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An assessment of the climatic suitability of Namibia for tourism using the Tourism Climate Index (TCI)

A Thesis submitted to the Faculty of Science in fulfilment of the requirements for the degree of Master of Science (MSc)

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DECLARATION

I hereby declare this research is my own, unaided work, except where acknowledged otherwise. This thesis is being submitted to the School of Geography, Archaeology and Environmental Studies at the University of the Witwatersrand for the fulfilment of a MSc degree.

Signed at ______________________________on this day____of __________

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Kirsten Noome

ABSTRACT

The Tourism Climatic Index (TCI) is the most widely used index to quantify climate suitability for tourism. The wealth of this research is concentrated in the Global North. To date, only a handful of studies have been conducted in southern Africa. This study aims to contribute to closing this gap in tourism-climate research in the Global South. This study presents the application of the TCI in Namibia. The region is heavily reliant on the tourism sector, which primarily comprises outdoor activities, for economic income. Namibian nature-based tourism includes game-viewing and wildlife tours, sight-seeing, cultural visits, climbing, hiking, camping, 4x4 trails and quad-biking. Climatic conditions are often conducive to these activities taking place, and tourist satisfaction. The length of season for these activities and the timing of peak tourist arrivals is mainly reliant on favourable climatic conditions. Rising temperatures, changes in relative humidity and precipitation pose real threats to nature-based and adventure tourism in Namibia. The economic reliance of tourism and specific climatic conditions that promote successful tourism in Namibia prompted the use of the TCI. As a result of the latitudinal position of Namibia, the seasonal migration of the Intertropical Convergence Zone (ITCZ), Subtropical High Pressure Zone and southern hemisphere Westerlies influence the climate of the country. The results of the TCI classify Namibia as having ‘good’ to ‘excellent’ climatic conditions for the period 2008–2018. TCI scores for Namibia reveal a bimodal-shoulder and winter peak, meaning the peak climatic conditions are in the austral spring, autumn and winter months. This agrees with the literature regarding peak tourist seasons, which also aligns with school holidays. The spatial and seasonal distribution of climate resources in Namibia derived from the TCI results of this research may greatly assist in positive efforts towards tourism and other economic sectors sensitive to climate.

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LIST OF GENERAL ACRONYMS

BCI: Beach Climate Index

GDP: Gross Domestic Product

GHG: Greenhouse gas

HCI: Holiday Climate Index

IPCC: Intergovernmental Panel on Climate Change

ITCZ: Intertropical Convergence Zone

Masl: Metres above sea level

TCI: Tourist Climate Index

UNWTO: United Nations World Tourism Organisation

USA: United States of America

WTTC: World Travel and Tourism Council

LIST OF SCIENTIFIC ACRONYMS

CA: Average Thermal Comfort

CD: Daytime Thermal Comfort

CIT: Climate Index for Tourism

P: Rainfall

S: Sunshine

W: Wind

CHAPTER 1: INTRODUCTION

1.1. INTRODUCTION

Climate strongly influences the success of the tourism sector in different destinations around the globe (Amelung *et al.,* 2007; Fitchett et *al.,* 2017). Tourist destination selection can involve comparing the climate of multiple locations, the length of stay at a destination and the quality experience of the visitation can be linked to climate (Scott and McBoyle, 2001; Mishev and Mochurova, 2008; Amelung and Moreno, 2012; Grigorieva, 2019). Continued climate-driven degradation and disruption to cultural and natural tourism resources, particularly in developing countries,will have severe impacts on the tourism sector of thoseregions (Tervo-Kankare *et al.,* 2018). The attractiveness of tourists destinations can be influenced by changes to rainfall patterns and increased temperatures, reduced attractiveness in the destination due to climate will have a negative impact on the economic opportunities for local communities in Namibia who rely on natural and cultural tourism as a source of income (Tervo-Kankare *et al.,* 2018). Tourism is salient for economic growth in developing countries, like Namibia, as the foreign investment generated from tourism leads to increased employment and economic income as well as improvements to existing infrastructure (Reid *et al.,* 2007; Scott *et al.,* 2012; Scheyvens and Biddulph, 2018; Noome and Fitchett, 2019).

Namib, in the local Nàmá language, means “an area where there is nothing” (National Geographic, 2013). Due to its dry climate, Namibia has been acknowledged as one of the most vulnerable countries to the impacts of climate change (Keja-Kaereho and Tjizu, 2019). The recognition by ministerial local and regional government of the fragility of the arable land for cultivating agriculture or livestock (particularly with the view of the current climate change outlook) in Namibia and the environmental degradation the country has bared witness to has led to the diversification of income through maximising conservation and tourism, mainly through foreign exchange (Gargallo, 2020). Trophy hunting is one of the most prominent discourses in wildlife tourism and is often closely linked with the Community Based Natural Resource Management (CBNRM) programme, an initiative that involves acclimating the public and private sectors in tourism activities with a strong emphasis on conservation (NASCO, 2009; Christie *et al.,* 2014; Koot, 2015; Gargallo, 2020). Effective collaboration between the public and private sectors in terms of tourism planning for infrastructural development, conservation and investment opportunity creates a positive internal framework in Namibia (NASCO, 2009; Christie *et al.,* 2014).

Globally, tourism is one of the fastest growing sectors and provides a boost for national economic development and local entrepreneurship (Ateljevic and Page, 2017). The social and economic facets of the sector are comprised of several actors including tourists, the government and non-government organisations, the people and activities at the tourism destinations (Scott *et al.,* 2019a). Tourism depends largely on the weather and climate of a region for the types of tourism that can be offered (Aylen *et al.,* 2014). Weather is the short-term changes in the atmosphere at a given time or location and is thought of in terms of temperature, precipitation, cloudiness, visibility or sunshine brightness, wind and (high or low) atmospheric pressure (NASA, 2017). Climate is the long-term average weather over time and space; over a minimum of thirty years (Barry, 1992; New *et al.,* 2006; NASA, 2017). There are a number of controls on climate, these include: latitude, altitude, proximity to land or water, low- and high-pressure cells, wind and air masses, mountain barriers and ocean currents (Bakun *et al.,* 2015; Ragettli *et al.,* 2016). Weather and climate affect tourists' decision-making processes, including the selection of destination and tourist activities (Aylen *et al.,* 2014; Grigorieva, 2019). Climate change is a major threat to the tourism sector as it has the potential to influence both, directly and indirectly, the long-term sustainability and viability of global tourism (Hoogendoorn and Fitchett, 2018a). Therefore, climate change has the potential to alter the popularity of tourism destinations since weather patterns play a key role in tourists' decisions on where and when to travel (Aylen *et al.,* 2014; Wilkins *et al.,* 2018).

The intersection of tourism and climate research has grown within the last two decades, aiming particularly at adaption methods to the consequences these climatic changes will have on the competitive relationships between tourist destinations (Fitchett *et al.,* 2016; Hoogendoorn and Fitchett, 2018a; Pandy, 2018). Tourism and climate change have been argued to have a bilateral relationship since tourism has a robust impact on the environment as well as the climate, through the direct (air travel) and indirect (petrol and electricity) use of CO_2 emissions (Hamilton *et al.,* 2005; Becken and Patterson, 2006). As one of the most pressing issues of the twenty-first century and after decades of unsuccessful climate change negotiations, climate change was outlined in a legally binding agreement by the United Nations Framework Convention on Climate Change (UNFCCC): *L' accord de Paris* (Hopkins and Higham, 2018). The Paris Agreement's framework aims toward mitigation, adaption and financing of greenhouse gases (GHG) reductions (Hopkins and Higham, 2018). This agreement emphasises the urgent need for GHG reductions and brought climate change back into the fore of the public's consciousness (Hopkins and Higham, 2018).

There has been limited research concerning the relationship between changes to the climate and tourism in the past, especially considering the dependence of the tourism sector on climate (Scott and McBoyle, 2001). Within the last two decades, research on the intersection of tourism and climate has grown, aiming particularly at adaption methods to predicted consequences of climatic change as well as the effect these changes will have on the competitive relationships between tourist destinations (Hoogendoorn and Fitchett, 2018b). For progressive development in the tourism sector, understanding the intersection of tourism and climate through investigating the complexity of climatic preferences of tourists is a useful approach (Mieczkowski, 1985; Li *et al.,* 2018a; Noome and Fitchett, 2019). Tourism-climate indices have been used to assess the suitability of the climate for tourism, since climate is a highly influential factor in travel destination satisfaction (Mieczkowski, 1985; Fitchett *et al.,* 2016; Noome and Fitchett, 2019). Currently in Southern Africa there have been only a handful of works that use these tourism-climate indices, the Tourism Climate Index specifically (Fitchett *et al.,* 2017; Noome and Fitchett, 2019). Noome and Fitchett (2019) conducted the TCI in Lesotho which discussed the reliance of certain tourism activities on specific climate conditions, the reliance of Lesotho on snow or snow production for its ski season for example, and how changes to climate in these regions can result in the loss of tourism. The paper also resulted in a critical insight into the issue of data availability, in African countries specifically. This research will use the Tourism Climatic Index (adapted by Perch Nielsen *et al.,* 2010) to evaluate the climatic suitability of Namibia as a tourist travel destination.

