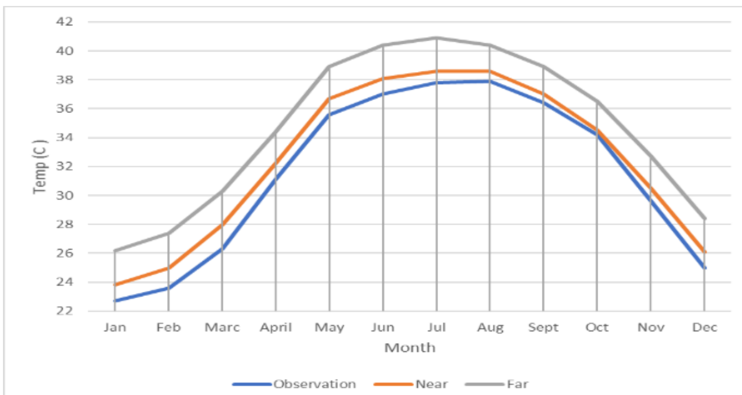


**Figure 4.5. Kish station Prediction of average minimum temperature changes based on CMIP5 output based on RCPI8.5 Scenarios**

## 4.3.1.1. Mean Annual Temperature Trend Changes in Kish Island 1976-2021

Time series data of Kish Island, of the Mean annual temperature throughout 1976 to 2021, is mainly the average of both annual minimums and annual maximums over this period, is calculated and put in a graph table. It suggests evidence of warming between 1976 and 2021, as shown in Table 4.2. shown below.

The data were set into the four clusters of decade time periods of 10 years, and the mean of Minimum Temperature and mean of Maximum Temperature results of the analysis test were calculated. The P value and the slope were calculated, and the standard of both Mean Minimum and Maximum and their P value and their slope were assessed as shown in Table 4.2.

**Table 4.2. Kish Region Mean Annual Temperature Trends for All Historical Decades**

| | $T_{min}$ | | $T_{max}$ | | $T_{mean}$ | |
|---|---|---|---|---|---|---|
| Period | Trend (*p*-value) | Slope ($^{\circ}C$ 10 year$^{-1}$) | Trend (*p*-value) | Slope ($^{\circ}C$ 10 year$^{-1}$) | Trend (*p*-value) | Slope ($^{\circ}C$ 10 year$^{-1}$) |
| 1970-1980 | 0.00 | 0.58 | 0.00 | 0.19 | 0.00 | 0.38 |
| 1980-1990 | 0.00 | 0.31 | 0.16 | 0.10 | 0.00 | 0.20 |
| 1990-2000 | 0.57 | 0.05 | 0.22 | 0.12 | 0.31 | 0.09 |
| 2000-2010 | 0.00 | 0.43 | 0.00 | 0.20 | 0.00 | 0.31 |

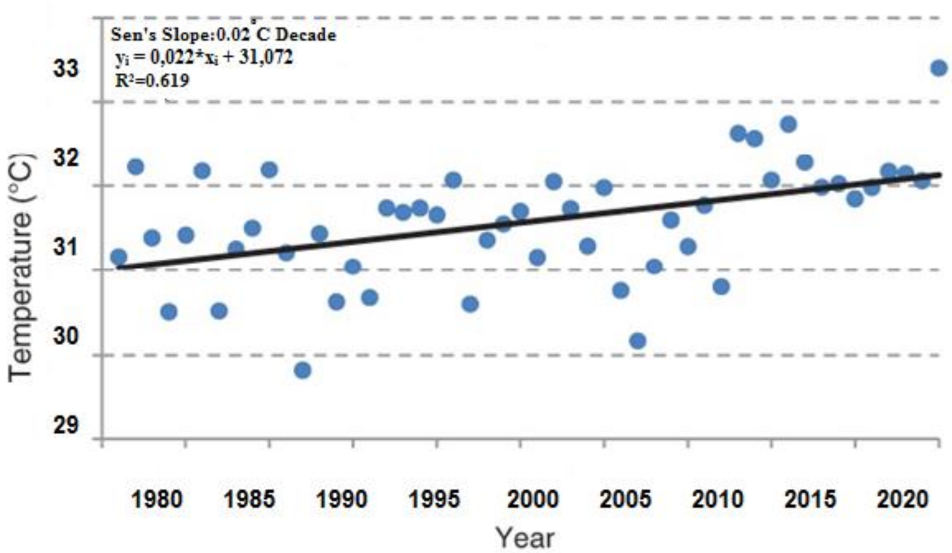


**Figure 4.6. Kish Island Historical Mean Temperature Change**

The collected time series data for Kish Island are subjected to Sen's Slope test. To do the test, it is advised that if both a step change and a trend are apparent, the data series must be first de-trended before the test application. Therefore, any significant linear trend is removed from the raw time series using the slope calculated by the Sen Approach. It was detected that a change-point from the late 70s and early 80s continued steadily for all decades ahead until the current date, indicating an abrupt increase in mean annual temperatures in Kish Island station. In other words, a lower average temperature before the change point decade is replaced by a higher average temperature after the change point year. For example, in the late 1970s, the average temperatures for de-trended data were 31∘C and 32.2∘C in 2020's. Moreover, the differences in average temperatures between the original temperature time series and its de-trended periods are statistically significant. These results are consistent with previous global studies showing that the last decade of the previous century was substantially warmer than earlier decades in Kish Island and Iran.

On Kish Island, temperature trends indicate an increase of about 1.2°C. The temperature increase at the Kish Island weather station was statistically significant in Mann- Kendall trend analysis, as shown in the next section. These results were confirmed earlier by findings by IPCC (2000), that the Middle East warmed by about 0.3 °C and 2.3 °C per decade between 1960 and 2000.

As global warming is part of climate change and Kish Island is not an exception, such high temperatures may affect tourist comfort and flora and fauna that must adapt to the ever-increasing temperatures. Evidence suggests that regional warming in Kish Island has accelerated in recent years due to climate change and variability. An increasing number of heat waves in the area harshly exceeded the 40- year Maximum temperature average over the past decade. In Kish Island, all the years post-2010 had their maximum temperature above the 40-year average of 30.5°C. Over the past 40 years, 18 years recorded temperatures above average.

From 1976 to 2021, seven years out of 20 recorded high temperatures above average. This trend shows sharp changes, and both residents of Kish Island and even tourists who frequently travel to this popular destination witnessed above-average temperatures, which were far from comfortable for any touristic activities, even coastal ones. During the last decade, noticeable variations happened. One of them is the highest temperature for 40- inrs, s witnessed in 2015, 2020, and 2021 and rose above 50°C.

From the Kish Island station, the average temperature for the 40 years is 29.65°C. Over this period, 20 years recorded above-average temperatures. Between 1976 and 1995, only seven years recorded above-average temperatures, while the remainder 13 of the 20 years were recorded in the last 25 years, from 1996 to 2021. It should be noted that only two years were below average during the previous decade, with eight years recording temperatures above average.

In Kish Island, the past six years of weather stations from 2016 had above-average temperatures, with the record highest temperature being in 2018 and 2021 when the Kish airport station to 48.3°C. Overall, the last decade (2011-2021) has been the warmest during the period under review at both stations.

Notably, annual and monthly temperature patterns have changed in the Middle East and the Persian Gulf. Therefore, it is unsurprising that some months of the year showed substantial temperature increases in Kish Island while others showed slight changes with no fluctuations. The months of December, January, February, and March show no change at Kish Island station, with its average temperature around 30°C. However, from the Kish Island Station, the month's winter has a pattern of a steady temperature of about 30°C. On the other hand, Kish Island, it realizes the actual size during the long period in the whole wintertime; the winter temperature trends indicated that temperature increases of 1°Cover the same period from 28.1°C to 29°C.

Through studying the patterns of changes in historical records of Kish Island, annual temperature changes in months of autumn, which are not among the Tourism high season, also recorded significant temperature increases over the past 40 years, with October recording the highest temperature changes in Kish station. November was also like October because there was a meaningful change of more than a degree temperature increase.

#### 4.3.1.2. Kish Island Future Temperature Forecast based on RCPI Scenarios using Historical Data

According to the findings of data analyses output of maximum temperature changes on Kish Island is increasing until 2100 (Table 4.3.). The maximum temperature in this region will increase further during the three months of March, November, and December.

**Table 4.3. Average min temperature change for Kish Island Tourism High season selected months (1986-2005)**

| Month | Average Minimum The temperature in1987 ℃ | Average Minimum The temperature in 2021 ℃ | Average Temperature Change ℃ |
|---|---|---|---|
| **June** | 27.9 | 29.8 | 1.9 |
| **July** | 31.2 | 32.8 | 1.6 |
| **August** | 32.9 | 33.9 | 1 |
| **September** | 28.1 | 29.7 | 1.6 |
| **December** | 17.9 | 19.1 | 1.2 |
| **January** | 17 | 18.9 | 1.9 |

According to RCPI scenario 4.5 increments 0.7 to 1/2 CCMC model, 0.6 to 2 MRI model, 0.6 to 1.7 CCSM model, 0.6 to 1.6 BCC-CSM1 model and 0.4 to 2.2 degrees It will average Celsius for the EC-EARTH model by 2100. At the same time, the minimum temperatures are also growing in

Kish Island, especially during the summer months of June, July, August, and September, and also during December and January, which are the Autumn and winter months. Maximum temperature change threshold for Kish Island station according to scenario 8.5 CCMC model, 1.3 to 2.8 ° C, MRI 1.2 to 2.5, CCSM model 1.3 to 2.3, BCC-CSM1 model 1.3 to 2 / 2 and the EC-EARTH model, will be 0.8 to 2.4 ° C. The maximum temperature changes of Kish Island are estimated in between 0.2 to 1.5 ° C, according to the RCP4.5 scenarios, and between 0.3 to 1.7 ° C, accordingly to the RCP8.5 scenarios. Further, in the long term, based on the two mentioned scenarios will be 1.3 to 2.7 and 2.3 to 4 degrees Celsius.

In CMIP5, there are a total of 42 models. In this study, it only refers to the RCP4.5 and RCP 8.5 scenarios because the following reasons. (1) There are more data available since it is part of the "Core" experiments and all the models have information associated (Taylor et al., 2012) compared to the other scenarios like RCP6.0 and RCP2.6. (2) D2.0 is never achieved under RCP2.6 by 2100 (IPCC, 2013b). (3) RCP4.5 is defined as a mitigation scenario (reducing the greenhouse emissions) contrary to RCP8.5, which represents the "business as usual" scenario (van Vuuren et al., 2011a). The forecast of the maximum temperature shortly of Kish Island indicates that according to the RCP4.5 scenarios, the annual temperature will increase from 31.3 to 32.2 ° C and, in the distant future, to 33.4 ° C, according to the RCP8 scenario. 5. It will increase more than observation period so that soon it is estimated at 32.4 ° C and soon at 34.6 °. The Figure 4.7. illustrates of what is described above.

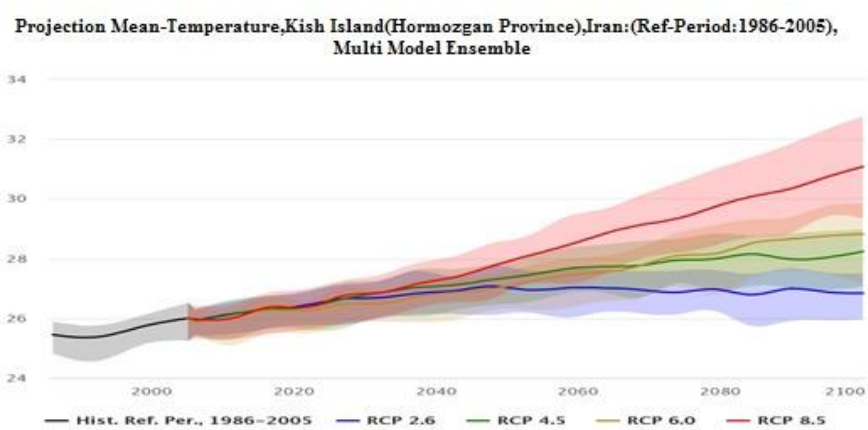


**Figure 4.7. Kish Island (Hormozgan Province), Iran, Projected Mean Temperature based on RCP2.6, RCP 4.5, RCP 6.0, RCP 8.5, Source:( https://climateknowledgeportal.worldbank.org/)**

### 4.3.1.3. Kish Island Future Precipitation Change Forecast based on RCPI using Historical data from 1986-2005

Rainfall is one of the most important climatic variables, the variability and fluctuations of which greatly influence other environmental factors like soil moisture, vegetation, water resources, and temperature; the environmental changes caused thereby are inevitable. The collected secondary data about rainfall was sampled from two stations: The Kish station meteorological station located at the Kish International Airport on the island. Kish station is in the south of the Iranian mainland, whereas the Persian Gulf is also in the entire southern coastline of the country. Rainfall occurs in winter, which is not hot and humid, with the summer season being hot and dry from April in Kish Island. The rainfall pattern on the two stations shows many similarities and minor differences, as shown in precipitations patterns.

The difference could be attributed to the altitude difference between the two places. The two stations indicate that the rainfall pattern is highly variable and difficult to predict, as demonstrated by extreme swings of lows and highs from year to year and season to season. Over 40 years, there has been evidence of a meaningful decline in rainfall on Kish Island. Rain at the Kish Island station shows stability with a slight increase over the same period. The Figure 4.8., presented below, is illustrates of what it has been  described.

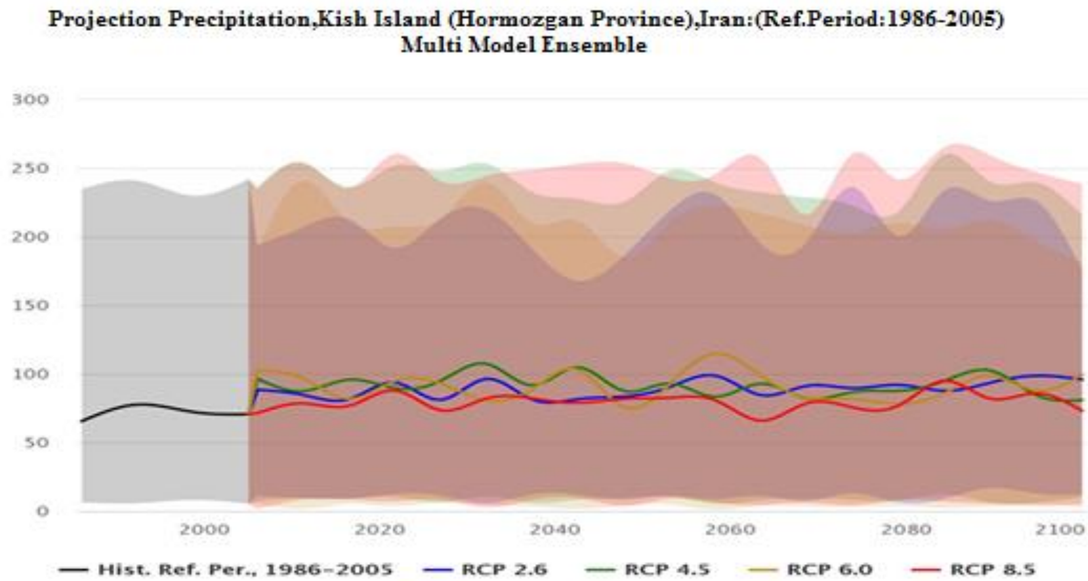


**Figure 4.8. Kish Island(Hormozgan Province), Iran, Projected Precipitation Change based on RCP2.6, RCP 4.5, RCP 6.0, RCP 8.5 Models, Source:(https://climateknowledgeportal.worldbank.org/)**

The highest and most wet year over the 40 years was recorded in 2008. That year, the Kish Island station recorded high rainfall of 417mm against an annual average of 344mm. The lowest amount for the station, 306mm, was recorded in 2002, less than half of the average rainfall. The Kish Island station recorded slightly less rainfall than in 2012, where 511mm was received, which was also a record high for the 40 years. On the other hand, the lowest rainfall receipts were in 1994, when a total of 143mm was received. This was against a long-term rainfall average of 344 mm.

### 4.3.2. Algarve Region Station Weather Specifications

To prepare for the potential prediction of the potential possible changes in various regions of the world, it was decided to adopt an appropriate observation and model based on our study, which had initially identified the Mediterranean region as one of the most notable climate change hot spots. Hotspot case study regions are situated in areas susceptible to the effects of climate change. Several CORDEX domains, including those for Europe, Africa, the Mediterranean, and the Middle East/North Africa, incorporate a section of this study; monthly temperature, and precipitation on fields from simulations of regional climate models run over several CORDEX domains are gathered and evaluated.

The CMIP5 series models were used based on the CORDEX domain, which covers the Algarve region as a Mediterranean location. These models make use of the new RCPI scenarios, such as RCPIs 2.6, 4.5, 6, and 8.5, which were developed in 2010 by a scientific committee working under the direction of the IPCC to provide a set of data from which the primary drivers of climate change can be identified and whose findings can be applied to climate models.

The CMIP5 scenarios are based on the different specifications of the technological level, social and economic situation, and policies in the future, which can lead to varyingthe levels of greenhouse gas emissions and climate changes in any case. In each version of this scenario, the effect of greenhouse gas emission is divided into four categories based on its role of radiative forcing; They have been classified until the end of the 21st century. Also, the results of these scenarios cover from 1850 to the end of the 21st century and have been formulated until 2300.

The Mean annual temperature changes of the Algarve region in the observation and future period based on the two scenarios are shown in Table (4.2.). The simulation of the minimum temperature in the RCPI scenario shows an increase in temperature in all months of the year based on all models analysed. Still, the incremental changes in the CCMC model have an output. According to all possible future model assessments, the change threshold is between 0.7 and 2 in Celsius.

### 4.3.2.1. Mean Annual Temperature Trend Changes in Algarve Region 1976-2021

To investigate the Temperature trend changes over time in the Algarve region to see whether there is any increase or decrease in mean annual temperature, the time series data of the Algarve region weather station, which consists of the historical secondary field data, are utilised. The mean annual temperature from 1976 to 2021 is calculated and put in a graph table. It suggests evidence of warming between the years 1976 and 2021, as shown in Table 4.4. below.

The collected time series data for the Algarve region are subjected to Sen's Slope test. To do the test, it is advised that if both a step change and a trend are apparent, the data series must first be de-trended before the test application. Therefore, any significant linear trend is removed from the raw time series using the slope calculated by the Sen Approach.

**Table 4.4. Algarve Region Mean Annual Temperature Trends for All Historical Decades.**

| | $T_{min}$ | | $T_{max}$ | | $T_{mean}$ | |
|---|---|---|---|---|---|---|
| Period | Trend (*p*-value) | Slope ($^{\circ}$C 10 year$^{-1}$) | Trend (*p*-value) | Slope ($^{\circ}$C 10 year$^{-1}$) | Trend (*p*-value) | Slope ($^{\circ}$C 10 year$^{-1}$) |
| 1970-1980 | 0.12 | 0.68 | 0.22 | 0.47 | 0.16 | 0.46 |
| 1980-1990 | 0.29 | 0.44 | 0.27 | 0.39 | 0.23 | 0.33 |
| 1990-2000 | 0.46 | 0.11 | 0.32 | 0.27 | 0.29 | 0.29 |
| 2000-2010 | 0.63 | 0.61 | 0.28 | 0.51 | 0.37 | 0.61 |

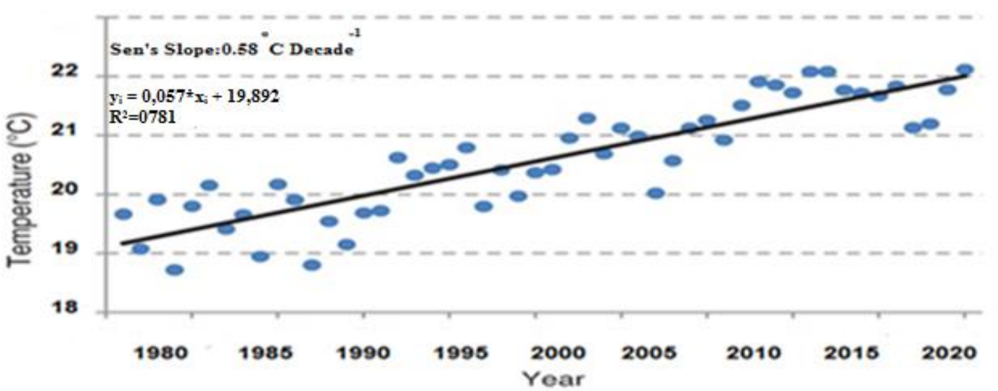


**Figure 4.9. Algarve Region Historical Mean Temperature Change**

The data were set into four clusters of decade time periods of 10 years, and the mean of Minimum Temperature and mean of Maximum Temperature results of the analysis test were calculated, as well as the P value, the slope and the mean, as are shown in Table 4.4.

From 1976 to 2021, years out of 20 years recorded high temperatures above average. This trend shows sharp changes, and residents of the Algarve region and even tourists who were frequently travelling to this popular destination witnessed above-average temperatures, which were far from comfortable temperatures for any touristic activities, even coastal ones. During the last decade, noticeable variations happened. One of them is the highest temperature for the 40- years witnessed in 2015 and 2020,2021and to 2022, which rose above 35°C.

The Algarve region has witnessed five years from 2010 above-average temperatures, with the record highest temperature being in 2018 and 2021 when the Faro airport station to 38.3°C. Overall, the last decade (2010-2021) has been the warmest during the period under review.

By analysing historical data in the Algarve region, the Mean annual temperature was about 19.2°C in 1976, rising to an estimated 22.3°C in 2021, which shows an ascending pattern. This represents a 2.1°C temperature increase in the 40 years. The growth of Minimum Temperature with high P values in the last four decades suggests that evaporation and humidity will also rise, leading to higher minimum degrees overnight because the moisture is a temperature stabiliser and prevents the decrease of weather overnights. The temperature increase is way above the current IPCC forecasted model and scenarios and models over the same period for most of the European Continent.

Increased summer temperature in the Algarve region has different impacts on tourists and will decrease their level of satisfaction. Also, it will lead to increased demand for cooling systems at Hotels and Touristic accommodations. Since the electric energy supply is heavily dependent on hydroelectric power plants in the Algarve region, which also suffer from extreme droughts and a decrease in their water reservoirs, increased energy demand will also result in increased running costs for the tourism sector. In addition, increased temperature is likely to result in increased evapotranspiration rates which may lead to water shortages for the ecosystem and human beings. Fire incidences also increase as dry vegetation runs up to the rainy season.

### 4.3.2.2. Algarve Region Future Temperature Forecast based on RCPI Scenarios using Historical Data

The average minimum temperature of the Algarve region increases from 23.2 ° C in the observation period based on the highest rate of change according to the two scenarios, RCP4.5 and RCP8.5, too, respectively, 24.8 and 25.5 ° C.

The intensity of incremental temperature changes according to two scenarios in all evaluation models during February and March.

The average annual minimum temperature of the Algarve Region varies from 23.2 according to the RCP4.5 scenarios to 24.2 ° C shortly; And will reach 25.4 ° C in the distant future. According to the RCP8.5 scenarios, the temperature forecast indicates a further increase in the near and distant future (34.7°C). According to the findings of the data analyses output of minimum-maximum temperature changes in the Algarve region is increasing until 2100.

The minimum-maximum temperature in this region will increase further during the three months of March, November, and December. According to RCPI scenario 4.5 increments 0.7 to 1/2 CCMC model, 0.6 to 2 MRI model, 0.6 to 1.7 CCSM model, 0.6 to 1.6 BCC-CSM1 model and 0.4 to 2.2 degrees It will average Celsius for the EC-EARTH model by 2100.

At the same time, the minimum temperatures are also growing in Kish Island, especially during the summer months of June, July, August, and September, also during December and January, which are the Autumn and winter months, as shown in Table 4.5. below:

**Table 4.5. Average min temperature change for Kish Island Tourism High season selected months (1987-2020)**

| Month | Average Minimum The temperature in1987 ℃ | Average Minimum The temperature in 2021 ℃ | Average Temperature Change ℃ |
|---|---|---|---|
| June | 27.9 | 29.8 | 1.9 |
| July | 31.2 | 32.8 | 1.6 |
| August | 32.9 | 33.9 | 1 |
| September | 28.1 | 29.7 | 1.6 |
| December | 17.9 | 19.1 | 1.2 |
| January | 17 | 18.9 | 1.9 |

In general, the simulated output found in this study based on the RCP8.5 scenarios also shows an increase in temperature by 2100. The minimum temperature change threshold, according to the pessimistic situation, the RCPI 8.5 model will be 1/1 to 2.2 ° C. According to RCP 4.5 scenarios, the threshold of temperature changes will fall between 0.6 to 1.4 ° C and, according to RCP 8.5 scenarios, between 0.8 to 1.6 ° C. It will be even 1.7 to 2.6 degrees Celsius during heat waves. In the prediction models for the minimum temperatures for the future in the Algarve region based on the 5 CMIP models as shown below (Figure 4.10. to Figure 4.13.), there is an ascending rate even in the Min Temperatures.

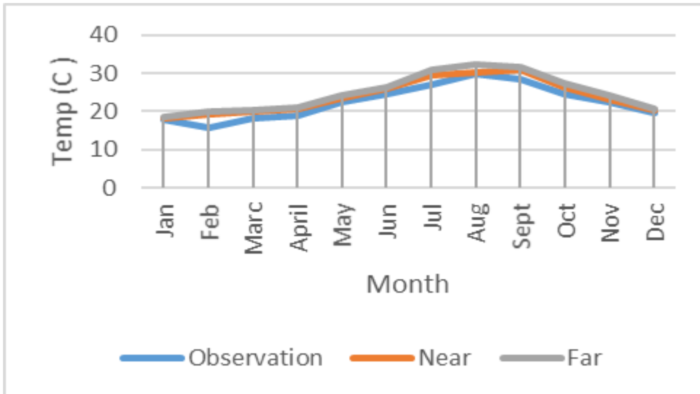


**Figure 4.10. Algarve Region Station Prediction of average minimum temperature changes based on CMIP5 output based on RCP2.6Scenarios**

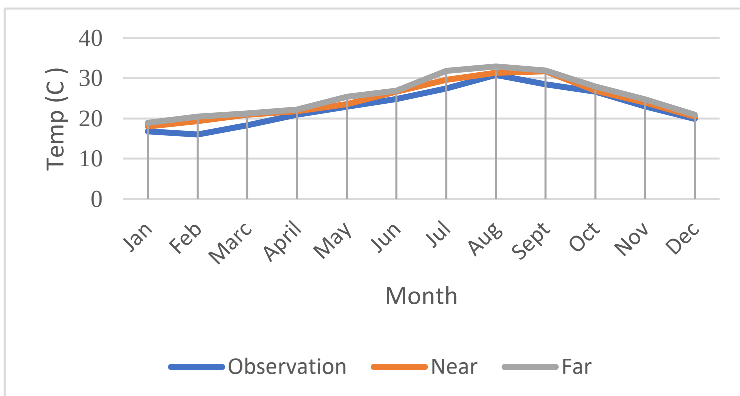


**Figure 4.11. Algarve Region Station Prediction of average minimum temperature changes based on CMIP5 output based on RCP4.5 Scenarios**

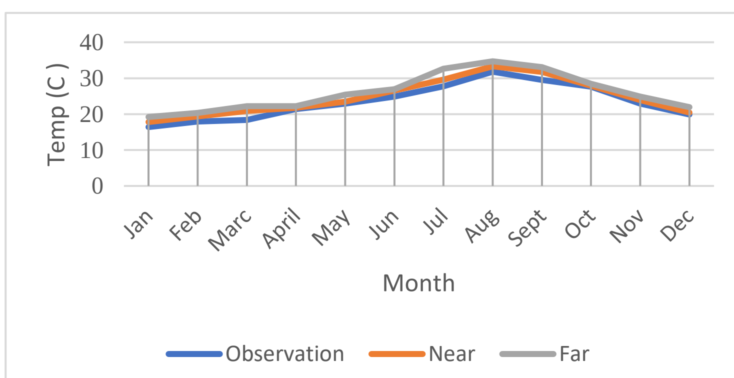


**Figure 4.12. Algarve Region Station Prediction of average minimum temperature changes based on CMIP5 output based on RCP6 Scenarios**

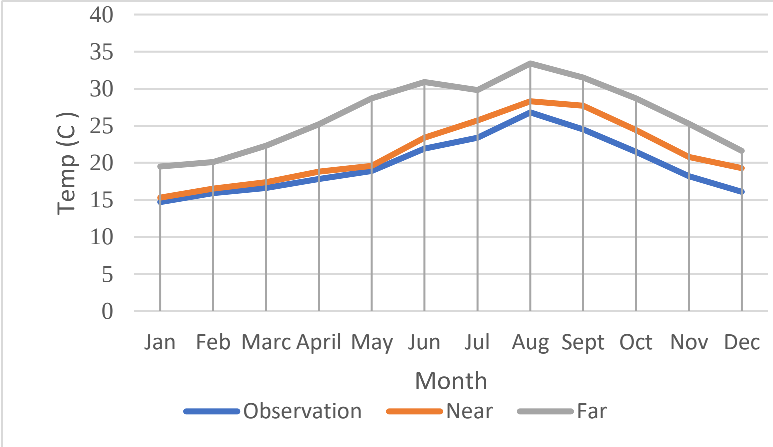


**Figure 4.13. Algarve Region Station Prediction of average minimum temperature changes based on CMIP5 output based on RCP8.5 Scenarios**

### 4.3.2.3 Algarve Region Future Precipitation Change Forecast based on RCPI using Historical data from 1982-2021

As it is observed based on an annual cycle, the Algarve Station in Faro reported 15 years of below-the-average expected yearly rainfall in the last 26 years, while the Portimão station recorded 19 years of rain below the mean. This shows an increase in drought occurrence in the area, posing a threat to vegetation, animal, and water bodies; of the five driest years recorded for the Faro station, three features in the past 26 years, while four out of five of those years were reported in the same period in Portimão town. A close look at the rainfall pattern suggests that the Algarve region suffers occasional droughts and estimated seven meteorological drought years, recorded between 1982 and 2021 at the Algarve station in Faro and about 12 years from the Portimão station. In the recent past, however, data shows that drought episodes have become more frequent and prolonged, spanning as much as three to four years. The 2017 drought lasted four consecutive years, with rainfall consistently falling below average in Kish Island station. The Algarve station reported severe drought shortages in the 2011/12 and 2014/15 rainy seasons.