1.2. RATIONALE

There is a large gap in the literature for tourism-climate research in the southern hemisphere, particularly in Africa (Hoogendoorn and Fitchett, 2018b). Currently, the Global North dominates the use of the Tourist Climate Index (TCI; Fitchett *et al*., 2017). This research will be the first to apply the TCI in Namibia and will be among a handful of studies to apply the TCI in southern Africa. Climate influences the length of the tourism season and the peak in tourist arrivals to a large degree (Gössling *et al.,* 2018, Noome and Fitchett, 2019). Changes to the climate of a travel destination through rising temperatures, changes to the patterns of relative humidity and precipitation pose real threats to tourist satisfaction at the chosen destination. Effective management planning and adaptive strategies are crucial for protecting the tourism sector (Noome and Fitchett, 2019), especially in Namibia which is largely economically reliant on tourism (Tervo-Kankare *et al.,* 2018). Without effective strategies and management for the threats of climate change on the tourism sector, tourist satisfaction is negatively impacted, and the probability repeat visitation is unlikely (Hoogendoorn and Fitchett, 2016; Pandy and Rogerson, 2018). This study was prompted by the need for high accuracy information regarding the reliability of specific climatic conditions for successful tourism in Namibia (Moreno and Amelung, 2009).

1.3. STUDY AIMS AND OBJECTIVES

The primary aims of this research is to contribute to the existing southern African and international literature on the tourism-climate relationship. Specifically, this research will determine the climatic suitability of Namibia for tourism using an adapted version of Mieczkowski's (1985) Tourism Climate Index (TCI), as adapted by Perch-Nielsen et al. (2010). This has been previously applied to Lesotho and South Africa (Fitchett *et al.,* 2017, Noome and Fitchett, 2019)

This aim will be achieved through three objectives:

1. To calculate the TCI for seven weather stations spread across Namibia, over a 10-year period from 2008-2018.
2. To assess the variability in the TCI for the seven weather stations selected in Namibia.
    a. To determine the annual spatial distribution of the TCI scores
    b. To map the seasonal distribution of the TCI scores
3. To explore how climate variability will influence the TCI scores and the suitability of destinations in Namibia for tourism.

1.4. STRUCTURE OF THESIS

Seven chapters will be presented in this study. Firstly, background and introductions to the research followed by the aims and objectives under *Chapter 1*. Secondly, *Chapter 2* which provides critical review of the literature relating to tourism and climate change, evaluating the key threats to the interrelationship of tourism-climate as well as different scales of the perception of climate change (local and global scale). The section locates the research study area in space and provides the climatic and tourism background of Namibia which is synthesised under C*hapter 3*. The methods of the various stages towards the calculation of the TCI for the research is provided in C*hapter 4.* The results of the TCI are presented in *Chapter 5. Chapter 6* critically analyses the results in *Chapter 5* through discussion referring to literature on climate, tourism and tourism-climate indices to explicate the results. Lastly, *Chapter 7* provides a synopsis of this research.

CHAPTER 2: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter describes the dynamics in the existing literature on global climate change and its relationship with tourism by assessing the impact climate change has on both developing and developed nations tourism. Additionally, the perceptions of people regarding climate change are explored as well as the role these perceptions play in relation to the implementation of adaptation and mitigation strategies against climate change. This chapter will provide a comprehensive review on the literature surrounding climate change globally, in developing regions, southern Africa and finally in Namibia. To fully integrate the literature surrounding climate change and tourism in Namibia, an extensive review of the literature in Namibia is comprised; and discusses the evolution of the tourism landscape in Namibia within the last few decades. Lastly, the chapter explores the various methods of assessing climate suitability for tourism, specifically the Tourism Climate Index (TCI), and the anticipated changes to the Namibian climate.

2.2. VULNERABILITY OF TOURISM TO CLIMATE CHANGE

Climate change is a firm reality in the twenty-first century and is a cause for extreme concern for the global population (Nicholls, 2006). Climate is a significant resource for tourism, specifically outdoor tourism, as it is a climate-dependent sector, relying on key characteristics of climate such as it is a free and renewable resource, however, it cannot be transported or stored (Gómez-Martín, 2005; Amelung *et al.,* 2007). Three facets of climate were defined by de Freitas (2003) as particularly important as a tourism resource: the thermal, physical and aesthetic components. These components actively impact the tourist satisfaction at a destination, where thermal component affects the thermal comfort of tourists; the physical component (which includes precipitation and wind) may limit when tourist activities can occur; and the aesthetic component (which includes sunshine, cloud cover, fog and sky colour) acts with the thermal and physical components to attract tourists to a location (Tang, 2013). These climatic variables act as a “pull” factor to attract tourists to a particular destination (Dann, 1981; Tang, 2013:12). A study by Moreno (2010) was conducted to investigate the perception of tourists’ in the Mediterranean using surveys to determine the factors that attracted the tourists to the region. The study revealed that out of total 14 attributes, 61 per cent of the tourists’ identified climate as the most important attribute to the attractiveness of the region. However, climate is not a constant resource for destinations, this may constrain the distribution of climatic resources as it will vary seasonally and is not homogeneous around the world (Gómez-Martín, 2005).

Climate poses more risks than opportunities to the tourism sector (Thuiller *et al.,* 2006; Friedrich and Stahl, 2019). Although the following statement was made a decade ago; it still bares significance as the tourism sector continues to endure the threats of climate change (Hall *et al.,* 2013:

> “Climate is a key resource for tourism and the sector is highly sensitive to the impacts of climate change and global warming, many elements of which are already being felt …”
>
> [UNTWO and UNEP, 2008: 13]

Vulnerability has become a key term in the discourse of climate change and tourism (Perch-Nielsen *et al.,* 2010; Maher *et al.,* 2011). For the purpose of this study, vulnerability is defined as the extent to which health, economy, nature, and biodiversity are exposed to and impacted by climate change (Martens and Chang, 2017). The physical measures of vulnerability are based on the relationship between the climate and the impact that it has on the surrounding environment (Jedd *et al.*, 2018). The level of vulnerability to climate change by the tourism sector is informed by the Intergovernmental Panel on Climate Change (IPCC, 2014, Tervo-Kankare *et al.,* 2018) in the form of a conceptual equation:

$$\text{Vulnerability} = \frac{\text{Sensitivity x exposure}}{\text{Adaptive capacity}}$$

[Adapted: Jedd *et al.*, 2018]

Unfortunately, as one of the key concepts of climate change impacts, research surrounding vulnerability has not been explicitly explored for the tourism sector (Perch-Nielsen, 2010). Vulnerability has been investigated mostly through its three dimensions: sensitivity, exposure and adaptive capacity (Perch-Nielsen, 2010). Sensitivity of the tourism sector to sustained changes in climate are analysed using statistical methods (mainly interviews) to determine the degree of climatic sensitivity of particular tourism activities (Yu *et al.,* 2009; Perch-Nielsen, 2010). Literature on the exposure within the tourism sector to climate change and sustainability of future climate, especially changes in snow cover, is critical(Amelung *et al.,* 2007; Scott *et al.,* 2004; Perch-Nielsen, 2010; Grillakis *et al.,* 2016). Events such as the Olympic Winter Games and the Paralympic Winter Games, which are the pinnacle of winter sport competition, are particularly vulnerable to changes in climate, specifically rising temperatures impacting the conditions needed for snow production (Rutty *et al.,* 2015; Scott *et al.,* 2019b). Olympic and Paralympic games are one of the world's largest events, having substantial socio-economic (and political) benefits for the host nation (the surrounding region and host city), this often includes a short-term peaked interest in the host nation's tourism sector (Leung *et* *al.,* 2012; Moss *et al.,* 2019). According to Rutty et al. (2015), based on the future effects high-GHG emissions will have on rising temperatures and other climatic changes the cultural heritage symbolised by the Olympic Winter Games and the Paralympic Winter Games will be profoundly affected. This is seen in the increase in average daily maximum temperature from 3.1°C in the Olympic Winter Games and Paralympic Winter Games of 1960s to 1990s to 7.8°C in the twenty-first century between 2002 and 2014 (Rutty *et al.,* 2015).

Conditions for competitors are problematic under the threat of increased temperatures, several competitors from different countries (Canada, Russia, UK and USA) raised concerns about the safety of the conditions for the snow-based events (Scott *et al.,* 2019b). Over several decades, there have been a wide range of adaptation strategies developed to manage the weather risks to the games (Rutty *et al.,* 2015). The high dependency of the Olympic Winter Games and the Paralympic Winter Games on weather conditions have forced organising committees, sporting federations and the International Olympic Committee to develop and refine strategies to reduce the weather risks on the event, including: holding some of the activities indoors, artificial snow-making and investment in advanced weather forecasting (Scott *et al.,* 2018).

Summer outdoor tourism is also affected by the changes to climate as weather conditions influence the tourists' satisfaction with the tourist activities and the destination (Kim *et al.,* 2017). According to the United World Tourism Organisation (UNTWO), climate change will impact the tourist destinations competitiveness and sustainability as changes to the climate of these locations alters the attractiveness of the destinations (UNWTO and UNEP, 2008; Reddy, 2012). Perch-Nielsen (2010) attempted to analyse beach tourism vulnerability to climate change by means of an index. Beach tourism was selected as the appropriate form of tourism for this research as it is a specific type of leisure tourism with climatic preferences that differ between the tourist activities, sunbathing and skiing for example are strongly linked to specific weather conditions (Perch-Nielsen, 2010). Indicators for sensitivity, exposure and adaptive capacity were defined for the relative vulnerability of beach tourism and compared in 51 countries (Perch-Nielsen, 2010). The problems arise with significantly correlating a large number of potential indicators as proxy for variable vulnerability factors and selecting those as the final indicator as there has yet to be determined a tangible element of vulnerability (Adger and Vincent, 2005; Perch-Nielsen, 2010). Thus, Perch-Nielsen (2010) proposed a set of criteria based on a culmination of the literature on vulnerability (Table 2.1.):

Table 2.1: Set of criteria for the selection of indicators (adapted from Perch-Nielsen, 2010).