The increased drought has implications for flora and fauna, including the aquatic life in the area and surrounding national parks. Droughts disturb biogeochemical cycles; consequently, ecosystems as net primary productivity are often compromised. Evidence suggests that drought patterns promote bush encroachment, reducing animal food availability. Such intervals of patterns of drought and rain abnormality may result in reduced animal reproduction, and population growth is hampered as some animal species fail to adapt. Rapid vegetation deterioration and forest fire in most drought years over the area were attributed to extreme drought-related temperatures.

Reducing vegetation cover will affect herbivores and increase wildfires in the Algarve region forests. Wildlife is a secondary attraction to the Algarve region, and they are an essential tourist attraction. Most importantly, since river flow regimes follow the precipitation pattern, the river systems will fluctuate further and potentially result in less water flow at the Ria Formosa attraction.

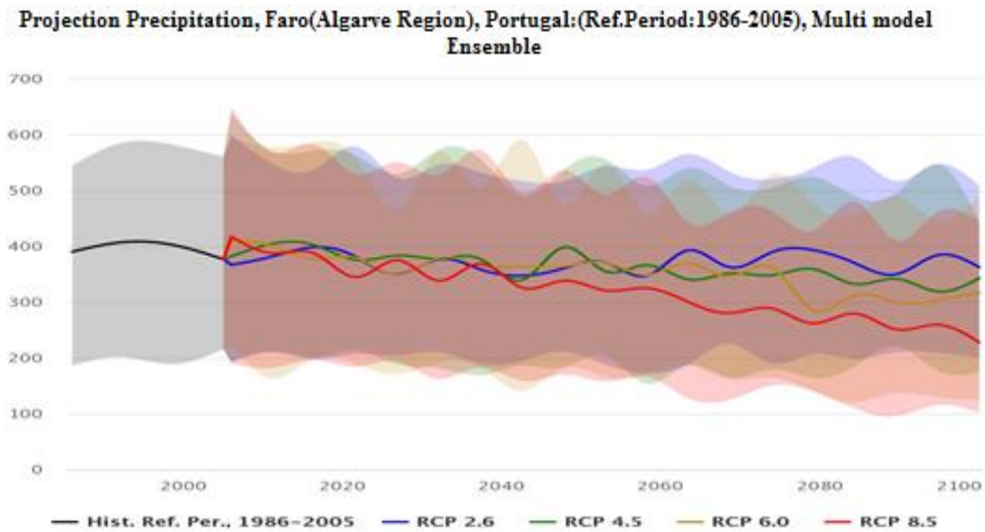


**Figure 4.14. Projection Precipitation in Algarve Region (Faro Station) Multi-model Ensemble RCPI Forecast Source: ( https://climateknowledgeportal.worldbank.org/)**

While there is evidence of slight changes in annual rainfall patterns, there is evidence of changes in rainfall data on a month-on-month basis except for the two months of March and December. These trends are similar for both stations over the past 40 years, as shown in Figure 4.4.2. Climate variability has been evident with extremes of high rainfall recorded in 2010 and 2015, where 143mm and 141mm were registered for April in Faro airport station compared to its long-term average of 19mm. This was followed by years of extreme aridity. The high incidence of climate variability in the Algarve region, especially in Faro, confirms the earlier trend. October has been marked by significant changes, as drying up during the month over the years at both stations. Rainfall for October stood at 40mm in Faro in 1976. These figures were reduced to about 0mm recorded in 2019.

The careful study of the rainfall patterns has indicated that rainfall in the Kish Island area starts from October to April. The drop from 40mm to 0mm in October signifies a delay in the onset of the rainy season. The results confirm the findings by Marvel et al. (2017) that climate change will result in a temporal and spatial shift in rainfall patterns. Evidence shows that the rainfall season at both stations is now starting in November instead of the historic month of October, with no indication that the rainy season extends to May.

This implies that the rainfall season has been shortened by about one month. However, there is an increase in rainfall amount in November. The delay in the onset of the rainy season could have ramifications on animal habitat, migration patterns and flora and fauna life cycles in Kish Island. The research further found that November and January recorded more rainfall than usual. In 1996 the average rainfall amount for January was about 180mm on Kish Island and about 310mm in the Algarve region. Over the last 20 years, the two stations have been recording about 200mm for the Algarve region and 100 mm for Kish Island for the period in question.

An increase and decrease in rainfall intensity over a short period could result in increased or decreased surface runoff as precipitation quickly exceeds infiltration capacity. This could result in increased and decreased river discharge over a short period marked by picked water fluxes. This could be both a blessing or harmful and a curse for the tourism sector—high river discharge results in an increased aesthetic value of the waterfalls and the vegetation cover. From the tourist survey, tourists enjoy seeing more lush greenery in any tourist destination.

#### 4.3.2.4. Annual Mean Temperature Trend Change in Algarve Region (1986-2005)

The annual minimum temperature has remained relatively steady over the past 30 years, with a noticeable increase reported around 2014. This coincides with one of the most intense El Niño events in a 150-year history that lasted close to three years on record. Throughout the 40-year history, there was an increase in minimum temperature from about 13°C to about 14.1°C. The trend is also associated with small variability between the years (Figure 4.15.).

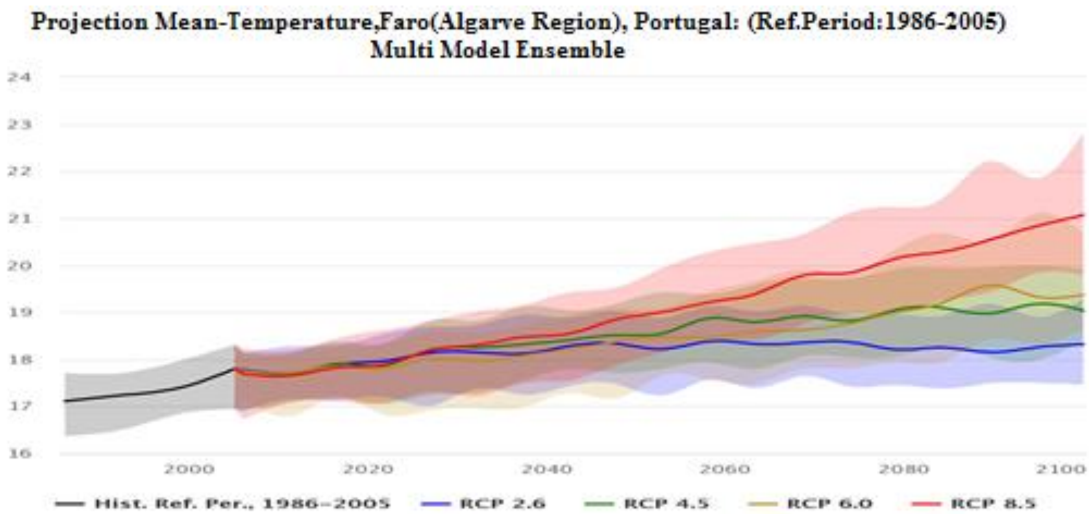


**Figure 4.15. Algarve Region(Faro) Projection Mean Temperature, Multi-Model Ensemble RCPI Forecast, Source: ( https://climateknowledgeportal.worldbank.org/)**

In the monthly trends depicted above, significant changes have happened. Therefore, evidence of climate variability is visible between years. There is evidence that winters are becoming warmer and records for winter minimum temperatures and other months. The most significant minimum temperature increase was registered during the winter months. As discussed under maximum temperature, the temperature rise has similar implications for the plant cycle, wild animals, and human comfort. Winter season precipitations have witnessed the tragic challenge of declining rainfall and increasing maximum and minimum temperatures. This may result in a dried Algarve Region during this period.

**Table 4.6. Average min temperature change for Algarve Region Tourism High season selected months (1987-2021)**

| Month | Average Minimum The temperature in1987 °C | Average Minimum The temperature in 2021 °C | Average Temperature Change °C |
|---|---|---|---|
| **June** | 21.9 | 23.8 | 1.9 |
| **July** | 23.2 | 24.7 | 1.5 |
| **August** | 24.9 | 25.9 | 1 |
| **September** | 22.1 | 23.7 | 1.6 |

### 4.3.3. Kish Island Climatic Historical Data Trend Detection with M-K Model

To detect the changes in the climatic variables, the Mann-Kendall Trend Test hereafter referred to as the M-K test. The Mann-Kendall is a statistical test widely applied in the trend detection of the hydro-meteorological time series data analyses for forecasting future possible trends and scenarios.

This test is applied to analyse data collected over the recorded history for studies in both cases, including Kish Island and Algarve region, to determine if there is a consistently increasing or decreasing trend in Y values. It should be noted that it is a non-parametric test, which means it works for all distributions. It can be applied when the climatic data does follow a normal distribution. Therefore, it is possible to run simple linear regression instead.

In this part, the climate variables of the Algarve region were put in the Mann-Kendal to find meaningful trends. The first phase is to start by testing the normal approximation. It should be noted that there is a by default set hypothesis, the Ho saying there are no meaningful changes in the trend of available historical data, which is about to be evaluated and verified to be correct after the test.

### 4.3.4. Kish Island Mann-Kendall Trend Test by Normal Approximation

In this part, the historical climatic data for two case study regions, including Kish Island and Algarve region, are collected in the form of time series, which be extracted from the files and put in the mini tab software for trend analyses. The number of available data matters in the M-K test. The more data points, the more likely the test will find an actual trend. There is a minimum threshold limit in the M-K test. The minimum number of recommended measurements is at least 8 to 10. The hypothesis is defined with the following description:

- The null Hypothesis (Ho) for this test in all the below tests is that there is no monotonic trend in the historical climatic data series.
- The Alternate Hypothesis (Ha) is that a trend exists. This trend can be positive, Upper ward, ascending, or non-null.

The M-K Test also includes a p-value, primarily intended to lessen the seasonality effect in the test and boost test accuracy. It can be determine whether a trend is seasonality-related using the seasonal Mann-Kendall test. Given that the null hypothesis is disproved by the p-value (0,0001), it can be infered that time series, after accounting for 12-month seasonality, has a significant trend. Suppose the p-value for the Mann-test Kendall's is less than a certain level of significance (popular options are 0.10, 0.05, and 0.01). In that case, it is possible to conclude that a trend exists in the time series data based on statistically significant evidence.

#### 4.3.4.1. Mann-Kendall Trend Test by Normal Approximation for Kish Annual Min Temperature

Considering that:

- Ho: No trend in T. Min; The calculated z = 2.94183.

To assess the changes in the Annual Minimum Temperatures recorded in the historical time series, data set of time series were put in the Mini Tab19.1, an M-K Trend Test was performed, and the final results for the Kish Island case study implicated that:

- For Ha: Upper ward trend, the p-value = 0.002.

At alpha = 0.05, there is enough evidence to determine an upward trend. As the value of Z at 95% confidence level and the value of error 0.05 show, the minimum annual temperature of Kish has a significant increasing trend and means climate change. Z value greater than +1.96 and p-value less than 0.05.

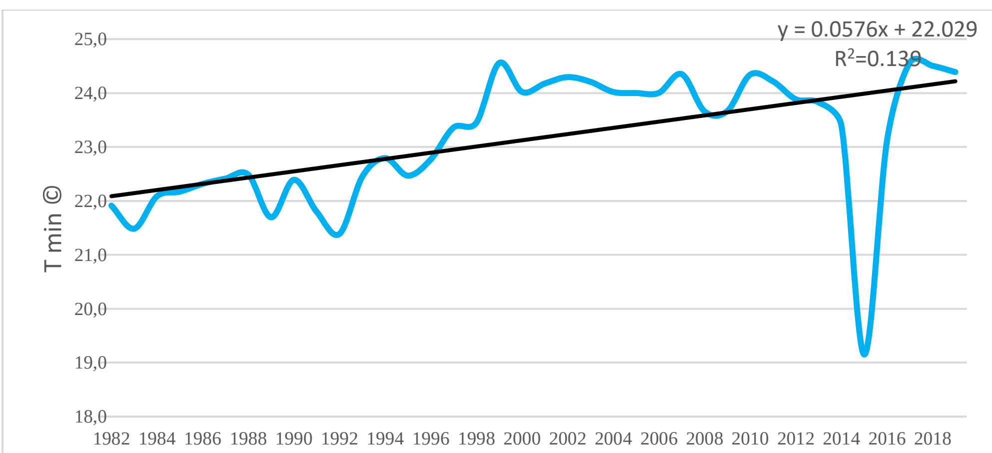


**Figure 4.16. M-K Trend Detection Test Result for Kish Island annual Min Temp (1982-2018)**

### 4.3.4.2. Mann-Kendall Trend Test by Normal Approximation for Kish Mean Annual Temperature

Considering that:

- Ho: No trend in T. Mean; The calculated z = 4.50074.

To assess the changes in the Annual Mean Temperatures recorded in the historical time series, data set of time series were put in the Mini Tab19.1, an M-K Trend Test was performed, and the final results for the Kish Island case study implicated that;

- For Ha: Upper ward trend, the p-value = 0.001.

At alpha = 0.05, there is enough evidence to determine an upward trend. As the value of Z in the 95% confidence level and the error value of 0.05 show, the mean annual temperature of Kish has a significant increasing trend and means climate change. The value of Z is more significant than +1the .96, and p-value is less than 0.05.