	Criterion Explanation	**Criterion Explanation**
Validity	Well-founded	Based on a tested theoretical framework
	Accurate	Really measuring what it should
	Non-ambiguous	Agreement on the direction of influence between the indicator and vulnerability
Use	Comprehensible	Relatively easy for users to understand
Type	Relevant	Applicable to many geographic and economic conditions
	Responsive to changes	Can be influenced by action
	High information content	No yes/no indicators, and preferably actual performance data instead of model-based data
Data	Available	Data that is publicly and easily available
	Homogenous and periodical data	Data that is collected homogeneously, making it suitable for international comparisons

By combining the three components of vulnerability with various factors in the tourism sector that are affected either directly or indirectly by climate change, Perch-Nielsen (2010) developed a matrix for the assessing the degree of vulnerability of tourism(Table 2.2.). This matrix identified seven important mechanisms by which climate change may affect the tourism sector (directly or indirectly) including: changes in mean climate, extreme events, sea level rise, biodiversity, water availability, snow, and mitigation measures (Table 2.2; Perch-Nielsen, 2010). Furthermore, the societal and economic relevance of climate change regarding tourism critically depends on the mitigation and adaptation methods specific to different regions, as some regions will be negatively affected by climate change whilst others may thrive under increased temperatures or changes to the rainfall patterns (Table 2.2; Mishev and Mochurova, 2008).

Table 2.2.: Conceptual framework for climate change impacts and tourism vulnerability (adapted from Perch-Nielsen, 2010).

	Mean Climate	**Extreme Events**	**Sea Level Rise**	**Biodiversity**	**Water Availability**	**Snow**	**Mitigation Measures**
Exposure	Change in the suitability of the climate for the different types of tourism at the destination	Change in the frequency and intensity of extreme events which may impact different types of tourism	Rise in sea levels impact tourism at coastal destinations	Changes in the composition of plants and animals and their interaction	Changes in precipitation and evaporation	Change in availability of snow during winter seasons	Policies to reduce GHG emissions
Sensitivity	Dependence on tourism that relies on the current climate	Proximity of tourism resources and infrastructure to extreme events Value of the tourism resources and infrastructure that are at risk The resilience of tourism resources and infrastructure in the face of extreme events	Proximity of tourism resources and infrastructure to the maximum shoreline Value of the tourism resources and infrastructure that are at risk Dependence on coastal tourism	The dependence on current tourism relying on the existing biodiversity Aesthetic value of the new emerging plants and animals	Water consumption of the tourism sector	The dependence of tourism relying on snow Snow making abilities Alternative tourism attractions	Elasticity of current tourism demand Carbon intensity of current tourism activities
Adaptive Capacity	Economic resources available to tourism to adapt Innovation potential of tourism entrepreneurs Technologies available to tourism to adapt Knowledge within the tourism sector on climate change and its potential impacts						

2.2.1. Climatic motivation for tourism destination selection

Climate has been described as having a simultaneous push and pull factor, creating winners and losers under climate change impacts (Scott *et al.,* 2004; Ehmer and Heyman, 2008; Li *et al,* 2018a). Global North research is saturated in terms of the impacts of climate change, whilst the Global South has limited literature concerning the risks and possible adaptive strategies to climate change in the tourism sector (Fitchett *et al.,* 2017). Climate and tourism have a multifaceted and highly complex relationship (Scott and Lemieux, 2010). Climate is one of the macroscale factors influencing the tourism sector (Scott and Lemieux, 2010). Tourism supply (tourism destinations and tourism operators) and demand (tourism arrivals and travel patterns) are considered climate sensitive (Figure 2.1.; Scott and Lemieux, 2010).

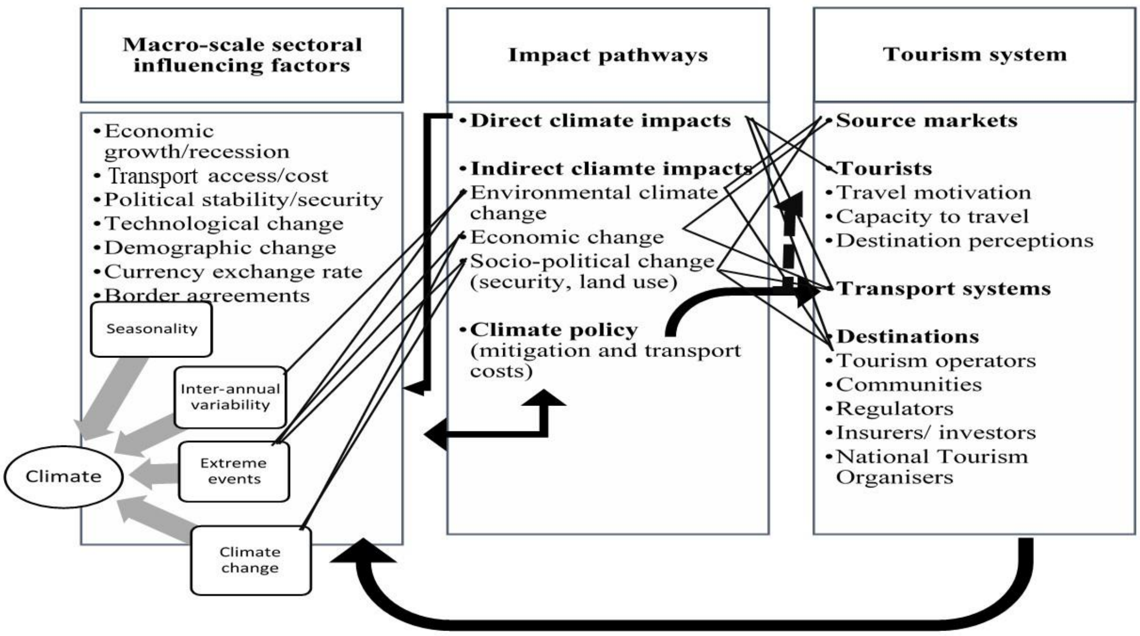


Figure 2.1: Climate is one of the major influences on the tourism sector (After: Scott and Lemieux, 2010).

Research into the relationship between the origin and destination selection of tourists reveals that the climate of the tourist's origin country influences the process of choosing a destination to suit desired climatic requirements that often differ from the 'unfavourable' climate in their home region, therefore affecting the timing of travel, consequently causing a degree of seasonality in tourist arrivals (Amelung *et al.,* 2007; Gössling *et al.,* 2012; Goh 2012; Li *et al.,* 2018a). Therefore, the assessment of the difference between both the climate of the origin and destination of the tourist is important, as are the roles of climate as a push and pull factor (Hamilton *et al*., 2005). Since tourists respond best to conditions based on an integrated weather environment, the appropriate climate elements need to be aggregated in order to measure the influences of integrated climate on tourism for the comparison across tourist origins and destinations (de Freitas et al., 2008; Giddy *et al.,* 2017; Li *et al.,* 2017).

Climate change impacts on tourism destinations through climatic events, including; rising temperatures and sea level, flooding, changes to rainfall patterns, and changes of wind strength and direction; particularly affects the winter and coastal tourism destinations (Scott *et al.,* 2012; Fitchett *et al.,* 2016a; Hoogendoorn *et al.,* 2016; Kovács *et al.,* 2016; Li *et al.,* 2018a). Outdoor tourism, including: winter tourism, sports tourism, coastal tourism, wine tourism, adventure or nature-based tourism, and water tourism, is considered the most impacted sector by climate change (Nicholls, 2006; Scott *et al.,* 2008; Csete *et al.,* 2013; Fitchett *et al.,* 2016a; Jedd *et al.,* 2018). Regional and seasonal shifts in the global tourism sector are projected in the future resulting in both "winners" and "losers" under the threat of climate change (Amelung *et al.,* 2007; Perch-Nielsen *et al.,* 2010: 377). Canada, USA and the New Zealand are the only countries outside Europe on the winning side of climate change for tourism due to their versatile tourism market (Figure 2.2; Scott, 2003; Ehmer and

Heymann, 2008). In Europe, countries that could gain from climate change include; the Benelux and Baltic countries (Figure 2.2; Ehmer and Heymann, 2008). The diverse tourism offerings of France and Italy mean that these regions will be slightly favoured (Figure 2.2; Ehmer and Heymann, 2008). However, the Mediterranean will be particularly impacted by climate change. Issues surrounding water shortages and temperatures that exceed the comfort threshold could deter tourists in the tourism peak season (La Jeunesse *et al.,* 2016). This is particularly true for countries in the eastern Mediterranean (Ehmer and Heymann, 2008). Negative climatic consequences have the potential for serious effects if climate-sensitive tourism has major economic importance, the island states in the South Pacific and the Indian Ocean are particularly reliant on tourism for their economies. This also applies to Malta, Cyprus, Spain, Austria and Greece (Ehmer and Heymann, 2008). In the Caribbean, the Bahamas and Jamaica are disproportionately affected; as well as in Asia and Africa (Figure 2.2; Ehmer and Heymann, 2008; Jeffrey *et al.,* 2017; Hoogendoorn and Fitchett, 2018a).