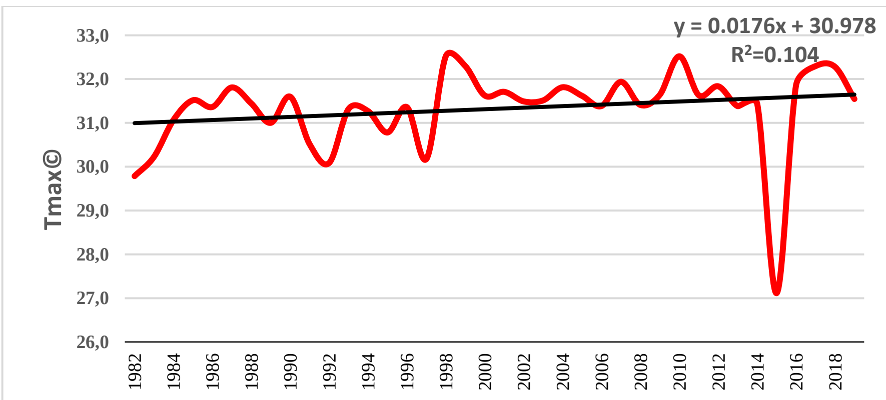


**Figure 4.17. M-K Trend Detection Test Result for Kish Island Annual Mean Temp (1982-2018)**

### 4.3.4.3. Mann-Kendall Trend Test by Normal Approximation for Kish Annual Rain Fall

Considering that:

- Ho: No trend in Annual Rainfall; The calculated z = -2.23780.

To assess the changes in the Annual Rainfall Temperatures recorded in the historical time series data set of time series were put in the Mini Tab19.1, an M-K Trend Test was performed and the final results for the Kish Island case study implicated that;

- For Ha: Downward trend, the p-value = 0.013.

At alpha = 0.05, there is enough evidence to determine a downward trend. As the Z value at 95% confidence level and error value 0.05 show, Kish annual rainfall has a significant decreasing trend and means climate change. The z-value is less than -1.96, and the p-value is less than 0.05.

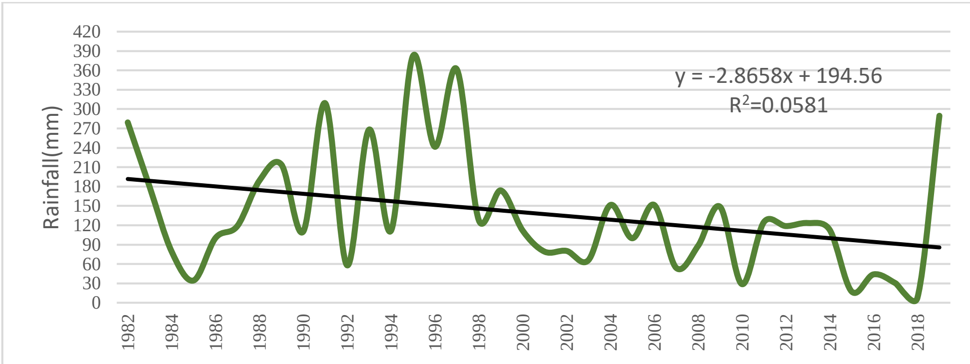


**Figure 4.18. M-K Trend Detection Test Result for Kish Island Annual Precipitations (1982-2018)**

## 4.3.5. Algarve Climate Future Forecast Based on Mann-Kendall Trend Test

To detect the changes in the climatic variables in the Algarve region, the Mann-Kendall Trend Test was applied to find out if there is a consistently increasing or decreasing trend or not in the Y value, such as what was done for the Kish Island case.

### 4.3.5.1. Mann-Kendall Test by Normal Approximation for Algarve Annual Rainfall

Considering that:

- Ho: No trend in Algarve Rainfall; The calculated z = -0.30683.

To assess the changes in the Annual Rain Fall recorded in the historical time series, data set of time series were put in the Mini Tab19.1, an M-K Trend Test was performed, and the final results for the Algarve Region case study implicated that;

- For Ha: Upper ward trend, the p-value = 0.621.

At alpha = 0.05, there is not enough evidence to determine that there is an upward trend.

- For Ha: Downward trend, the p-value = 0.379.

At alpha = 0.05, there is not enough evidence to determine that there is a downward trend. As the Z value at 95% confidence level and error value 0.05 show, the Algarve region's annual rainfall has not a significant decreasing or increasing trend and means climate change. The z-value is less than -1.96, and the p-value is less than 0.05.

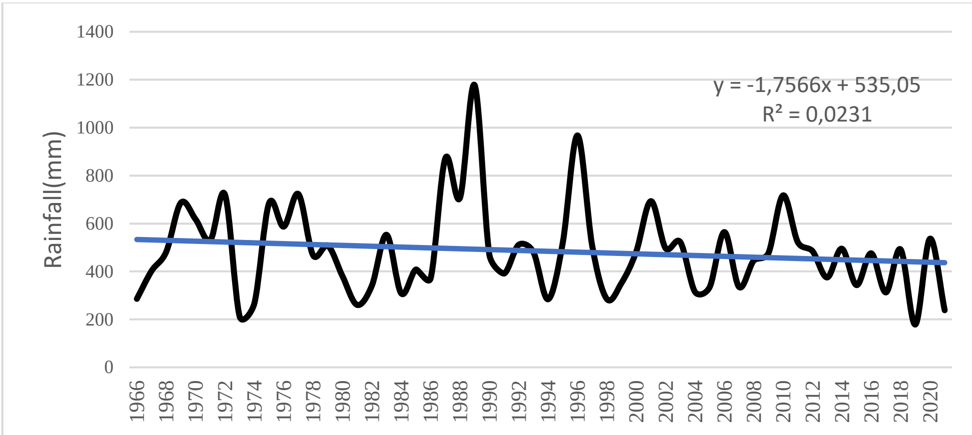


**Figure 4.19. M-K Trend Detection Test Result for Algarve Region annual precipitation (1966-2020)**

## 4.3.5.2. Mann-Kendall Trend Test by Normal Approximation for Algarve Mean Temperature

To assess the changes in the Annual Mean Temperatures recorded in the historical time series data set, time series were put on the Mini Tab19.,1 and M-K Trend Test was performed and the final results for the Algarve Region case study implicated that:

- Ho: No trend in Mean Temperature; The calculated z = 7.13781.
- For Ha: Upper ward trend, the p-value = 0.001.

At alpha = 0.05, there is enough evidence to determine an upward trend.

- For Ha: Downward trend, the p-value = 0.999.

At alpha = 0.05, there is not enough evidence to determine a downward trend, as the Z value at 95% confidence level and an error value of 0.05 show. A region's annual Mean temperature has a significant increasing trend and means weather.

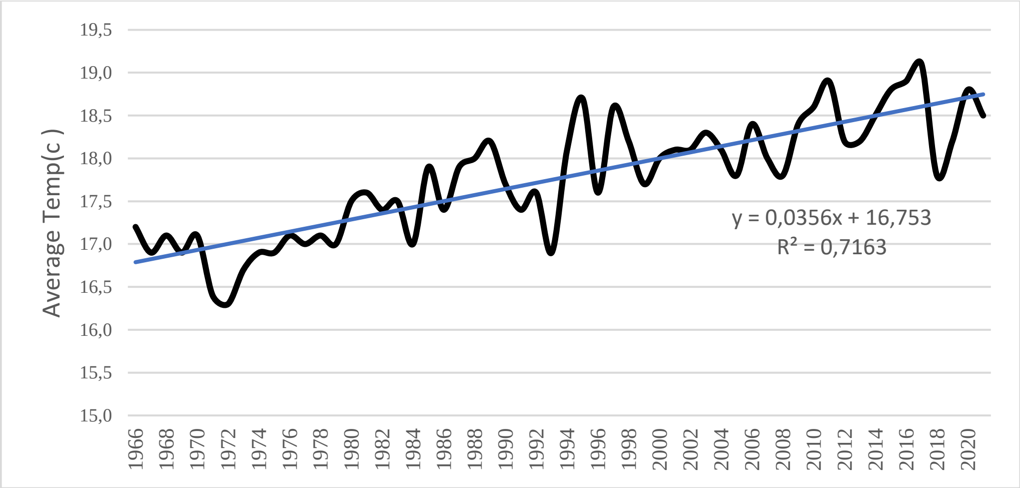


**Figure 4.20. M-K Trend Detection Test Result for Algarve Region Annual Mean Temp (1966-2020)**.

### 4.3.5.3. Mann-Kendall Trend Test by Normal Approximation for Algarve Max Annual Temperature

To assess the changes in the Annual Maximum Temperatures recorded in the historical time series, data set of time series were put in the Mini Tab19.1, the Trend Test was performed, and the final results for the Algarve Region case study implicated that:

- Ho: No trend in Max Temperature; The calculated z = 4.99962.
- For Ha: Upper ward trend, the p-value = 0.001.

At alpha = 0.05, there is enough evidence to determine an upward trend.

- For Ha: Downward trend, the p-value = 0.999.

At alpha = 0.05, there is not enough evidence to determine that there is a downward trend.

As the Z value at 95% confidence level and error value 0.05 show, the Algarve region's annual Max temperature has a significant increasing trend and means climate change.

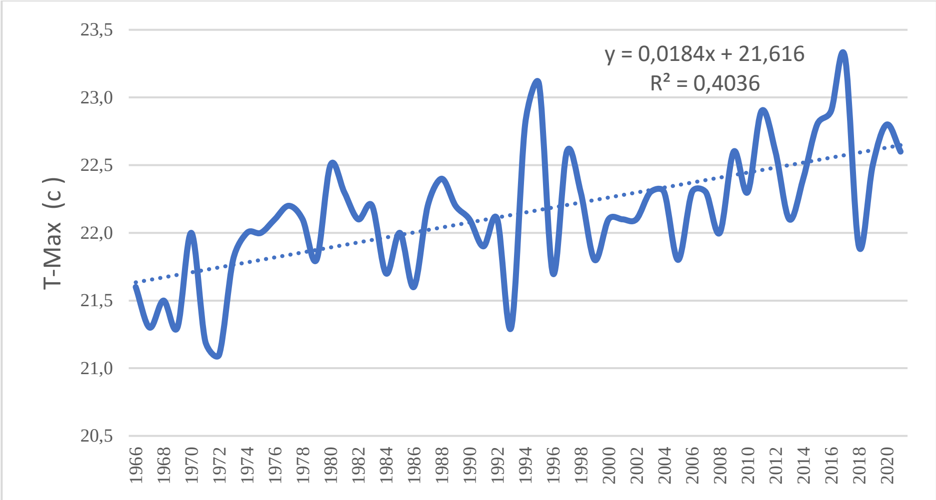


**Figure 4.21. M-K Trend Detection Test Result for Algarve Region annual Max Temp (1966-2020).**

### 4.3.5.4. Mann-Kendall Trend Test by Normal Approximation for Algarve Region Minimum Annual Temperature

To assess the changes in the Annual Minimum Temperatures recorded in the historical time series, data set of time series were put in the Mini Tab19.1, an M-K Trend Test was performed, and the final results for the Algarve Region case study implicated that:

- Ho: No trend in Min temperature; The calculated z = 7.28836.
- For Ha: Upper ward trend, the p-value = 0.001.

At alpha = 0.05, there is enough evidence to determine an upward trend.

- For Ha: Downward trend, the p-value = 0.999.

At alpha = 0.05, there is not enough evidence to determine that there is a downward trend. As the Z value at 95% confidence level and error value 0.05 show, the Algarve region's annual Minimum temperature has a significant increasing trend and means climate change.

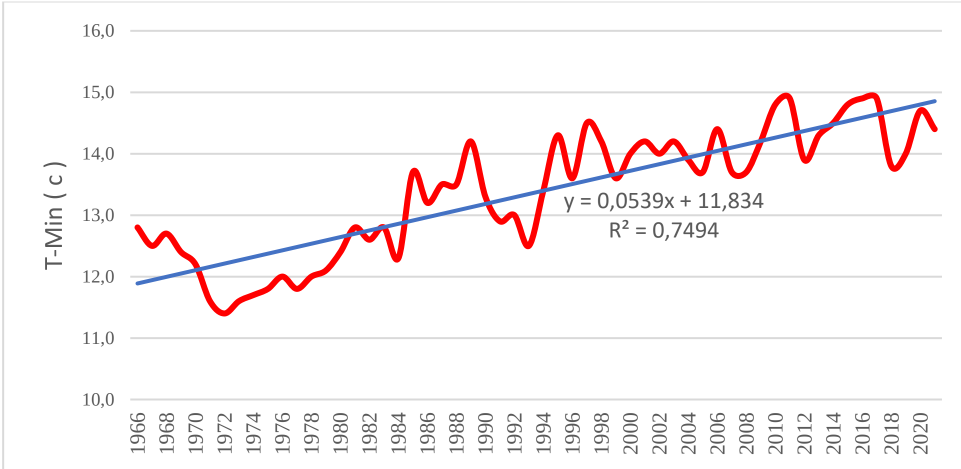


**Figure 4.22. M-K Trend Detection Test Result for Algarve Region Annual Minimum Temp (1966-2020).**

### 4.3.6. Kish Island TCI Future Period Prediction

To assess the climate comfort range for tourism planning in Kish Island, weather and climatic data in synoptic stations obtained from IRIMO are used in TCI computation. As mentioned above, the TCI index developed by Mieczkowski (1985) was based on previous research on climate classification for tourism and recreation (Crowe, 1976). In general TCI index consists of five sub-indices, each represented by one or two monthly climate variables.

The five substitute indications and their constituent variables were in this manner:

- **i)** Daytime comfort index (maximum daily temperature (°C) and minimum daily relative humidity (%));
- **ii)** Daily comfort index (mean daily temperature (°C) and mean daily relative humidity (%));
- **iii)** Precipitation (total precipitation, (mm));
- **iv)** Sunshine (total hours of sunshine);
- **v)** Wind (average wind speed (m s-1 or km h-1).

The TCI index is depicted by the Equation calculated below:

$$TCI = 2(4 \times CID + CIA + 2 \times S + W) \quad (4.2.)$$

R is precipitation (mm), S is the number of hours of sunshine, W is the mean wind speed (m s1), and the daytime comfort index (CID) is made up of the mean maximum air temperature (°C) and the mean minimum relative humidity (%). In contrast, the daily comfort index (CIA) is made up of the mean air temperature (°C) and the mean relative humidity (%).

The daytime comfort index is likely given the best weight in Mieczkowski's calculation to indicate that tourists are typically more active during the day. The second most essential weights are daily thermal comfort and wind speed, followed by the quantity of the case study regions' sunshine and precipitation patterns. The index generally had a maximum value of 100 and an optimal rating of 5.0 for each variable. The suitability of each place for each tourism activity was then graded based on a scale starting from -30 and ending at 100 based on the TCI index value for each one of the case studies' locations. It varies from perfect condition (90-100), excellent condition (80-89), and excellent condition (70-79) to severely unfavourable situation (10-19) and impossible for any tourism activities (9 to -30), Mieczkowski (1985) split this scale into ten groups which are shown in (Table 4.4.).