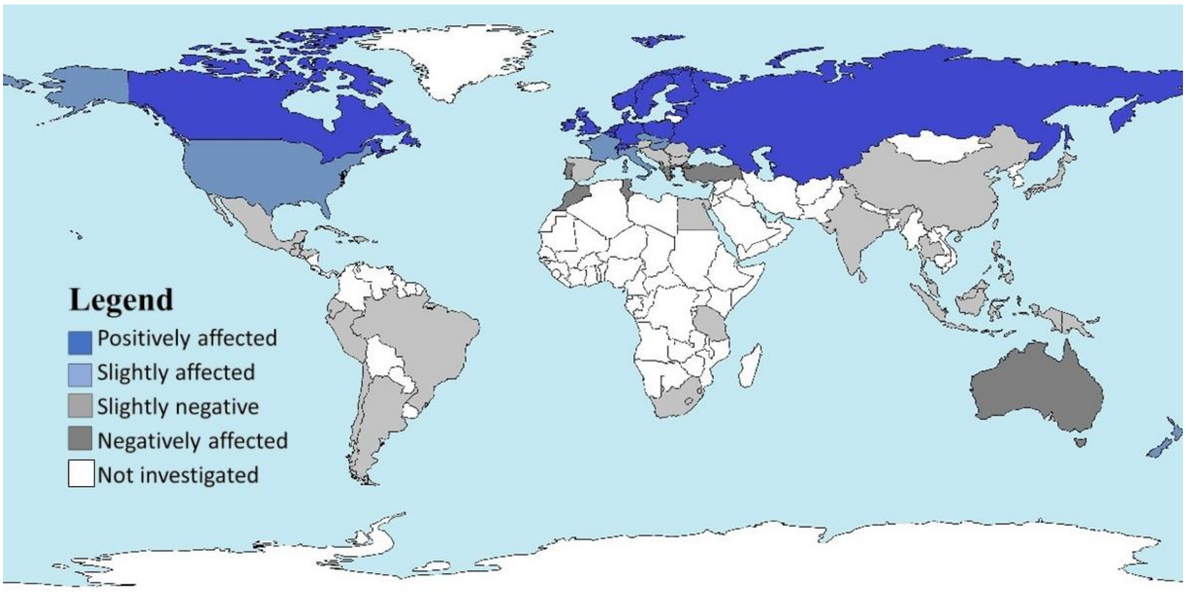


Figure 2.2: Map demonstrating the extent to which climate change influences tourism (after Ehmer and Heymann, 2008).

The choice of the method(s) used to study the relationship between tourism and climate depends largely on the objectives of the study (Peeters and Dubois, 2010). Steiger et al. (2016) suggest that there are four main approaches used to investigate the tourism-climate interface: (1) stated behaviour and preferences; (2) revealed preferences; (3) the recollected or observed on-site past behaviour of tourists; and (4) climate indices. Recently, in all these categories, there has been a fundamental increase in the number of publications (Steiger *et al.,* 2016). Studies surrounding stated preferences are used to derive the perceived ideal, acceptable or unacceptable weather thresholds of tourists (Li *et al.,* 2018a). Stated behaviour and preferences of tourists are conducted through interviews or surveys by which the impact of hypothetical situations on tourist behaviour can be assessed and tested (Steiger *et al.,* 2016). Lohmann and Kaim (1999) were some of the first researchers to note that there was a deficiency of empirical evidence regarding the importance of weather and climate in the decision-making process of tourist destination selection. This relationship between climate and tourism was the subject of their study using a representative survey of German tourists to determine the importance of a destination's characteristics (Lohmann and Kaim, 1999).

Weather was found to be ranked third; the first being the landscape and aesthetic value of the destination (Lohmann and Kaim, 1999). The survey revealed that although weather is highlighted as a relatively important factor for choosing a travel destination, tourists would choose a destination with unfavourable weather according to the popularity of the tourism destination (Lohmann and Kaim, 1999; Zhang and Wang, 2013). Other qualitative impact studies of climate change on tourism have been carried out all around the world, including: the Mediterranean (Nicholls and Hoozemann, 1996; Perry, 2006; Amelung *et al.,* 2007; Bigano *et al.,* 2008; Drius *et al.,* 2019), the Caribbean (Gable, 1997; Moghal and O'Connell, 2018), in

Canada (Rutty and Scott, 2016) and more. These studies tend to vary in their focus and techniques. Surveys with both the tourist and tourist sector operators are the most common method of analysis (Hamilton *et al.,* 2005).

Deficiencies in snow cover have been a focal point of stated behaviour and preferences in recent studies determining potential impacts climate change may cause on the spatial redistribution of winter season demand (Dawson *et al.,* 2013; Rutty *et al.,* 2015). Rutty et al. (2015) conducted an in-situ survey for skiers in Ontario, Canada to determine whether tourists would change their participation patterns in the region if their preferred ski resort was closed due to insufficient snow cover. The study focused on the current behavioural responses of the participants rather than solely hypothetical situations (Rutty *et al.,* 2015). The results indicate that novice and infrequent skiers and skiers that have children are more likely to lessen their participation in the tourist activity compared to experienced skiers that would engage in spatial substitution (Rutty *et al.,* 2015). The summer season in mountainous regions may have a positive result under climate change (Steiger *et al.,* 2016). Pröbstl-Haider et al. (2015) investigate the effect climate change will have on the summer season in the Alps using a two-step survey to explore the effect additional days of sunshine will have on visitation. The findings of the study reveal that the likelihood of destination substitution due to additional sunshine days is low at present. For beach tourism, additional sunshine days may have a negative effect on the tourism of the Mediterranean (Rutty and Scott, 2010).

The literature discussing climate change and tourism demand in the Mediterranean (Agnew and Viner, 2001; Perry, 2006; Amelung and Viner, 2006; Amelung *et al.,* 2007; Moreno, 2010b) stresses that climate change will very likely push temperatures in the region past the threshold of human comfort by mid-century in the summer season. Perry (2006) and Amelung and Viner (2006) supplemented their stated preferences and behaviour arguments using analysis using a tourism-climate index developed by Mieczkowski (1985) known as the Tourism Climate Index (TCI; Pham *et al.,* 2010). Scott et al. (2008) argue that increasing maximum summer temperatures will not align with optimal temperatures for beach holidays and that there will be a notable reduction in summer tourism.

On the contrary, Rutty and Scott (2010) argue that warmer temperatures will not necessarily equate to altered tourist perceptions of the Mediterranean as a tourism destination. They conducted a survey on the perceptions of what conditions are considered “too hot” at beach or urban destinations for comfortable tourism and tourism activities in five countries: Austria, Germany, the Netherlands, Sweden, and Switzerland (Rutty and Scott, 2010: 268). An important question, suggested in the study which relates to the decision-making process when selecting a destination, is to what the degree media has on influencing holiday plans and perceptions of tourists (Rutty and Scott, 2010). It is argued that solely based on stated temperature preferences, temperatures are not projected to become equally and unacceptably hot across the Mediterranean as there are multiple other climatic parameters that must be considered, including: wind and precipitation (Rutty and Scott, 2010). Importantly, Rutty and Scott (2013) call attention to the understanding between the interaction of climate preferences and the age or socio-demographics (such as travelling with children) of tourists which remains insufficiently understood.

Tourist weather preferences can be investigated using statistical relationships between the demand (visitation) and the climatic variables of the region (Steiger *et al.,* 2016). The overall impact of climate on tourism demand can be revealed as well as adaptation of tourists identified (Steiger *et al.,* 2016). Known relationships between climate and tourism assist in modelling the potential temporal and regional distribution of tourist flows (Steiger *et al.,* 2016). With identified relationships, potential changes to the temporal and regional distribution of tourist flows can be modelled (Steiger *et al.,* 2016). Applications of that approach have been conducted for destinations on a global (Hamilton *et al.,* 2005), regional (Hamilton and Tol, 2007; Falk, 2010; Falk, 2014) and local scale (Li *et al.,* 2018a); they are also useful for specific tourist attractions including national parks (Scott *et al.,* 2007), golf courses (Scott and Jones, 2006) as well as ski regions (Falk, 2015). Statistical-based models can be viewed as an expression whereby tourist behaviour is a function of weather, climate and other factors (including; travel costs), in other words the interaction between travel choice and climate is seen as determinist (Gössling *et al.,* 2006).

An example of a statistical approach would be the panel data technique. Bigano et al. (2005) used this approach to explore the impact of temperature and precipitation, based on monthly tourism data, on domestic tourism demand in Italy. The results show that with the exception of winter sports regions, temperature and precipitation have a significant effect on seasonal tourism demand. Temperature, in particular, was identified as the strongest factor influencing domestic tourism demand in Italy. Li et al. (2017) also used a dynamic panel data technique to study the tourist demand of 19 major cities in Hong Kong, China. The panel data model is used to provide information on individual behaviour across time and is useful for assessing not only the effects destination climate and home climate have on tourism demand but also the influence differences between home and destination climates have on tourism demand (Li *et al.,* 2018a). This enriches the tourism demand literature hand how it is influenced by climate (Li *et al.,* 2018a). The results of the study reveal that home climate, destination climate and the difference between home and the destination climate all significantly influence tourism demand (Li *et al.,* 2018a).

Research has shown that American tourists require unique experiences when travelling, in terms of their tourist activities and destination choice (Kim *et al.,* 2007; Giddy *et al.,* 2017). Giddy et al. (2017) contributed to the South African research significantly by examining the experience of American tourists with weather in South Africa. The study conducted a survey of American tourist experiences with the South African climate on a day-to-day basis (Giddy *et al.,* 2017). The responses that indicated negative climatic conditions were correlated with meteorological data, clustered with their origin to test of the subjectivity of the climatic perceptions (Giddy *et al.,* 2017). The responses revealed that climatic conditions were not a significant attraction for visitation to South Africa for some tourists, but that for others the perceived climatic conditions did not match the experienced conditions of excessive heat which is argued to be a possible result of their country of origin, nevertheless, the weather conditions prevented some of the tourists from engaging in desired activities (Giddy *et al.,* 2017). As a country that relies heavily on outdoor tourism this is highly problematic as it can have a negative economic impact in the future with South Africa expected to have rising temperatures due to climate change (Giddy *et al.,* 2017).