To assess the TCI, a proposed software developed in Iran called the Iran Tourism Climate Index Calculator (ITCIC) provides different contexts for tourism management and hospitality. This is an easy-to-use, cross-platform software. The program accesses the necessary data files, converts them to Excel files and automatically saves them to the same drive.

The program is set up to omit years with incomplete weather data and to calculate standard climate variables by month for TCI. Calculated general weather information for each station includes daily maximum and average temperatures, daily minimum temperatures and average relative humidity. This information is then mapped to ASHRAE's effective temperature charts to determine each month's CIA and Cid ratings separately. TCI values grounded on comfort indicators are obtained from the forecasted future based on the historical trend test, calculated by Sens Slopes and M-K test and predicting the future by downscaling large numbers of climatic data using LARS WG6. It is tried to produce forecasting climatic data in a way that complies with the psychometric diagram that the ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) thermal comfort standard has introduced.

Thermal comfort, as defined by ASHRAE, is the mental state that allows for the expression of environmental enjoyment. The thermal zone, with a grade of 5.0 points, is the best for the TCI, claims ASHRAE (1972). According to an ideal set of sequential values, the rating scale steadily declines on both sides of the optimal zone. The effective temperature lines taken from the ASHRAE comfort chart are the borders between the rating zones. In this work, it is decided to extract the equations of the ASHRAE comfort chart using TCI findings for both cases study regions to predict the possible level of comfort in future among coastal tourists who may visit these two case study regions.

The long-term data covering both stations are used to compute TCI under baseline conditions (1981–2015) and a climate change scenario of CMPI 5 using different RCPIs.

The program was written in Excel software, and the rating of CIA and CID were determined for each month in studying stations. Daily Comfort Index (CID): To calculate this sub-index, maximum daily temperature and average minimum daily relative humidity are used. This sub-index shows the thermal comfort conditions when there is maximum environmental activity, and its share in (TCI) is 40%. Circadian Comfort Index (CIA): The variables used in this sub-index include average daily temperature and average daily relative humidity. Because this index shows thermal comfort conditions throughout the day and night, even when people are resting, it is less important than the previous index and only has a 10% share in (TCI). To calculate the 24-hour comfort index, the variables of daily average temperature and average daily relative humidity are used based on the comfort factor diagram (Figure 5) (37). In general, the share of two indices (CID) and (CIA) in the amount of (TCI) of a region is 50%.

To measure thermal comfort, temperature and humidity variables are used based on the comfort factor diagram, and its figures are obtained from the intersection of temperature and relative humidity. In terms of comfort index, the most favourable and optimal area in terms of thermal comfort is between 20-27 degrees Celsius and relative humidity of 30-70%, whose value (TCI) is determined by a value of 5. The average monthly climatic statistics related to 12 months of the year for each desired climatic variable were extracted and calculated using the TCI calculator semi-software. The TCI calculator's point is to determine the wind speed weight. This variable is not a critical factor for assessing TCI.

This program has five boxes, each related to a general index. In the daily thermal comfort index section, the ENR index is obtained. Coefficients are obtained. The same conditions are valid for the night comfort index. In the wind section, in this study, the default coefficients below ten kilometres per hour for the peak months of coastal tourism are considered. Because our average monthly temperatures in many months in Allegro are more than 24 degrees Celsius, and in Kish, the tropical climate index is used due to the average being above 34. By default, the number of daily sunny hours is 14 in the year's first half and 10 in the second half.

To interpret the findings of the TCI for the two case study regions of Kish Island and the Algarve Region Scott and McBovle model is applied. Based on Scott and McBoyle's model, which was established in (2001) they have proposed that the climate could be classified for each tourist destination into one of six annual distributions if TCI ≥ 80 for each month of the year, the Tourism climate typology in the model is 'optimal'. Suppose TCI ≥ 80 for each month of the year, the Tourism climate typology in the model is 'optimal'. If TCI < 40 throughout the year, it suggests a 'poor' year-round tourism climate.

The peak curves for 'summer' and 'winter peak' were similar and outstanding by season in which more suitable climatic conditions occurred. A 'summer peak' corresponds to amid- to high latitude locations where summer was considered the most pleasant period for tourism activity. A 'winter peak' would occur in the lower-latitude places where cooler and/or lower humidity conditions in winter make conditions more comfortable for tourists compared to hot and/or humid summer weather. Where spring and fall months were more suitable for tourist activity, a 'bimodal' or 'shoulder peak' distribution was shown. The tourism climate resources in regions with separate wet and dry seasons mainly depended on precipitation. The TCI in these regions displayed a dry season peak when the climate was most conducive to tourism activity (Scott et al., 2004).

Psychometric charts interpret the TCI results for Kish Island and the Algarve Region case study areas. This is very important in many ways, including B, in the design of air conditioning and human comfort. These calculations consider the relationship between dry and wet bulb temperature, relative humidity, enthalpy, and specific volume. The TCI index, CIa (Daily Comfort Index) and the Cid (Daytime Comfort Index) are considered comfort indicators. The values for each indicator are taken from the ASHRAE psychometric chart (American Society of Heating, Refrigerating and Air Conditioning Engineers) thermal comfort standard has been drawn.

As defined by ASHRAE, thermal comfort is an intellectual state in which one can express satisfaction with one's environment. According to ASHRAE (1972), the thermal zone is the best for TCI, with a score of 5.0 points. The rating scale is then gradually decreased on either side of the optimal zone according to an ideally assigned set of continuous values. Boundaries between evaluation zones are effective temperature lines derived from the ASHRAE comfort chart. In this study, due to a large amount of data and necessary calculations, the author decided to extract the equations of lines and curves of his ASHRAE comfort chart by a set of points. A short program was then written in Excel software to determine each month's CIa and CId scores on a learning station.

Table 4.7. to 4.12. shows the output of the program used to determine the CId and CIa rates from the Kish Island station in the forecasted predictions for the future based on the IPCC scenarios and RCPI 4.5 and RCPI 8.5 models for both near future periods which will be from 2020 to 2050 and far future from 2025 to the year 2100.

**Table 4.7. Heat condition based on ASHRAE scale, 2020-2050.**

| January | February | March | April | May | June | July | August | September | October | November | December | Scale ASHRAE TSN(T) PMV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.3 | 0 | 0.6 | 1.7 | 2.8 | 3.5 | 4 | 4.2 | 3.8 | 2.8 | 1.5 | 0.4 | **Kish Island** |
| Neutral | neutral | Bit warm | Warm | Hot | Hot | Very hot | Very hot | Very hot | Hot | Warm | neutral | |

**Table 4.8.-PPD Forecasted Mean based on Survey, 2050-2100.**

| December | November | October | September | August | July | June | May | April | March | February | January | PPD forecasted mean based on a survey (percentage) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100% | 64.% | 77.8% | 86% | 98.1% | 97.% | 89.9% | 69% | 19.2% | 18.9% | 16% | 11% | **Kish Island** |
| Satisfied | Non-satisfied | Non-satisfied | Non-satisfied | Non-satisfied | Non-satisfied | Non-satisfied | Non-satisfied | Satisfied | Satisfied | Satisfied | Satisfied | |

Orange colour: highest non-satisfaction level

In Kish Island, the favourable conditions for travel during December, February and January are based on the PMV index and, according to the CIT index, during March with ideal conditions. Evaluation of the physical variable (P) of wind and then precipitation; The frequency of days with the wind over 6 meters per second in March 285 days, February 226 days and January 170 days during the statistical period, this number of occurrence days covers nearly one-third of the study days of each month and can be a limiting factor.

For coastal tourists, it should play a role in disturbing the comfort and moving the sand. According to the findings of the predictions of the annual precipitations for the Future in the Algarve region, the highest amount of rainfall falls during January and December.

The occurrence of daily rainfall is higher than 3 mm per day in January (70 days), December (69 days) and March (56 days). The limiting factor of rainfall during March can affect the circulation conditions. However, this factor was of low importance according to the respondents compared to 900 days, which is insignificant. The aesthetic variable (A) indicates the predominant state of clear weather with sunshine and only days with more clouds; It is specific to January (59 days), which is not one of the ideal months for beach tourism.

The findings of trend check about the past with the help of the M-K trend test helped us to find the possible prediction for changes in future precipitations, which showed negative impacts of climate change for both RCPI 4.5 and RCPI8.5 for near and far Future in the Kish Island station.

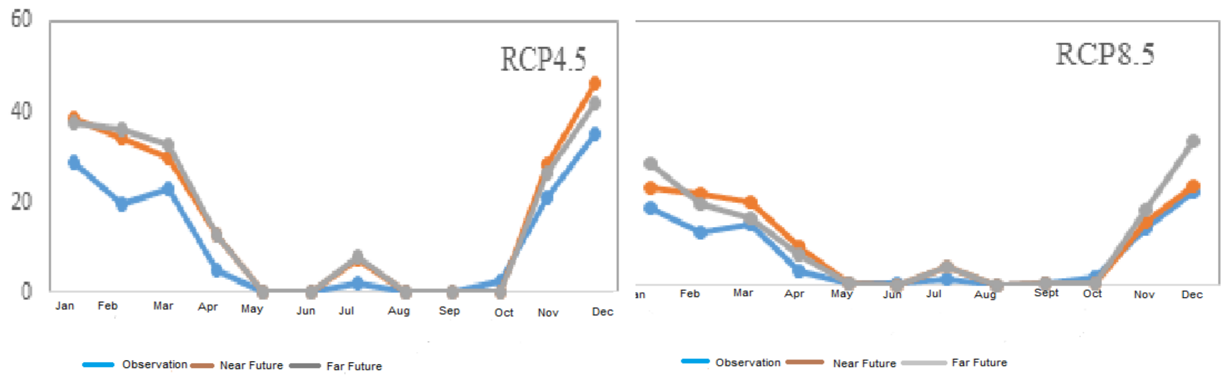


**Figure 4.23. Predicting the average changes of precipitation at Kish Island station based on 5 CMIP output models according to two scenarios, RCP4.5 and RCP8.5**

**Table 4.9. Changes in Predicting the Thermal Mental State based on RCP4.5 scenarios in the near future (2020-2050)**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 0.3 | 1 | 2 | 3.1 | 3.9 | 4.3 | 4.4 | 3.9 | 3 | 1.7 | 0.6 | **Kish Island** |
| Neutral | Neutral | Bit warm | warm | hot | Very hot | Very hot | Very hot | Very hot | hot | Warm | Bit warm | |

**Table 4.10. Changes in Predicting the Thermal Mental State based on RCP4.5 scenarios in the far future (2050-2100)**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.3 | 0.7 | 1.4 | 2.3 | 3.5 | 4.3 | 4.7 | 4.7 | 4.2 | 3.3 | 2.1 | 1 | **Kish Island** |
| Neutral | Bit warm | Bit warm | warm | hot | Very hot | Non-toleratable heat | Non-toleratable heat | Very hot | Hot | Warm | Bit warm | |

**Table 4.11. Changes in predicting the thermal Mental State based on RCP8.5 scenarios (in the near future (2020-2050)**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.3 | 0.7 | 1.1 | 2.1 | 3.2 | 4 | 4.4 | 4.5 | 3.9 | 3 | 1.8 | 0.7 | **Kish Island** |
| Neutral | Bit warm | Bit warm | warm | hot | Very Hot | Very hot | Very hot | Very hot | Hot | Warm | Bit Warm | |

**Table 4.12. Changes in predicting the Thermal Mental State based on RCP8.5 scenarios in the far future (2050-2100)**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.7 | 1 | 1.8 | 2.7 | 3.9 | 4.7 | 5 | 5.1 | 4.5 | 3.6 | 2.4 | 1.3 | **Kish Island** |
| Bit warm | Bit warm | War m | Hot | Very hot | Non-toleratable heat | Non-toleratable heat | Non-toleratable heat | Very hot | Very hot | Warm | Bit warm | |

In the future, it may analysed a shift in time (backwards and forwards) because of the maximum increase during these months. The ideal period is shifted to the previous and subsequent months. This shift extends from January to February, and these months will be known as favourable months for beach activities. The months with low heat stress will no longer have suitable conditions for beach activities and travel. and change their status to acceptable.

In fact, during the spring period, during future periods, tourists will have less incentive to travel to these areas due to the occurrence of thermal restrictions, and travel in this period will be reduced. On the other hand, due to time dispersion, the event of precipitation will not have a significant effect like the temperature element, this element will have a limited behaviour in the future, and its period is short-term, which means that its occurrence may lead to floods. It is not possible to make an accurate prediction about its time frame.

## 4.3.7. Algarve Region TCI Future Calculation

As mentioned in the previous section and to assess climate comfort range for tourism planning in the Algarve region same methods were applied, secondary data about the weather and climatic data in synoptic stations of the Algarve region obtained from the website of the world climate organisation (https://community.wmo.int/climate-metadata) to be used in TCI computation. The main formula for the TCI index applied in this work was the one developed by Mieczkowski (1985). The same index were chosen and used for the Algarve region, consisting of five sub-indices, each represented by one or two monthly climate variables.

Trends of changes were detected and based on the scenarios for the future, the monthly mean TCI values in the Algarve region were calculated, which are mainly between 71 and 84, and therefore the climate comfort can be categorised as ranging from acceptable to excellent through all the year (Figure 4.14.).

The same five sub-indices and their constituent variables, such as the ones used in the assessment of Kish Island, have been applied. To assess the TCI for the Algarve region, the same method for Kish Island is applied by using the Iran Tourism Climate Index Calculator (ITCIC), which provides different contexts for tourism management and hospitality. Again same, in the Kish Island case, Scott and McBovle's model is also used to interpret the TCI's results for the Algarve Region in the same manner. According to this model, each tourist destination's climate, such as Algarve Region, could be categorised into one of six annual distributions. In this model, if TCI is 80 or above, it will bring satisfaction and be considered Ideal for each month of the year. If the TCI is consistently below 40, the tourism sector's overall state is considered unsatisfactory or "bad."

There are "summer peak" and "winter peak" peak curves for each destination which are not comparable with places and are mainly distinguished by the season in which more favourable climatic conditions may occur. As Algarve is a coastal destination in high latitude, there is only a "summer peak", typically related to mid- to high-latitude regions where summer is regarded as the most pleasant year for tourism. There is not an absolute "winter peak" in the Algarve region. However, there are lower-latitude regions such as Kish Island, the southernmost province in the Persian Gulf of Iran, where winter weather is warmer and/or more humid, which is more comfortable for tourists than hot and/or humid or humid summer weather.

There is only a "shoulder peak" distribution where spring and fall were better for some of the tourist activities in the Algarve Region. It should be noted that the main factor affecting the tourist climatic resources in Mediterranean areas is precipitation; therefore, when the weather was at its driest in these areas, the TCI showed a peak satisfaction among tourists.

The rating scale is gradually decreased on either side of the optimal zone. Effective temperature lines, which are used as evaluation zone boundaries, are taken from the ASHRAE comfort chart for the Algarve region. It was decided to extract the equations of the lines and curves of his

ASHRAE comfort chart by a set of points in this study due to the enormous amount of data and complicated computations required. Then, a quick Excel application was created to calculate each month's CIa and CId scores on a learning station.

Table 4.13. to 4.18. shows the output of the CId and CIa rates from the Algarve region in the forecasted predictions for the future based on the IPCC scenarios and RCPI 4.5 and RCPI 8.5 models for both near futures, which will be from 2020 to 2050 and far future from 2050 to the year 2100.

**Table 4.13. Algarve Region Heat condition based on ASHRAE scale, 2020-2050**

| January | February | March | April | May | June | July | August | September | October | November | December | Scale ASHRAE TSN(T) PMV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.9 | -0.7 | -0.6 | -0.5 | 1.8 | 2.2 | 3 | 3.2 | 2.7 | 2.1 | 1.0 | 0.2 | **Algarve Region** |
| Neutral | Neutral | Neutral | Neutral | Warm | Bit warm | Hot | Hot | Hot | Bit warm | Warm | Neutral | |

**Table 4.14. PPD Forecasted Mean based on survey, 2050-2100**

| December | November | October | September | August | July | June | May | April | March | February | January | PPD forecasted mean based on a survey (percentage) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 95% | 93% | 89.8% | 14.% | 99.1% | 17 % | 14.9% | 69% | 75.2% | 83.9% | 97.6% | 98.9% | **Algarve Region** |
| Non-Satisfied | Non-satisfied | Non-satisfied | Satisfied | Non-satisfied | Satisfied | Satisfied | Non-satisfied | Non-satisfied | Non-satisfied | Non-Satisfied | Non-Satisfied | |

Orange colour: highest non-satisfaction level

Based on the TCI findings, the conclusions of the future level of satisfaction among coastal tourists should be considered. The predicted percentage of dissatisfaction (PPD) has been chosen to represent the findings.

**Table 4.15. Changes in predicting the thermal Mental State based on RCP4.5 scenarios in the near future (2020-2050).**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.3 | 0.7 | 1 | 1.5 | 2.3 | 3.1 | 3.4 | 2.7 | 1.8 | 1 | 0.6 | **Algarve Region** |
| Neutral | Neutral | Neutral | Warm | Hot | Hot | Very hot | Very hot | Hot | Warm | warm | Neutral | |

The limiting factor of rainfall during March can affect the beach conditions, but this factor was of low importance, according to the TCI. In general, during winter, clear weather with sunshine and only days with more clouds happen more during April, which is not one of the ideal months for coastal tourism. According to the CIT index findings, the Algarve region has no favourable conditions for coastal activity during November, December, January, February and March. Based on the evaluation of the physical variable of wind and precipitation in the Algarve region, as there is a high frequency of days with the wind over 6 meters per second during winter for coastal tourists, it plays a negative role in disturbing the comfort and moving the sand.

**Table 4.16. Changes in predicting the thermal emotional state based on RCP4.5 scenarios in the far future (2050-2100).**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.3 | 0.5 | 0.8 | 1.3 | 1.9 | 2.3 | 2.7 | 3.4 | 3.3 | 2.9 | 1.7 | 0.7 | **Algarve Region** |
| Neutral | Neutral | Neutral | Warm | hot | Hot | Very Hot | Very Hot | Very hot | Warm | Warm | Neutral | |

**Table 4.17. Changes in Predicting the Thermal Mental State based on RCP8.5 scenarios (in the near future (2020-2050).**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.6 | 0.9 | 1.5 | 2.3 | 2.9 | 3.2 | 3.5 | 3 | 3 | 1.8 | 0.9 | **Algarve Region** |
| Neutral | Neutral | Neutral | warm | hot | Very hot | Very hot | Very hot | Very hot | Hot | Warm | Neutral | |

The highest precipitation amount in the Algarve region happens during January and February. The daily rainfall of more than 10 mm per day occurs more in January and February.

**Table 4.18. Changes in Predicting the Thermal Mental State based on RCP8.5 scenarios in the far future (2050-2100).**

| January | February | March | April | May | June | July | August | September | October | November | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.7 | 1 | 1.7 | 2.1 | 3. | 3.2 | 3.7 | 3.5 | 2.6 | 2.4 | 1.3 | **Algarve Region** |
| Bit warm | Bit warm | warm | Hot | Very hot | Very hot | Very Hot | Very Hot | Very hot | Warm | Warm | Bit warm | |

This shift extends to January and February, the favourable months for beach activities from tourists' point of view. The months with low heat stress will no longer have suitable conditions for beach activities and travel. and change their status to acceptable.

In fact, during the spring period, during future periods, tourists will have less incentive to travel to these areas due to the occurrence of thermal restrictions, and travel in this period will be reduced. On the other hand, due to time dispersion, the event of precipitation will not have a significant effect like the temperature element, this element will have a limited behaviour in the future, and its period is short-term, which means that its occurrence may lead to floods. It is not possible to make an accurate prediction about its time frame.

### 4.3.8. Comparing Trend Changes for the Case Study Regions

Based on the Findings of the Man-Kendall and Slope Sen test, some differences were found as below:

The meaningful Z value difference in the Kish station and Algarve station - the Z value for the Algarve is more than seven, and the Z value for Kish is around 2- suggests that the mean annual temperature is higher in the Algarve region. The other interpretation for the difference in the Z value in Kish and Algarve is due to different patterns of global warming happening in the Algarve region, which is harsher and more steady. The Z value of 2 in Kish Island shows that despite the ascending pattern of T min and T max, the increase in the Minimum Temperature was not that much compared to the results in the Algarve region, during the last four decades, the minimum temperature, which refers to night temperature, has constantly been growing without any change in the rising pattern.

The phenomenon justification is the growth of the daily temperature and temperature at the surrounding Ocean. This increased the amount of water evaporation into the atmosphere, preventing the temperature from decreasing during the evening. This meaningful trend shows that climate change in the case of warming is happening at a greater rate in the Algarve region despite its location, which is more northern than Kish Island. This Hazardous sign should be considered because the findings show that continuing this trend will result in the physical dissatisfaction of coastal tourists.

Another issue is the fact that most visitors to the Algarve region are coming from European Northern Latitudes, and these people, by nature, are not adapted to the sweltering temperatures compared to the tourists who are visiting Kish, who are mainly from the Middle Eastern region and are more psychologically and physically exposed and adapted to high temperatures.

The process of acclimatization for a tourist at the destination is an issue that climate change is going to have a severe impact on it, and this growing temperature will increase the probability of dissatisfaction for the tourists who are travelling to destinations with a significant difference in their climatic patterns compared to their original place of residence.

The evaluated extreme temperature trend changes over the Algarve region found that both maximum and minimum temperatures are increasing; maximum temperature is expected to increase to 3.2°C and 4.7°C in summer under the B2 and A2 scenarios under IPCC will worsen the case. In general, the increase of maximum temperature in the recorded history of the last four decades is up to 2.7°C and 4.1°C in the minimum temperature in the summer season, which is coastal tourism high season also another caution for tourism policymakers in the Algarve region. Another severe impact of climate change on the Algarve region is forest fires, such as in the 2022 summer high season, which are projected to increase dramatically in the future in case of no adaptation measures.

### 4.3.9. Comparing TCI Results for the Case Study Regions

To develop tourism in a region requires analyzing data throughout the year. For tourists, the destination's climate is quite essential. Therefore, climatic indices can aid in local tourism planning and the best use of time. In this study, the climatic conditions of two case study regions, Kish Island in Iran and the Algarve region in Portugal, have been assessed, and their TCI were evaluated. In this part, the results for these two case study regions will be compared using synoptic climatic indices during 40 years and the tourism climate index (TCI), together with the holiday patterns and high season calendar for each in various months.

The comparison between the two region indices showed that TCI demonstrates a wide range from unfavourable to favourable conditions throughout the year, with different fluctuation patterns for each. TCI has additional findings for each studied area, which is no surprise. It was also shown that the maximum temperature and relative precipitations affect regional tourism attractions the most in addition to daytime hours.

Regarding the two case study regions and the findings of the TCI assessments, it was found that January, February and March in Winter and October and November are the best months for coastal tourism planning in Kish Island because of their pleasant weather, which are different from the nice months for region Algarve even though there are both located in the northern hemisphere and have the same pattern of meteorological seasonality but other Tourism seasonality calendar due to their difference in their latitude.

According to the findings of the TCI assessment for the case of the Algarve region, it was found that June, July and September will be the best months in future for Coastal Tourism activities with a higher level of satisfaction. Comparing the results of the two case studies found a meaningful trend in changes in a climatic variable for both Kish Island and the Algarve region, as both Minimum and Maximum recorded temperatures are rising. The ascending trend is quite visible from another side number of frequencies of heat waves and drought is also increasing. On another side, there are anomalies in precipitations. There is also a descending trend of rains in the last decades. The minimum and maximum temperatures are more significant in the Kish Island area than in the Algarve. In contrast, the rate of changes in the Algarve region is more meaningful and shows more hazardous trends that should be considered.

The results suggested that both Kish Island and Algarve region will become warmer destinations in the winter and autumn and more hot in the spring and summer seasons. This means more significant changes in the case of seasonality and limitations and possibilities for performing outdoor tourism activities in both destinations.

Rising temperatures can devastate Kish Island's vulnerable coastal and marine life due to its sensitive coral reefs. It can change the shape and patterns of waves in the Algarve, as has already happened with significant damage to coastlines. On the other side, negative aspects of climate change disturb the function and structure of the ecosystems, among other notable issues. Sea level (1,7 mm/year) quickly changes the shape of coastlines, contributes to coastal erosion and leads to flooding in both case studies.

### 4.3.10. Conclusion

The Chapter examined evidence of climate variability and change in Kish Island and the Algarve region. An analysis of climate and hydrological records over the past 40 years shows evidence of climate variability and change in the area with a statistically significant annual increase in the climatic parameters, including minimum, maximum and mean temperature. Regarding rainfall patterns, there have been slight yearly changes in average rainfall, which are insignificant, although the rainfall season shifted and is much shorter. There is also proof of climate variability and extreme rainfall patterns marked by intense rainfall in some years and extreme aridity in others. There has been a stronger leaning towards increased drought years in the recent past due to increased El Niño and La Niña phenomena attributed to climate change.

The research found marked delays and a shortening of the rainy season, which was previously running from November to April and now from October to April, with increased rainfall in November, January, and April. In addition, the temperature for Kish Island resort town has risen significantly over the years, with the marked increase being recorded in October and November, which accounts for the more significant portion of the temperature increase. Winter warming trends emerged as winter months, mainly June, significantly increased over the past 40 years. Changes affect wildlife, tourists, and tourist activities in the resort town.

Eight of Algarve's ten warmest years occurred in the last 20 years, and temperatures have risen over the past few decades. In Portugal, heat waves have become more frequent and intense, mainly hitting the Algarve region in the country's south. According to the world climate vulnerability map published by IPPCC, Portugal is a climatic hotspot, and out of 26 locations around the world, and Algarve region in the south, the Mediterranean region of Portugal, is expected to undergo the most drying challenges in future.

The frequency and severity of extreme weather phenomena, such as heat waves and droughts, are growing in several frequencies and magnitudes of devastation in Portugal. The population, agriculture, and economy, mainly tourism, are already impacted by the escalating severity of drought, flooding, and wildfires. Portugal's typical "wildfire season" was extended from two to five months in 2017 due to an increase in jungle wildfires, primarily caused by climate change; during the same year, hundreds of people passed away.

The Algarve region had one of its hottest summers and a rise in wildfires in 2022. 96% of the Algarve region was categorized as experiencing an extreme or severe drought in June. Therefore, this doctoral thesis tries to explain why there should be more concern about the effects of climate change due to potential negative hypotheses supported by scientific evidence. In contrast, many scientific scholars and politicians in Portugal ignore climate change's indirect and direct consequences. During the most recent heatwave in mid-July 2022, numerous locations in Portugal experienced record-breaking high temperatures of about 47°C. The frequency of wildfires in Portugal will grow as temperatures and dry conditions rise. Portugal is experiencing more and more droughts. Portugal had 10 of the 12 driest winters in the past 20 years between 1902 and 2010.

The yearly precipitation was down 90mm per decade as of 2017. According to climate simulations, the precipitation deficit will persist. Rainfall in the Algarve region would decline by 30% in the south and 15% in the north under scenario RCP6.0, in which global warming hits three °C by 2100. The seasons in the Algarve region have a significant impact on precipitation drops as well. In the summer, values are predicted to decline by more than 50%. Nearly the whole area of the Algarve was experiencing a severe drought at the end of May 2022, and essential dams and waterways had dried up.

Most European coasts, including Portugal, have seen an increase in sea levels. The average sea level around the world has risen by around 20 cm since the turn of the 20th century. Climate change has caused the temperature to rise and precipitation to decrease, particularly in the Algarve region in southern Portugal. In this Mediterranean region, both the frequency and intensity of droughts have increased. Sea level rises to threaten the Algarve region, with 155 km of coastline on its southern side and 55 km on its western side. These changes may affect the region's biodiversity, infrastructure, food systems, and livelihoods. Under scenario RCP4.5, where global warming hits 2.5°C by 2100, the Algarve region is anticipated to have more than a 0.4 shift in relative sea level in 2081-2100 compared to 1986-2005. This may lead to flooding in the region and more severe coastal erosion.

According to Climate Analytics, whole summer and fall temperatures in the Algarve region will rise by up to 8°C under the scenario RCP8.5, in which global warming reaches 4.3°C by 2100. Maximum spring and winter temperatures increase by 2 to 4 degrees Celsius. Under this scenario, temperatures typically exceed 40°C and never go below 2°C.

This scenario confirms the social media outcry of 2915/16 that the falls were drying up. Given the evidence of climate variability and change, there is an extension of activities such as swimming at Tavira's Devil's Pool. There is also the shortening of specific activities like swimming in the Atlantic Ocean in the Algarve region due to cold abnormal water temperatures. Furthermore, warmer winter months will likely reduce energy demands, while warmer summer months may result in increased energy demands, increasing carbon emissions that lead to global warming and climate change.

Climatic changes in recent decades in Kish Island, a typical coral reef island in the Persian Gulf, have led to drastic environmental changes. Continuous reduction in rainfall and prolonged droughts have led to increased Land Surface Temperature, evaporation, and water body and vegetation cover decline.

In this period (1985-2019) for the Kish region, the annual rainfall decreased (Z = -2.13). However, the maximum temperature (Z = 2.72), minimum temperature (Z = 5.11) and average temperature (Z = 4.48) have met an increasing trend. The trends mentioned above in rates indicate that climate change has occurred in this region.