Observed 'real' behaviour of tourists in the tourism environment (for example on the beach) provides an indication of the limits of acceptance or tolerance towards weather conditions (Moreno and Amelung, 2009; de Freitas, 2015; Steiger *et al.,* 2016). De Freitas (2015) conducted a study located on the coast of Queensland, Australia, that included on-site observations of the atmospheric variables and beach-user behaviour during daylight hours over a period of 45 days within 12 months. Through the observations on-site adaptations of tourists, including sitting in the shade and use of clothes, can be derived (de Freitas, 2015; Steiger *et al.,* 2016). Recollected experiences with weather conditions provide prepared behavioural adaptations (Gössling *et al.,* 2016). Temperature is cited as the dominant weather parameter by tourists, with rain, storms, humidity, sunshine hours and air pollution seen as neglected parameters (de Freitas, 1990; Gössling and Hall, 2006; Scott *et al.,* 2008; Aylen *et al.,* 2014). The results of the study are indicative that behaviour is a reliable gauge for changes in weather conditions, for example the use of shade or clothing by the tourists best represent changes to thermal comfort (de Freitas, 2015). Therefore, in the absence of ideal conditions tourists can alter their personal microclimate to an acceptable degree, the behavioural adjustments serve to reduce the individual's sensitivity to on-site atmospheric conditions, with the stated preference remaining the same (Rutty and Scott, 2010; de Freitas, 2015; Steiger *et al.,* 2016).

To capture the complexity of the thermal aspect of climate, a number of numerical indices have been developed to allow comparisons of suitability between different destinations for different tourism activities (Gössling and Hall, 2006). Climate indices were developed to assess the climatic suitability of a location for tourism (Mieczkowski, 1985; Morgan *et al.,* 2000; Scott and McBoyle, 2001; Amelung *et al.,* 2007; de Freitas *et al.,* 2008; Scott *et al.,* 2016). The original expert-based index, known as the Tourism Climate Index (TCI), was first developed by Mieczkowski (1985) and was used to assess potential changes in climatic attractiveness due to climate change on a global level. To correct some of the limitations of the TCI, other indices were developed since 1985 including the Beach Climate Index (BCI), Climate Index for Tourism (CIT), Holiday Climate Index (HCI), Modified Tourism Climate Index (MTCI) and the Universal Thermal Climate Index (UTCI) (Steiger *et al.,* 2016). One limitation is that is common in almost all tourism-climate databases used for modelling is that they do not differentiate between business tourists, leisure tourists, or travelling to visit friends and relatives on holiday (Gössling and Hall, 2006). Each of these groups have substantially different travel behaviours and elasticities of demand (Gössling and Hall, 2006).

Other limitations of models for the role of weather information in decision making is the importance of non-climatic parameters such as political instability or risk perceptions (for example, risk of food poisoning, diseases); and the role unpredictable events such as terrorism or natural disasters can have on destination selection (Kim *et al.,* 2007; Scott *et al.,* 2012, Osland *et al.,* 2017; Yeung and Yee, 2019). Therefore, using a combined strategy of climate variable measurements and stated weather perceptions based on structured interviews, Mansfeld et al. (2003) assessed the biometeorological comfort of tourists in Eilat, Israel. The results show that differences in wind velocity and cloudiness had a significant influence on the tourists' comfort perception and that moderate temperatures of 20–24°C was viewed as negative. Mansfeld et al. (2003) remarks that perceptions on seasonality may change this perception, and that perceptions might be very different under summer conditions, whereby wind velocity and cloudiness might be perceived as positive. Furthermore, the study revealed that domestic tourists were more sensitive to weather conditions than international tourists, this highlights the importance of other aspects, such as tourist origin for travel destination choices (Mansfeld *et al.,* 2003).

Similarly, a case study in Zanzibar provides more evidence for the complexity of climate perceptions. Gössling et al. (2006) conducted an in-situ study based on interviews with leisure tourists. Tourists were asked to rate the importance of 'climate' for their travel decision on a Likert scale from 1 (very important) to 5 (not important at all; Gössling *et al.,* 2006). More than half of the tourists rated climate 1 or 2, which corresponded to 'very important' and 'important', respectively. A notable find was that approximately 30% of the interviewed group said that climate would be 'not very important or not important at all' for their travel decisions. Tourists were also asked whether changing weather patterns would have an influence on tourism in Zanzibar, the answers indicated a high degree of variation, reflecting heterogeneous understandings and perceptions of different weather parameter (Gössling e*t al.,* 2006).

A more recent study used a mixed-methods and qualitative and quantitative analysis for studying the relationship between tourism and climate. The study was built on the works of Fitchett et al. (2016a) analysed the rising sea levels and the potential impacts this could have on beach tourism destinations, including economic losses from flooding, and expands on the study range of beach tourism in the Eastern Cape Province of South Africa (Fitchett *et al.,* 2016a; Pandy and Rogerson, 2020). Climate change may have several impacts on beach tourism but sea level rise (SLR) is becoming a more serious risk factor for coastal destinations as this will be coupled with more extreme weather conditions (Friedrich and Stahl, 2019). SLR is predicted to cause inundation of approximately 50% of beaches along the coast of South Africa, as well as the effects of increased intensity of extreme events such as droughts (Friedrich and Stahl, 2019). SLR may affect the "touristic" value of destinations along the coastline of South Africa, especially second-home tourism along the coastline of South Africa (Friedrich and Stahl, 2019: 167), through shore protective action reducing the attractiveness of a location, erosion and inundation of the beaches as well as flood damage (Hoogendoorn and Fitchett, 2018a). The infrastructure (and maintenance of the infrastructure) against flooding is also costly and requires maintenance (Hall, 2018). Hoogendoorn et al. (2016)

discuss the urgent need for adaptation strategies for beach tourism in South Africa. Friedrich and Stahl (2019) contribute to this area of research through in-situ survey data along the coastline of South Africa that explores the pattern of tourist behaviour in relation to climate in order to identify and predict potential behavioural changes to combat changes to the climatic conditions on beaches or coastal settings. This was used in relation to precipitation and temperature for the Representative Concentration Pathway scenarios (RCP 4.5 and RCP 8.5) and SLR hazard-activity pairs to provide information and understanding of these factors in vulnerability assessment for beach tourism in South Africa (Kilungu *et al.,* 2019). The results show that there were significant correlations between tourists' perceptions of climate importance and the climate zone of their origin (Friedrich and Stahl , 2019; Friedrich *et al.,* 2020). The study supplemented the TCI from the work of Fitchett et al. (2017) with these perceptions to validate the TCI classification of the study sites as suitable or non-suitable for tourism.

This is similar to the work done by Fitchett and Hoogendoorn (2019) whereby the climatic sensitivity of tourists is compared to the TCI scores of various locations throughout South Africa. The study found that there was an inverse relationship between climatic mentions in the TripAdvisor reviews and the climatic suitability of a location for tourism based on the TCI scores of Fitchett et al. (2017) for the same destinations. Under the RCP4.5 and RCP8.5 scenarios, it was found that maximum temperature rise is not significant for a negative effect on beach tourism in South Africa, this correlates to the research of Fitchett et al. (2017) where TCI scores increased over recent years. From this it can be deduced that beach visitor preference is flexible to the point where there is an 'ideal' temperature range (27°C to 32°C) but can tolerate (warmer) temperatures outside their preferred beach weather (Rutty and

Scott, 2015; Friedrich and Stahl, 2019). Research into this regard is important for accurate forecasting of future changes in the seasonal variation of tourism, policy makers would find this useful for tourism marketing, planning and investment potential (Hoogendoorn *et al.,* 2016; Zhang and Kulendran, 2017).

2.2.2. Tourism seasonality

Various factors have been highlighted that play a role in the seasonality of tourists such as religious or pilgrimage travel, availability of leisure time, school, university and employee holidays, festival events, social pressures and more (Amelung *et al.,* 2007; Petrevska, 2015; Rogerson, 2017). Seasonal tourism demand and the selection processes for a destination are also shown to be highly dependent on climatic variables (Li *et al.,* 2018a). The relevance and urgency of improving the understanding between the relationship of tourism seasonality and climate change has only recently been explored in the literature (Amelung *et al.,* 2007; Goh, 2012; Becken, 2013). Hadwen et al. (2011) conducted a study which found that over multiple climate zones, climate is a major driver of seasonal tourism, which provides a more general understanding of the role climate plays in tourism seasonality. The study conducted an analysis on the visitation pattern across six climate zones of eastern Australia to determine the degree to which climatic variables (including: mean monthly rainfall and maximum and minimum temperature) influenced visitation patterns in order to understand how the relationship between climate and tourism could be used to assist the tourism operators in predicting various future tourism scenarios (Hadwen *et al.,* 2011). The findings reveal that climate is a principal driving force behind seasonal patterns of visitation for equatorial, tropical, grassland, desert and temperate zones, while seasonality in alpine and sub-alpine regions was driven by a more complex factors of natural and institutional settings (Hadwen *et al.,* 2011). Therefore, climate variability has a significant impact on the seasonality of the tourism demand (Jones and Scott, 2006; Amelung *et al.,* 2007; Li *et al.,* 2018a).

Tourism seasonality has various advantages, most prominently opportunities for economic income, but there are a considerable amount of negative feedbacks caused by excess seasonality (Amelung *et al.,* 2007). An overflow in tourist seasonality, from an economic perspective, holds the potential to negatively affect the profit margin of a region if the region does not have the infrastructure or tools to cope with the amount of tourist flow (Gössling, *et al*., 2012; Fang and Yin, 2015; Nasabpour *et al.,* 2017). From an environmental perspective, an excessive peak season generates a higher concentration of visitors which can place considerable pressure on the local environment; affecting traffic congestion, trash disposal, the local water supply, among other disadvantages to the local community services or infrastructure (Saenz-de-Miera *et al.,* 2012; Giddy, 2013; Petrevska, 2015; Giddy, 2017). Therefore, researchers' and policy makers' attention need to be placed on the reduction of tourism seasonality to a manageable market (Amelung *et al.,* 2007). Presently, aside from climate change research, there has been a substantial movement in policymaking and marketing devoted towards the key factors that contribute to excessive seasonality (Rosselló and Sansó, 2017; Rashid, 2020). The timing and length of school holidays is an exemplar factor that has been considered for institutional alteration (Amelung *et al.,* 2007).

Forward-thinking tourism stakeholders have in the meanwhile focused on diversification of their tourism market, extending their market in to previously 'shoulder' or off-peak periods (Kim *et al.,* 2007). Some strategies towards this aim are to market to new segments, including; senior citizens, business tourism through increased conferences or events, special-interest tourist and pricing strategies (Amelung *et al.,* 2007). Alterations to the competitive relationships between destinations on the other hand, must be well-planned and managed or it may affect the profitability of tourism on a global scale (UNTWO, 2009; Reddy, 2012). Switzerland, for example, is heavily reliant on tourism for its economy, as are many other alpine regions (Elsasser and Bürki, 2002).

Winter tourism is often the prime source of income in regions like the Alps (Elsasser and Bürki, 2002). Snow-reliability is a key element for successful snow and winter tourism for these destinations (Elsasser and Bürki, 2002). Thus, financial viability for this type of tourism depends on snow conditions (Elsasser and Bürki, 2002). However, winter tourism is projected to be one of the most severely affected tourism sectors by climate change through increasing temperatures risking good snow conditions as skiing and other winter sports require a minimum temperature of approximately -7°C, which may not be viable under projected temperature increases (Perch-Nielsen *et al.,* 2010; Demiroglu *et al.,* 2018).

2.3. ADAPTATION STRATEGIES FOR CLIMATE CHANGE IN THE GLOBAL CONTEXT

Climate risks are not synonymous with climate catastrophes. The prevention of anticipated future environmental catastrophes due to climate risks is the discourse that must set in motion action towards mitigation and adaptation (Beck, 2010). With the perspective that mitigation is the anticipation of climatic changes before they occur and the adaption to these changes are acclimatised through cultural, psychological and physical dimensions (Hulme *et al.,* 2009; Osberghaus, 2017).Presently, many developing countries do not perceive climate change as a priority (Mertz *et al.,* 2009; Hoogendoorn and Fitchett, 2018b; Friedrich and Stahl, 2019). Heightened vulnerability and a lower adaptive capacity due to differing socio-economic stressors in developing countries like South Africa, compared to developed countries, mean that lower income countries, particularly in the Global South, have adaptation requirements that differ to developed countries in the Global North (Mertz *et al.,* 2009; Hoogendoorn and Fitchett, 2018b).

In the short-term, other socio-economic stressors, including poverty, economic growth, housing and service provision, are considered to require more immediate attention and level of importance in developing countries than action towards sustainable adaptation against climate change (Mertz *et al.,* 2009; Gössling *et al.,* 2012, Gössling *et al.,* 2016; Fitchett *et al.,* 2016a; Fitchett *et al.,* 2017). As developing countries become more "westernised", radical and unequal consequences of climate change and resource consumption are forced to be not a localised issue but rather one that requires a global effort (Beck, 2010). Thus, increasing pressure has been put on international stakeholders to review their roles in offering governmental support to countries that require dire support in action towards the effects of climate change (Reid *et al.,* 2008; Beck, 2010).

Adaptation is an important pillar for action against climate change, the IPCC Assessment Reports point out that adaptation and mitigation have complementary roles in the formation and implementation of climate change policy (Mimura *et al.,* 2015). However, the competing challenges in developing countries for economic and social development, particularly on the African continent, may setback adaptive capacity or strategies—especially in the landscape of tourism (Mimura *et al.,* 2015; Hoogendoorn and Fitchett, 2016; Pandy and Rogerson, 2020). Socially just adaptation to climate change through the facilitation and implementation of these strategies, require a deeper consideration of the factors that impeded progress (Shackleton *et al.,* 2015; Nursey-Bray*,* 2017).

Understanding vulnerability to climate change can be determined by examining the exposure, physical setting and sensitivity of a region (Hoogendoorn and Fitchett, 2016). Particularly vulnerable to climate change are the regions in the Global South (Moreno and Becken, 2009; Hoogendoorn and Fitchett, 2016). These regions have a comparatively lower adaptive capacity than the Global North due to a lack of capital intensity and the expense of technological innovation (Hoogendoorn and Fitchett, 2016). Developing countries are further affected by climate change due to the heavy reliance of the economic sectors and resources in these regions on a specific climate, including agriculture and tourism (Hoogendoorn and Fitchett, 2016). Therefore, careful economic analysis of effects climate change will have on environmental systems must be addressed (Figure 2.3; Reid, 2007). The system for evaluating a natural resource can be divided into the *use-value* and *non-use value*, whereby the first refers to direct contact with the natural resource and the second refers to the option value or existence value of the resource (Reid, 2007). These values are further divided into *consumptive* and *non-consumptive* values. The first refers to the direct use of a resource such as trophy hunting tourism and the latter refers to non-directly affecting a resource much like wildlife tours or sight-seeing tourism (Reid, 2007).

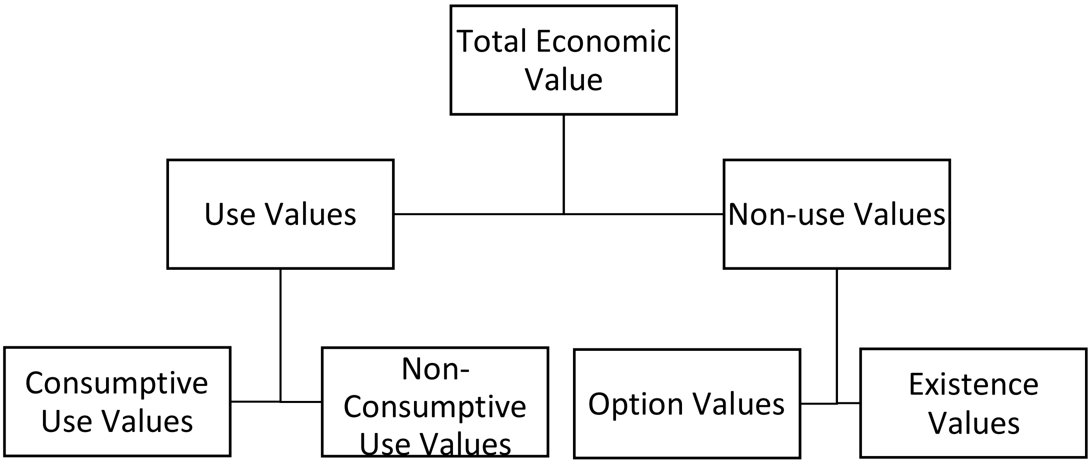


Figure 2.3: Process of placing economic value on natural resources (from Reid, 2007).

Furthermore, due to the heightened vulnerability and low resources and adaptive capacity, developing countries require different adaptation methods than those of the global North (Hoogendoorn and Fitchett, 2016). In the literature, scholars have increasingly aimed to identify barriers to adaptation frameworks (Shackleton *et al.,* 2015). Despite this progress, the literature that explores the barriers to adaptation in developing countries (particularly Africa) has remained scarce (Shackleton *et al.,* 2015; Hoogendoorn and Fitchett, 2016). A focus should be made on the causes underlying vulnerability and low adaptive capacity, specifically in the global South (Shackleton *et al.,* 2015; Hoogendoorn and Fitchett, 2016).

The fifth Assessment Report (AR5) of the IPCC in 2013/2014 concluded that climate change is "unequivocal", with human activity being the dominant cause (Scott *et al.,* 2015:8). However, current engagement with climate change from different agencies may not be necessarily conducive to the extensive interests of tourism sustainability (Scott, 2011). The avoidance or mitigation of climate change will involve immediate action toward sustained and substantial reductions of harmful emissions by 2050 and by 2100 the net emissions should be brought to zero (Allen *et al.,* 2016; Mearns, 2016). The IPCC (2018) report, which is built on the ideas of strengthening the global response to the threats of climate change through sustainable development and poverty eradication strategies in the IPCC Fifth Assessment Report (AR5), states that sustainable mitigative and adaptative actions towards limiting global climate change are under way but need to accelerate if the goal of limiting global warming to 1.5°C instead of 2°C is to be achieved. Therefore, a warming greater than 1.5°C is not unavoidable, the chance of whether it will occur depends on future policy and adaptive strategy action towards the reduction of emission rates (IPCC, 2018).

This potential future scenario—even with only a 0.5°C reduction in global warming— will provide both people and the natural environment and ecosystems more time to adapt and remain below relevant risk thresholds. For example, a global warming at 1.5°C decreases the likelihood of an Arctic Ocean free of sea ice during the summer season in this century; instead of the disappearance of sea ice in the Arctic once a decade under a global warming of 2°C, and a predicted decline of 70-90% of coral reefs compared to the virtual extinction (<99%) of coral reefs in the 2°C scenario (IPCC, 2018). With the many uncertainties associated with predictive modelling of the future climate, given the inherent and irreducible uncertainties in climate prediction and the multiple non-climatic factors influencing adaptation decisions, it can be argued that "climate prediction should not be the central tool to guide adaptation to climate change" (Dessai *et al.,* 2009: 72; Spear *et al.,* 2018). Approaches to dealing with uncertain climate projections typically involve the reframing of the problems to incorporate the decision thresholds and sensitivities (Singh *et al.,* 2018). Although the goal of climate prediction is to capture the most plausible climatic future for adaptative purposes, it is suggested that decision makers assess the performance of the potential adaptation strategies over a wide range of plausible futures (Dessai *et al.,* 2009; Daron, 2015). Rapid and global changes are needed in energy, industry, buildings, transport, land and cities to reach 'net zero' around 2050 (IPCC, 2018). Thus, the feasibility of not exceeding 1.5°C depends largely on the enabling conditions of geophysical, environmental, ecological, technological, socio-economic, socio-cultural, and institutional dimensions (Allen *et al.,* 2016).