Assessing the spatial environmental factors of the study indicates that rainfall, maximum, minimum, and average temperatures of LST and atmospheric pressure at the sea surface have been changed. This pressure initiates from south Iran (Persian Gulf region) and gains altitude towards the north. In this context, the rainfall, vegetation, concentration, and soil humidity have increased, and the factors of environment and earth surface temperature next to atmospheric pressure at different levels decreased.

Analyzing changes in the minimum, maximum, and average annual temperature of the Kish Island and Algarve region from 1980 to 2022 reveals the temporal changes at a 95% confidence level, with an ascending trend. In the non-parametric Mann-Kendall test, the significance is (Z = +5.11) for the maximum and (Z = +2.72) for the minimum and (Z = + 4.48) for the average temperatures in Kish Island and (Z = +5.01) for the maximum and (Z = +2.12) for the minimum and (Z = + 4.08) for the average temperatures. Minimum temperatures have risen from about 18˚ C in the 1980s to 21 ˚C in the 2010s for the case of Kish Island and from 13 ˚C to 19 ˚C for the case Algarve region. Daily temperatures rose from 33˚C to 35 ˚C, with an average of 25 ˚ to 27 ˚C for Kish Island and from 22 ˚C to 27 ˚C for the Algarve region.

Climate change (global warming, drought) and human activities (deforestation, wetland drying, and mismanagement) have increased dusty days around both case study regions, even though they are on different continents. The transition of dust from Africa and Morocco to the Mediterranean is the same as dust moving from the Saudi Arabian Peninsula to the Persian Gulf area. It should be noted that dust from synoptic conditions and environmental changes in the Arab region of the Middle East, which affects a significant part of Iran, differs from dust from a local source. Cooperation with the regional countries (Iraq, Turkey, Syria, Jordan, and Saudi Arabia) and the Euphrates and Tigris rivers' flow patterns would establish an efficient measure in confronting the environmental risks.

The same cooperation Methods are needed for the case of Portugal against dust movement from Africa to European Mediterranean zones such as the Algarve region. The transfer of dust of African origin will decrease the air quality in the Algarve, which can negatively impact coastal tourism, which stays outside most of the time during their visits.

# CHAPTER 5

# (Conclusion)

## 5.1. Summary of the Study

This thesis detects and monitors significant impacts of climate change that have been projected for tourism in both case study regions of the Algarve region and Kish Island. Typically, these projections took general outdoor tourism activities, mainly coastal activities and their climate requirements, as their point of reference.

This work tries to reassess the impact of climate change by looking deeply into specifically at coastal tourism, which is a crucial market segment in European destinations and specifically in the Mediterranean destinations such as the Algarve region in the south of Portugal and a deep look into the same issue in a peer to peer way in a Middle eastern coastal destination of Kish Island in the Persian Gulf in the south of Iran. Coastal tourism as an outdoor type of tourism requires a comparatively high level of environmental prerequisites in case of weather such as temperature, a high number of sunny hours, and not windy days, which may reduce or increase relative attractiveness in a destination—concerning the importance of the climate in coastal destination selection, considering that Europe's top destination for summertime is set to remain coastal tourism Mediterranean destinations for at least the next 50 years, same issue for other parts of the world including Persian Gulf regions such as Kish Island.

The study aimed to examine and understand the dual comparison between the impacts of change on coast tourism in two different case study regions located in Asia and Europe. To achieve this, this research identified three research objectives, namely:

1) to determine evidence of climate change and associated extreme weather events on the Case study regions of Kish Island in Iran and the Algarve region in Portugal and potential intervention measures to observe and monitor the past, present and future climate changes.
2) to assess and detect the climatic changes which have happened and recorded in the two case study regions, which may have possible direct and indirect impacts on tourism and vice versa, also indicating possible intervention models and measures for predicting climate scenarios for the future to increase the level of sustainability of the coastal tourist attractions in both case study regions and decrease the possible negative threads for the tourism market.
3) to map out possible hazards and direct and indirect impacts of climate change in the near and far future scenarios on the coastal tourism value chain and establish mitigation and adaptation policies to reduce negative aspects.

As it is argued in chapter one of this study that tourism in coastal zones is highly vulnerable to the impacts of climate change, and this is especially the case for Coastal tourism recreation due to its high exposure and sensitivity to weather conditions and because it is one of the most relevant types of tourism in Europe. Therefore, this thesis aims to address how climate change might affect Europe's tourism in coastal and marine environments and propose a way of assessing the sector's vulnerability. These objectives have been approached using these sub-questions:

(1) What is the state-of-the-art knowledge on climate (change) and tourism, and what are the main knowledge gaps about coastal and marine recreation?
(2) What are the weather determinants of coastal tourism?
(3) What consequences will climate change have for the destinations' climate suitability for Coastal tourism?
(4) How can the vulnerability of Coastal destinations such as Kish and Algarve be assessed?
(5) What kind of scientific proof of extreme climate-related weather events exists in the two case study regions of Kish Island and Algarve region, and which appropriate intervention measures could be put in place?
(6) Which possible advantages and disadvantages may the future climate change bring for coastal tourism in the prevalent case study regions of Kish and Algarve, and what intervention measures can be instituted?
(7) What are the vulnerability aspects of coastal tourism in case of climate change in both case study regions of Kish Island and the Algarve region, and what appropriate mitigation measures are available to reduce such adverse impacts?

In case study research using a quantitative methodology approach, the research utilised a pragmatism paradigm. Following the requirements of the research topic and triangulating data to assure the validity and reliability of the findings, various research methodologies were used. Meteorological and hydrological data from the Iranian and Portuguese meteorological departments and national and international Authority resources were collected and examined over 40 years to look into the evidence of climate change.

Data analysis was carried out by established procedures for examining both secondary and quantitative data. The process of future forecasting data analysis was aided by the qualitative data analysis that was carried out with the aid of the historical climatic data trend detection for both case study regions. Several software programs were used to examine the quantitative secondary data, including the Mann-Kendall Trend Test (change detection), the Excel Analysis TCI calculator, and Minitab 19 software. Furthermore, after thoroughly examining the data supervisors, secondary data were gathered ethically and by Algarve university norms.

The following parts present a summary of findings following the outline of this thesis' objectives and research questions mentioned above.

### 5.1.1. Climate Change in Kish Island Station

The study found evidence of climate change and harsh weather on the Kish Island. The statistically substantial temperature increase, the delayed or abnormal patterns of precipitation, and the flood rains after extended periods of no rainfall and droughts, as revealed by the analysis of historical climatic data recorded at the Kish Island station, are noteworthy. However, the variations varied from month to month and year to year, with some months experiencing significantly greater temperatures than others and, in turn, a rising trend in both the annual minimum and maximum temperatures. The trend detection of the mean yearly temperature revealed a more significant temperature increase of nearly 3°C over the previous 40 years (1986-2020), which corresponds to an increased rate of roughly 0.75°C per decade.

The historical analysis of the data showed that the temperature increased both in the winter and the summer, with the month of January experiencing a 0.53°C per decade warming. Despite the considerable annual variability, there were no statistically significant changes in rainfall for the period in question. This suggests that the region is experiencing extreme drought patterns and rainfall events.

Additionally, it was noted that there is a statistically significant tendency toward an increase in the frequency of yearly heat waves. However, there were noticeable monthly temperature changes in the historical data, with some months showing a sharp rise. The same rain anomalies have occurred, raising concerns about the state of water supplies overall and in the Algarve region in particular if the trend continues due to underground water shrinkage, which are the priisy source for sweet water usage in the rarea

### 5.1.2. Possible Impacts of Climate Change on Coastal Tourism on Kish Island

The tourism official, local managers, and stakeholders' role players fear that climate change will negatively affect the tourists' arrival in Kish Island, especially during the hot high summer season. Tourism statistics already report that tourism orgaorganisationse observed changes in Kish Island that could be attributed to climate change in recent years. If climate change is to alter the weather negatively, findings show that the Island could lose a big part of its tourism market in the coming years.

However, the Island heats up at this rate. In that case, it could bring new seasonality by changing tourism destination selection in certain months of the year by shifting tourist tourists destinations. This is a situation where there will be a massive change in the tourism market, and new mitigation policies should be considered. However, climate change, if brings severe heat could result in very few tourists visiting the area in some traditional high seasons. It will make new seasonality for coastal tourism which might have its benefits by creating new markets for recent marginal seasons which should be studied deeper to enhance the sustainability of tourism in the Island. Based on the analysis of the climate data Kish Island station during the period of 40 years (1980-2020) were used showed that the best period for the tourists on these islands the new seasonality is given birth already which is the autumn and spring season months, in which the comfort conditions are in the ideal situation which is new seasonality.

### 5.1.3. Climate Change in Algarve Region

One of the most popular seaside tourist attractions in Portugal and Europe is the Algarve region. In this work, a review of the past, present and future possible impacts of climate change on coastal tourism in the Algarve region is analyzed, presented and forecasted. The area is already experiencing some challenges about tourism sector, such as coastal erosion, cliffs collapse, heat waves, jungle fires also the exploitation of necessary natural resources, such as underground water.

Possible implications for the tourism sector in Portugal's coastal destinations, such as the Algarve region, are very significant such as coastline erosion, rise in the frequency of extreme weather events (such as prolonged droughts or sudden floods), a decrease in rainfall (between 30 and 40%), and an increase in average temperature are some of the most significant ones. All of these variables significantly affect rainfall, which will be substantially reduced in southern regions, interior places, and coastal areas that directly impact water resources.

In general, unplanned tourism development is behind some of these problems. In an era of climate change, however, these problems will likely be amplified. Due to the Algarve region's location in the Mediterranean (which has been identified as an impact hotspot) and its high dependency on tourism, it is argued that tourism in the Algarve region is highly vulnerable to the impacts of climate change. This recognition, however, has not permeated the tourism management institutions.

Climate change threatens to shift European coastal tourism from southern latitudes such as the Algarve region, which are facing more in-depth global warming and heat waves, to northern alternative destinations even during the last couple years which might get faster in the future. It is highly argued among tourism scholars and tourism sector stakeholders that regarding tourists' comfort in the Mediterranean destinations might retain its suitability in the coming 50 years.

As the thermal conditions in coastal tourism generator countries, which are primarily located in the northern latitudes of Europe is, improving during the summer high season thanks to growing degrees also, other climate change related issues in destinations such as water availability may, however, challenge this leading position of the Mediterranean in future.

Coastal destinations in the Mediterranean locations, such as the Algarve region, should include climate change in their development and management strategies if they want to keep leading European tourism. In this regard, it is argued that determining a destination's vulnerability is the first step in adapting it. There is a high probability of growth in the number of jellyfish, change in water salinity and sea level rise also widespread vector-borne diseases such as Malaria in the Algarve region in case of continued climate change with the same annual rates.

### 5.1.4. Possible Impacts of Climate Change on Coastal Tourism in Algarve

As Tourism is the largest sector in the Algarve region's local economy, with coastal tourism comprising the most significant part of the local revenue derived from the tourism sector in this area,a all possible impacts of climate change, either positive or negative may affect a large group of people who are living in the Algarve region so it is showing that it can be very critical and crucial to the local community and policymakers therefore to the academics who are engaged with the tourism in this area. Another possible scenario for biological hazards is the danger of widespread malaria mosquitoes which may find the Algarve region climatic situation, which is growing to become warmer and warmer, as an optimum place for migration from the African continen and finds it as a new nesting place which will grow health issue hazards in the region. Besides Malaria, other invasive species like Kongo and yellow fever flies might find the opportunity to fly, nest and reproduce in the region due to climatic changes.

On the other side, all possible climate-induced impacts on the tourism sector in the Algarve region have considerable ramifications for local, national, and regional economies, including the transportation, fishing, and agricultural sectors. Drivers such as ocean warming and acidification are likely to lead to changes in Marine life which are already happening. The composition and abundance of marine biodiversity and sea levels are changing, so these changes may lead to the spread of invasive species including jellyfishes which are a significant hazard for coastal activities during the high summer season when naturally the water is warming up. In addition, the sea level rising will lead to coastal erosion and movement of the sands and changing the sediment's geomorphological shape the extreme and abrupt climatic events such as storms and cyclones will impact coastal environments and communities.

The occurrence of heat waves also has another negative impact which is directly leading to forest fires which have been happening recently frequently in the Algarve region and can have negative publicity and damage the tourist image of the Algarve region. Heat waves also can lead to other health issues. They may become fatal for both tourists and residents in case they overpass the threshold of tolerance among European citizens who are very sensitive to high daily temperatures.

Collectively putting all these hazardous changes and considering the primary factors for coastal tourism, such as air temperature, precipitation, wind speed, etc., underwater parameters (invasive species like jellyfish, etc.), and coastal risks will alter as a result of the combination of these drivers (erosion, marine flooding). The primary elements of the tourism sector—such as visitor preferences, tourism operators' business strategies, and the transportation market—will be impacted by these changes, which will impact the supply and demand for tourism on a worldwide level. The extension of the high season the and emergence of the new shoulder season are also among the partial positive aspects of possible climate change scenarios in Algarve region.

## 5.2. Potential Implications on Case Study Regions

The coasts of the Algarve region in Portugal and Kish Island in Iran are both sensitive to climate change, necessitating adaptation measures to deal with its effects, maintain the growth of tourism in seaside areas, and ultimately safeguard developing economies and lessen its detrimental social effects (i.e. job losses, incomes decreases). Given that it is heavily dependent on climatic resources and because sea and sun tourism account for a significant portion of the profile market, the coastal tourism sector in these two regions will be particularly affected by climate changes.

Through comparing the possible impacts of climate change on both case study regions of Kish and Algarve, there will be many shocking results worth mentioning in this part of the work, such as creating a new shoulder season for coastal tourism activities and, at the same time shrinking summer traditional high season for seaside activities, increasing sea water temperature which equals a higher level of thermal satisfaction for coastal tourist and at the exact time change of jet streams directions with the possibility of bringing cold water flows closer to the coastline, coastal bleaching and erosion with the possibility of creating new forms of dunes and pristine coastlines along the formerly existing ones.

For instance, water shortages are highly relevant in both Kish Island and the Algarve region case study regions. Today, water resources are scarce, and hydrological modelling results suggest even more pronounced water stress due to climate change in the Algarve region. Being both "dependent on freshwater resources and an important factor in freshwater use, " the tourism sector is affected by and contributes to water shortages. Especially the concurrence of peak tourist and dry seasons aggravates water management issues. On a peak season day, tourists – including those lodging in non-official structures – raise the Algarve region's population by a factor higher than four times compared to local inhabitants.

In some parts of the Algarve region, the tourist impact factor exceeds 80. Tourists use more water when they are on holiday than at home and hence typically consume relatively more water than residents. Moreover, many tourism establishments are highly water intensive, including, among others, water parks, swimming pools, wellness and spa facilities, as well as golf courses. Especially in periods of drought, water consumption needs of the tourism sector aggravate conflict potentials with alternative water users – including residents, sector and agriculture.

According to the results of our analysis, climate change may help to relax the currently pronounced seasonality of tourism somewhat and relieve some of the pressure exerted on water resources during midsummer. On the other hand, total water availability in both case study regions is likely to decrease due to climate change, with significant reductions expected particularly for spring and autumn, i.e. for those times of the year when climatic conditions for coastal tourism are indicated to improve further and provide potentials for tourism demand gains. Hence, the pressure on water resources and the potential for water conflicts may increase significantly during spring and autumn.

While summer will see a drop in future in the Algarve region and Kish Island, it will see an increase in northern destinations in Portugal and Iran throughout the spring, summer, and fall. Sea level rise is one of the repercussions of climate change, which will ultimately result in coastal erosion, floods, and the loss of flat coastal zones in both case study regions (it is anticipated that erosion rates will increase by 15 to 25% on average during the 21st century).

## 5.3. Conclusions

Based on findings from this study, the climate in the Algarve region is changing at a faster pace than the envisaged global averages and even Kish Island. It emerged that climate change and variability are resulting in extreme weather events such as severe droughts, excessive rainfall, and rising temperature. Such extreme events primarily negatively affect wildlife and tourists in the area.

Climate change occurrence will result in disturbed tourist flow to the area depending on the severity of the negative impact of extreme weather events and changing climate. Climate changes have a detrimental effect on the tourism sector value chain, with chances of negatively affecting the tourists visiting calendar for both case study regions, including Kish Island and the Algarve region.

It is maintained that other effects of climate change, such as sea level rise or water supply, should receive more consideration. Environmental quality and activity diversity should be considered while planning a tourism project. In non-Mediterranean areas like Kish Island, a strategy is to concentrate on short- and medium-distance tourists who benefit from the new coastal tourism opportunities and to weigh the pros and cons of seasonal climate forecasting. Therefore, climate change is a potentially significant threat to the sustainability of tourism in both case study regions. On the other hand, tourism was found to be a driver of climate change through the production of carbon emissions, mainly those coming from the travel and hospitality sectors in both Kish Island and the Algarve region's traditional high season periods. The season length will be much more uniformly distributed over Europe, which is one of the consequences.

The rising sea level increase risk of storm surges, saltwater intrusion into estuaries and coastal aquifers, and the danger to wetlands and coastal ecosystems. Also, water resources in coastal regions, particularly in the south of Portugal, are negatively impacted. According to future climatic predictions, there will be a definite increase in the frequency of heat waves, with adverse effects on many socioeconomic sectors and ecological systems. Until the turn of the century, Algarve will experience an increased risk of forest fires. Undoubtedly, this will affect one country's most significant economic sector, the tourism sector.

For instance, the main adverse effects of climate change on tourism in the Algarve region are related to how the climate affects variables like tourists' thermal comfort, deterioration of water resources and air quality, or the loss of natural beauty, which do not appear to be as vulnerable to climate change (i.e., in terms of tourism attractiveness). The distribution profile of the area's significant markets may change due to these changes. Increases in the danger of tropical infectious disease transmission might severely damage the region's reputation as a travel destination. Climate change may extend the number of months ideal for beach travel in the Algarve region.

But by the end of the century, two scenarios suggest that July and August are less suitable for beach tourism and that there may be a shift in the seasonal pattern of demand (two peak seasons rather than one). Tourists' comfort and health could be in danger due to water- and food-borne illnesses. The probability of salmonella and other bacterial infections will rise as temperatures rise. The risk of microbial contamination in the sand and water off the Algarve coast will increase as temperatures rise and extreme precipitation events rise.

As a result of a build-up of biotoxins in bivalves and an increase in the risk of jellyfish in the coastal zone, there is evidence that the algal bloom risk is rising. Numerous beachfront communities have seen beach erosion due to climate change; it is anticipated that 67% of the Portuguese coast will experience erosion in the following decades. One of the most exposed places is the Algarve shore. In Algarve, it is also expected that there would be an increase in days with more extreme heat waves, an increase in days with comfortable levels of heat stress (which will concentrate 50% of these days in April, May, and October), and a decrease in days with pleasant levels of heat illness. Additionally, it is predicted that there will be fewer days in the Algarve with comfortable levels of heat stress (April, May, and October will concentrate 50% of these days), more days with more extreme heat waves, and fewer days with cold stress.

The travel demand may be impacted by this, particularly for coastal tourists. This indicates that the Algarve region will be more attractive in the autumn, but tourists may feel threatened by the chance of getting sick. Climate change is predicted to make it easier for infectious diseases to spread throughout spring and autumn, especially West Nile fever, leishmaniosis, and nodular escrow fever, even though the risk for the latter is already high during the summer. Although there is a low chance of the disease spreading, an increase in the number of days favourable to mosquito survival is anticipated in the case of malaria.

## 5.4. Suggestions

Coastal areas have been identified as the most vulnerable to climate change due to cumulative impacts (including temperature change, extreme events and sea-level rise) and high population density. It will be increasingly crucial for coastal tourism destination managers to understand their vulnerability to climatic changes and to devise appropriate adaptations to help destination managers. This work presents some suggestions; the following subsections offer some suggested solutions to the challenges that have been raised in the research project which can be adapted to assist in climate adaptation and mitigation.

Both Kish Island and the Algarve region case study regions have distinct characteristics, necessitating various adaptation and mitigation strategies for the impacts of climate change. Still, in general, it is tried here to propose some valuable suggestions which encompass similarities between these two places as below sub-sections:

### 5.4.1. Continuous Monitoring and Evaluation of Climate

The tourism sector is dependent on ideal climate conditions to prosper. Extreme weather events affect the tourist’s comfort and occurrence of certain activities. For example, helicopter views and satellite monitoring of the coastline erosions are in the case study regions. To this end, continuous monitoring and evaluation of weather conditions and hydrological cycles at the waterfalls are imperative. In addition, there will be a need to continuously inform the tourists and tourism role players on decisions such as what to pack for wearing or activities to undertake or not to embark on a day.

Constantly revising the climate change hydrological calendar is also necessary for informing planning processes. As highlighted earlier, the aviation sector and helicopter rides are particularly vulnerable to extreme weather events, and accurate providing weather is critical in adapting and mitigating the sensitive sector.

The resort needs to be protected by determining a population threshold for the area. This protects it from environmental degradation and mass tourism-associated carbon footprints. If properly managed, a carbon levy for all tourists out from both case study regions can assist the local community in adapting to climate change. Climate change is likely to result in increased water demand directly or indirectly, which might lead to increased water abstraction affecting the underground water resources in the Algarve region and intensifying gas consumption in water-sweetening power plants in Kish Island also leading to a higher level of carbon emission.

For the sector's sustainability, the tourism sector must tackle and reduce carbon emissions by all sectors of the economy. Transparency and accountability by all stakeholders will assist in achieving carbon neutrality.

### 5.4.2. Mitigation and Adaptation

It was discovered that stakeholders in the tourism sector are becoming more concerned and knowledgeable about the causes and effects of climate change. The growing level of awareness and sophistication about climate change among stakeholders, including tourists, tourism sector members, host destination residents, and tourism service providers, reduces obstacles that prevent the tourism sector from combating climate change. Even if awareness and worry about climate change are rising, the key stakeholders only make the barest efforts to combat it. This is a result of, among other things, a need for more understanding, responsibility, and ignorance.

There is a need to improve climate change knowledge across the tourism sector to fill the knowledge gap and equip tourism players with the necessary knowledge to act environmentally responsibly. The United Nations Framework Convention on Climate Change and the

Intergovernmental Panel on Climate Change, in collaboration with local government and other stakeholders, have a central role in climate change mitigation and adaptation.

Impacts of climate change, which typically manifest themselves in the form of temperature increases, sea level rises, and extreme weather events like heat waves and heavy rain, will manifest differently in different parts of the world. Tourism destinations will be impacted differently in this way, reflecting both good and negative consequences.

The specifics of the area (typically considered at a regional or national scale) or of the economic sector will determine how the effects of climate change vary and what repercussions they have. Therefore, various adaptation and mitigation measures must be implemented at multiple levels in this context, and diverse approaches (by region or activity) will be required to meet this challenge.

To increase the success of adaptation policies in these two case study regions, climate change-related information should be provided in a simple and usable manner for the host society. The line ministry must cement climate change education, sector-specific policy, and climate change guidelines. This will assist the sector in mitigating and adapting to climate change. Incentives and grants can be provided to assist the tourism sector, particularly in Kish Island and Algarve region case study region, to build adaptation measures.

Local government can also assist with putting in place laws and regulations on new buildings and structures to ensure that they are energy and water efficient. Restrictions on carbon emissions and taxes can assist in confirming that the aviation sector is transparent and complies with the sector's best practices regarding climate change mitigation. To expand knowledge and action, there is a need to include green tourism as part of the curriculum for tourism studies and to streamline climate change as part of the entire curriculum, as climate change is one of the biggest threats to communities in Iran and Portugal.

## 5.5. Designing Proper Localized Climate Change Assessment Methods

Having proper localised climate change assessment methods is necessary for both case study regions to record the changes and possible vulnerabilities happening in the case study territories. Here it is a suggestion to use a five-step vulnerability assessment methodology for tourism in coastal areas in both cases study regions, which should be localised based on the natural differences among the Kish Island and Algarve region case study regions.

These five steps are mainly including:

I. system analysis.
II. identification of activity and hazard sub-systems.
III. vulnerability assessments for the different sub-systems at risk;
IV. integration for the destination as a whole and scenario analysis and
V. communication.

The framework is illustrated by an example of how it might be applied to Kish Island and the Algarve Region. It is argued that a consistent methodology, like the one proposed, facilitates vulnerability assessments in a range of coastal destinations, allows comparison of vulnerabilities across different situations, provides a basis for more research into specific adaptation measures and assists goals to develop a more sustainable tourism sector.

## 5.6. Contribution to Knowledge

Therefore, this thesis aims to enhance our understanding of the relationship between climate and tourism and the impacts climate change might pose to the sector to facilitate vulnerability assessment and adaptation.

The research made a modest contribution to filling the knowledge gap about the state and level of threat of climate change to Kish island as a coral reef coastal destination in the Persian Gulf and Algarve region as the most critical Mediterranean coastal destination in Portugal, with a shortage of water that threathens the whole region. The research laid bare the weather and hydrological elements that have been altered due to climate change.

The study contributed to understanding the level of climate change and its potential implications for the tourism sector. Most importantly, the research covered the knowledge gap on the temperature changes, which is of the main issues which can increase or decrease the tourist's attraction toward choosing these two destinations during high seasons, especially in the summer. The picture portrayed allowed for an understanding of the flow pattern regime and trends over the past 40 years. It dispelled speculations featured in global media, such wildfires and coastal erosions in Algarve regions and coral reef destructions in Kish Island.

The drivers of climate change in the two case regions were also outlaid. In addition, the research advanced knowledge on the knowledge levels and attitudes of tourists who visit Kish Island and the Algarve region, which are detrimental to addressing or assisting in tackling climate change. The research made a significant contribution in highlighting the two-way linkage between tourism and climate change. As such, significant stakeholders like the tourism sector managers in both case study regions, local communities, and academics can utilize utiliseearch in several ways to their benefit.

## 5.7. Recommendation for Future Research

The research found that the climate in the case study areas is changing. However, what has yet to be discovered is how this will affect flora and fauna in this unique area, as the study had to depend on experts and literature references to published work elsewhere. The observation was that the weather in the area is becoming highly unpredictable, with some models failing to predict what will happen in the future.

The Intergovernmental Panel on Climate Change (IPCC) is the most important source of information in the field of climate change. In 2022 the IPCC published in Sixth Assessment Report (AR6), which encompasses the prior knowledge on the science, impacts and mitigation of climate change and adaptation. Based on the analysis, it is argued that although tourism has received increasing attention compared to previous IPCC reports, many gaps still exist that will need to be incorporated in future publications, especially about regional coverage disparities and the overlooked role of tourism as a driver of climate change. Therefore, further research must determine the exact extent of the challenge to allow the government, community, and other entities to make precise decisions.

Existing literature on weather and tourism highlights the unequal weight of weather variables for beach tourism, but studies on the subject still need to be completed. Moreover, analyses of climate change impacts on the case study regions emphasise the role of increasing temperature in projecting a shift in tourism flows within Europe and Asia in the coming decades.

Based on predicting the possible tourists' responses about the role of different weather parameters for coastal tourism and the potential behavioural responses to future climate change impacts. It is suggested that the function of increasing temperature should be considered crucial for beach recreation. Also, some attention should be given to other impacts, such as the emergence of diseases, water availability and forest fires.

The research has focused on the Algarve region in Portugal and Kish Island in Iran, one in the European continent and the other in the Middle East and Asian continent. As climate change in Iran and Portugal and their variability are a part of global climate change, if it occurs will affect the Tourism sector. In Iran and Portugal, changes and variability of climate elements in all ecological regions are different to some extent and in different areas. In general, the temperature is increasing; the sunshine duration is decreasing typhoon is moving in the South.

The effects of climate change and variability and climatic phenomena on Tourism are different in different ecological regions of Iran and Portugal. For sustainable development in the Tourism sector to cope with each climate change scenario, it will have to change the tourism calendar, and advertisement pattern, for every region (Amiri and Eslamian, 2010). New promotions should attract tourists due to changes happening in natural cycles and practices of the ecological season. In this present work, TCI was used as the primary index. However, a new upgraded climate index should soon be used because the TCI index is an old meteorological index which is monitoring the present scenarios of climate and their impacts on the tourist's comfort and had some shortages in forecasting changing patterns of far future climatic changes.

To establish the strategies mentioned above and tactics, as well as to improve the application of those results in Touristic practices, should be continued research projects on the impact of climate change, extreme climate events, and climate disasters on Tourism and measures to cope with them for every ecological zona in Kish Island in Iran and Algarve region in Portugal. To enhance the capability of meteorological application of climate and forecast and information for end users in the Tourism sector in Iran and Portugal, we have to continue this study: The impact of climate change and variability on Coastal tourism security in Kish Island and Algarve region to find strategies to cope with them. Strengthening capability meteorological networking and monitoring and advisory for Tourism on sustainable development in both regions.

There is a window of opportunity for avoiding the most damaging climate change impacts, but that window is closing: the world has less than a decade to change course. Actions taken or not taken in the years ahead will have a profound bearing on the future course of the Tourism sector and other human activities development. The world needs more financial resources and technological capabilities to act. What is missing is a sense of urgency, human solidarity, and collective interest. This study recommends that further research and development be considered novel methods to explore new Indices and methods and applications to mitigate to overcome climate change policy and reduce the increased risk of climate change effects. Technological affairs, researchers, metrological scientists, and international participants should support this target.

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