Efforts to deny climate change – specifically human-caused climate change – persists presently in society; often cresting when domestic or international action are aimed at reducing GHG emissions (Dunlop and Brulle, 2015; McCright *et al.,* 2016). Organised climate change denial reached its peak in 2009 when the United Nations Framework Convention on Climate Change set its agenda towards international action on reducing GHG emissions (Dunlop and Brulle, 2015). Formulation of adaptation and mitigation strategies are impacted by these denialist parties (Eriksen *et al.,* 2015; Atzori and Fyall, 2018). Adaptation in this research is defined as:

> "… those actions or activities that people undertake, individually or collectively, to accommodate, cope with, or benefit from, the effects of climate change, including changes in climate variability and extremes"
>
> [Becken and Hay, 2007:225]

What is considered as 'adaptive' is almost always political and contested; what is seen as a positive adaptation strategy to one group will be viewed as mal-adaptive to another (Eriksen *et al.,* 2015). Unfortunately, popular political organisations often align with a policy or strategy that fits their agenda, regardless of whether it is the best fit for the situation (Eriksen *et al.,* 2015). Thus, conversations surrounding the political nature of framing adaptation are an important discourse in order to assess changing vulnerability patterns (Moreno and Becken, 2009; Jedd *et al.,* 2018). Research regarding the capacity of tourism operators and their adaption to potential impacts of climate change are unequally distributed across the globe as most of the literature is conducted in the Global North (Scott *et al.,* 2012; Fitchett *et al.,* 2016a). Tourism has been identified as an important contributor, through the emissions of GHGs, to climate change; but it is also highlighted that the sector has a high-risk potential expected in the future of the global climate (Becken, 2004; UNTWO and UNEP, 2008; Mearns, 2016).

Tourism contributes significantly to the acceleration of climate change through increase CO_2 emissions from tourists using air travelling to move to and from destinations (Scott *et al.,* 2015). Globally, tourism is estimated to directly contribute to 5% of the energy related CO2 emissions (UNTWO and UNEP, 2008). There is an emerging type of adapted tourism known as “last chance” tourism that is the result of climate change (Lemelin *et al.,* 2010:477). Last chance tourism niche relates to the perceived suffering, tragedy or inevitable death of an attraction by tourists which prompts the tourists to visit these destinations before the phenomenon, location or the activity offered at the destination is “lost” to climate change (Scott *et al.,* 2012; Zerva, 2018:240). Ironically, this type of tourism increases the GHG emissions that leads to climate change acceleration that causes the damage or disappearance of these social, cultural, heritage, natural, environmental or other types of tourism (Lemelin *et al.,* 2010). A prime example of this is an increase in tourist arrivals in winter tourism around the polar regions, most common in the literature are areas surrounding the Arctic such as regions to the north including Norway, the Russian Federation, Sweden, Denmark, and Finland; but Canada and the US as well (Chen and Chen, 2016).

The increase in tourism of these regions has had significant economic benefits, however, it also significantly contributed to GHG emissions (Lemelin *et al.,* 2010). The role of increasing polar tourism under the premise of last chance tourism in the transitions of climatic, environmental, socio-economic and political states requires more integrated research as the majority of the research has been done in isolation (Hall and Saarinen, 2010; Chen and Chen, 2016; Stewart *et al.,* 2017). The impact of increasing tourism in this region due to its often-remote location means that there will be an increase in the number of flights; causing more GHG emissions, and the need for infrastructural change (better quality roads, accommodation; Hall and Saarinen, 2010). Thus, a better understanding of these key issues will assist policymakers as this type of tourism is an integral part of climate and environmental change adaptation and mitigation strategies (Hall and Saarinen, 2010).

Based on the observations and data comparisons of climatic conditions at different tourist destinations over time, the use of interviews to understand the different concerns of the stakeholders, tourists and the tourism sectors is a useful component to find a comprehensive plan to preserve and protecting the tourism sector under climate change (Demiroglu *et al.,* 2018). The majority of economic costs garnered by climate change are termed the "cost of inaction" and are important as it informs on the policies and adaptation methods effectiveness in the areas of concern and helps to identify these key areas (Mishev and Mochurova, 2008:19). The economic impacts of climate change on tourism are analysed in the current literature on a global and regional scale (Mishev and Mochurova, 2008; Dubois *et al.,* 2016). Bigano et al. (2006) analysed the effects development and climate change have on the international tourist flow. This simulated statistical model investigates the reactions to climate change through tourist behaviour, scrutinising their changes in domestic and international numbers and expenditure decisions (Bigano *et al.,* 2006).

According to this model, countries that market winter tourism will see an increase in domestic tourism; whilst countries marketed as summer tourism destinations will see a reduction (Bigano *et al.,* 2006; Mishev and Mochurova, 2008). Beach tourism faces threats from rising sea levels, increased temperature causing unpleasant thermal conditions for tourists, changes to the timing and amount of precipitation, and increases to the strength of the wind (Fitchett *et al.,* 2016b). Ski tourism in many regions is most likely to be negatively impacted by climate change through increasing temperatures, as the sector is highly reliant on specific climatic conditions, leading to increased tourism under the last chance tourism perception (Scott *et al.,* 2012; Mearns, 2016; Demiroglu *et al.,* 2018). Projected increases in surface and atmospheric temperatures as well as changes to precipitation patterns are a cause for concern as it affects the formation of snow and snow reserves (Campos Rodrigues *et al.,* 2018). Thus, ski tourism is caught in the middle of climate change; it both causes increased energy use and GHG emissions due to tourists travelling to the remote locations of popular ski resorts but is also vulnerable to the effects climate change have on the snow tourism sector (Campos Rodrigues *et al.,* 2018; Demiroglu *et al.,* 2018). Climate change models have been devised to predict the potential effects climate change will have on snow tourism under different scenarios; these models predict the glacial and perennial snow disappearances as well as what changes could be expected in the snow tourism season (Campos Rodrigues *et al.,* 2018).

To predict future weather conditions, statistical analysis and snowfall measurements are used for studying the rate of change to snow cover in various regions; this is useful for weather forecasting and adaptation purposes (Li *et al.,* 2018b). However, it has been noted that some tourist responses indicate that they are conscious of their influence on the environment and contribution to climate change but as it does not immediately affect them they are not under pressure to change their behaviour or travel choices (Scott *et al.,* 2012). Thus, it is imperative that behavioural changes (by the tourists) and structural and technological advancement or innovation (by the tourism operators) commence over the coming decades to reduce not only the contribution by tourists to rising GHG levels but the entire functioning of the tourism sector (Mearns, 2016; Bunakov *et al.*, 2018).

2.4. PERCEPTIONS OF CLIMATE CHANGE GLOBALLY

Climate change in the Public perception differ between nations and fluctuate over time (Capstick *et al.,* 2015). Despite the broad consensus in the scientific community that climate change is a real threat, there is continued disagreements amongst the policy makers and the perceptions of the public (Hall *et al.,* 2015; Visschers, 2018). It has been established that the perceptions of anthropogenic climate change are partly shaped by worldviews and ideologies (Luís *et al.,* 2018; Hornsey *et al.,* 2018). Responses to climate change by individuals, societies, politics and organisations are often contingent on the perceptions of the public towards consequences and their causes in the context of climate change (O'Connor *et al.,* 1999; Capstick *et al.,* 2015; Luís *et al.,* 2018; Thatcher *et al.,* 2018). The opinion or perception of the public on the wider implications of climate change are formed based on a variety of factors including; the personal experience encountered with climate change or extreme weather events; and the perceived psychological distance of climate change impacts relates to the action taken (Clayton *et al.,* 2015).

Age, gender, education, nationality, situational influences or psychological distance (for example, living in a developed versus a developing country), and political ideology are argued to affect the perception and therefore behaviour and action towards climate change (O'Connor *et al.,* 1999; Clayton *et al.,* 2015; Weber, 2016; Thatcher *et al.,* 2018; Hornsey *et al.,* 2018). Research has highlighted perception as a main cause for a lack of action in climate change adaptive strategies (Scott *et al.,* 2012; Pyhälä *et al.,* 2016). Within the last two decades, the role of mindfulness and perception regarding climate change adaptation has largely been absent (Wamsler and Brink, 2018). This relatively new avenue of research regarding the "inner dimensions" of human beings and mindfulness towards the climate and environment aim at exploring their role in opening new pathways for action towards sustainability (Wamsler and Brink, 2018:56).

Given that the solutions to climate change are in some way or other involved or controlled by governmental agencies it has been reasonably argued that people with a high sense of individualism or low sense of egalitarianism are often those who reject the science that claims humans are causing climate changes (Hornsey *et al.,* 2018). Hornsey et al. (2018) argue that climate scepticism and similar ideologies were stronger and more consistent in the United States than any of the other twenty-four countries in their study. This may reflect a facet of beliefs distinct to the US rather than a shared international phenomenon (Hornsey *et al.,* 2018). However, globalisation changes how the repercussions of climate change on the sustainability of many societies are addressed (Wamsler and Brink, 2018; Hornsey *et al.,* 2018). Thus, many researchers argue that climate change cannot be solved solely with new technology or policies, but rather a broader "cultural" shift is required (Wamsler and Brink, 2018:55).

2.4.1. Tourism and climate change perceptions

Climate "dice" has become a term to describe the uncharacteristic climatic phenomenon in regions around the world (Hansen *et al.,* 2012: 2415). The way in which climate change is perceived influences the individual's response towards climate change (Pyhälä *et al.,* 2016). The literature revealed that the perceptions of tourists on the temperature, rainfall, humidity, sunshine and wind of a location shaped their perception of the destination and was a significant factor in deciding whether the location was suitable for vacation, as well as what time of year would be most beneficial considering the climate of the destination (Scott *et al.,* 2008; Spence *et al.,* 2012; Smith and Leiserowit, 2012; Taylor *et al.,* 2014; Fitchett *et al.,* 2017). The perception of the travel destination relies on the expected physical (climatic) conditions imagined by the tourist experienced at the destination for tourist satisfaction (Spence *et al.,* 2012; Jopp *et al.,* 2015; Stockigt *et al.,* 2018). Kaján and Saarinen (2013) argue that the existing research on tourism and climate change is uneven both geographically and across the different segments of tourism. Existing literature in the global North holds the largest collection of the perception towards climate change and tourism research and is largely based on winter tourism and coastal tourism (Pandy and Rogerson, 2018).

In Germany there is a perception in the skiing regions that scientific facts are not consistent, this is due to mass media incorrectly reporting scientific facts (Hoy *et al.,* 2011). Hopkins and Maclean (2014) found that in five main skiing areas in Scotland, decision-makers and tourism operators are not taking immediate adaptive action towards climate change as they are waiting for more conclusive knowledge before strategising. Research into the perception of climate change risk in the Maldives by Shakeela and Becken (2015) reveal that there is no immediate concern by the stakeholders and the adaptation measures are inadequate for projected future climate risks. Some of these views are reflected in the global South (Pandy and Rogerson, 2018). Tervo-Kankare et al. (2018), for example, determined the perceptions of business entrepreneurs in rural Namibia on climate adaptation. Even though the majority of entrepreneurs were aware of the potential climate change impacts on its tourism sector, less than half of the respondents though that climate change would affect their own businesses. Mushawemhuka et al. (2018) conducted a survey to investigate the perceptions of nature tourism operators and the adaptation methods used to mitigate or cope with climate change in the Hwange National Park, Zimbabwe. The operators are highly aware of the climate change effects in the region and have (both "consciously" and "unconsciously") introduced a number of short-term and long-term adaptation strategies (Mushawemhuka *et al.,* 2018:122).

Understanding these perceptions is of high importance due to the impact tourism has on the economic and social development of a region (Atzori *et al.*, 2018). Using the perceptions of both the tourist and tourist destination on climate change is important for facilitating effective adaptative actions to certain tourism sectors that are reliant on specific climatic conditions (Stockigt *et al.,* 2018). Analysing the public's perception towards climate change and the risks associated with climate change are vital for the reduction of GHG emissions as citizens are an integral part of the decision making and implementation process for policy mandates and adaptation measures in this regard (Capstick *et al.,* 2015).

Present adaptive and mitigative action are vital in determining the extent to which climate change will impact various tourism economies in the future (Giddy *et al.,* 2017; Atzori *et al.*, 2018). However, if the adaptation strategies do not align with tourists' priorities the tourism sector may experience loss in visitation, identifying the positive and negative climate factors that influence tourist satisfaction on a short-term scale contribute to the improvement of the baseline from which successful tourism adaptation strategies are implemented for an improved tourist experience in the long-term (Spence *et al.,* 2012; Scott *et al.,* 2012; Stockigt *et al.,* 2018). Therefore, it is imperative that the message of the causes and impacts of climate change (both at present and in the future) instils a sense of responsibility into all facets of society to change unsustainable behaviour and take action against climate change (Lorenzoni and Pidgeon, 2006).

2.5. TOURISM AND CLIMATE CHANGE IN AFRICA

Global climate change is a significant risk to the success of African tourism (Hoogendoorn and Fitchett, 2016). Ironically, developing countries contribute the least to climate change in comparison to developed economies, and yet are some of the most vulnerable to the effects of climate change (Reid, 2007). Common impacts of changes are in the precipitation patterns and increased global pollution, seal level rise and rising temperatures are shared between developing and developed countries and climate change (Hoogendoorn and Fitchett, 2018a). Developing countries cannot cope with climate change responses as efficiently as developed countries due to a lack of sufficient capital, technology and necessities considered more important than sustainable adaption to climate change, such as efforts towards poverty reduction, economic growth, and service provision (Hoogendoorn and Fitchett, 2018a). In 2001 the Third Assessment Report of the IPCC with regards to climate change highlighted Africa as one of the most vulnerable regions due to the region's general low adaptive capacity

(Wilhelm, 2013). Possible impacts expected for Africa are changes to water resource availability and reliability, food security resulting from changes to precipitation and insulation, changes to the length of the growing season, carbon uptake, increased incidences of extreme weather events, flood risk, desertification, prevalence and distribution of diseases and pests (IPCC, 2001). Based on crop modelling, it is estimated that yield reductions in dry lands across Africa may leave millions of people at risk of food insecurity by the 2080 (IPCC, 2001).

Tourism in Africa is a key source of economic income, which is in jeopardy under current climate change scenarios (Rogerson, 2004; Reid, 2007). Increased average surface temperatures perpetuated by rising greenhouse gas emissions are currently the focal point of climate change research, as rising temperatures impact tourism both directly and indirectly (Table 2.3; Spence *et al.,* 2012; Hoogendoorn and Fitchett, 2016; Demiroglu *et al.,* 2018). For instance, tourism is directly impacted by sustained increases in temperature causing thermal discomfort for tourists, when temperatures exceed their comfort levels it could dissuade future visitations—although the degree of discomfort may vary depending on the tourists' place of origin (de Freitas *et al.,* 2008; Li *et al.,* 2017). Fortunately, there is a growth in the literature regarding climate change impacting different parts of Africa (Table 2.3; Hoogendoorn and Fitchett, 2018a). This is particularly important in order to gain an understanding of the potential impacts climate change can have on the tourism sector; this is essential for assessing the adaptive capacity of different types of tourism (Amelung and Moreno, 2009; Hoogendoorn and Fitchett, 2016).

Within the last decade, there has been a large addition of literature on climate change and tourism literature in Africa, though not to the same level as the literature of the northern hemisphere (Table 2.3 Hoogendoorn and Fitchett, 2016; 2018a; Fitchett *et al.,* 2017). The majority of these studies have been conducted in Egypt (Shaaban and Ramzy, 2010); Namibia (Reid *et al.,* 2007); Tanzania (Muganda *et al.,* 2013); Kenya (Sindiga, 2018); Botswana (Hambira *et al.,* 2013); Lesotho (Preston-Whyte and Watson, 2005; Stockigt *et al.,* 2018); and South Africa—which hosts the largest collection of literature within Africa regarding climate change and tourism (Steyn, 2012; Steyn and Spencer, 2012; Fitchett *et al.,* 2016a; Hoogendoorn *et al.,* 2016; Hoogendoorn and Fitchett, 2018a).

Table 2.3: Abridgement of the climate change and tourism literature in Africa (adapted from Hoogendoorn and Fitchett, 2018a).

Author	Year	Country	Climate change threats	Methods
Becker	1998	South Africa	Rising temperatures	Beach comfort index
Parish and Funnell	1999	Morocco	Improved tourism from increased temperatures	Literature review
Agrawala et al.	2004	Egypt	Sea level rise	Digital elevation model sea level rise projections
Hamilton et al.	2005	Global	Increasing temperatures	Tourist arrival and departure modelling
Preston-Whyte and Watson	2005	South Africa Lesotho Zimbabwe Zambia Botswana Swaziland	Theoretical: temperature increases, altered precipitation	Theoretical discussion of threats to nature-based Tourism
Gössling et al.	2006	Tanzania	Increased precipitation, increased humidity, more frequent storms	Interviews with tourists
Ahmed and Hefny	2007	Egypt	Theoretical: degradation of coral reefs, sea level rise	Theoretical discussion of potential threats
Amelung et al.	2007	Global	Rising temperatures and altered precipitation and humidity	Calculating and mapping of global TCI scores

Author	Year	Country	Climate change threats	Methods
Reid et al.	2007	Namibia	Increasing temperatures, altered precipitation, detrimental effects to nature-based tourism	Round table discussion
Awuor et al.	2008	Kenya	Theoretical: flooding and sea level rise	Theoretical discussion of potential threats on the basis off past disasters
Snoussi et al.	2008	Morrocco	Flooding and sea level rise	Digital elevation model sea level rise projections
Shaaban and Ramzy	2010	Egypt	Rising temperatures inducing greater seasonal differences, coastal degradation	Interviews with Egyptian policy-makers and tourism managers
Agnew and Viner	2011	South Africa Kenya Tanzania	Theoretical: flooding, drought, land degradation, wildlife redistribution	Theoretical discussion of potential threats
Marshall et al.	2011	Egypt	Tourist perceptions of poor climate	Interviews with tourists and tourism operators
Reddy	2012	South Africa	Increasing temperatures, altered precipitation patterns	Interviews with stakeholders in nature-based tourism
Steyn	2012	South Africa	Theoretical: increased temperatures, aridification, loss of fynbos species, changes in wind speed, increased ocean temperatures	Theoretical discussion
Steyn and Spencer	2012	South Africa	Theoretical: temperature changes, altered precipitationpatterns, shifts in seasonality, increased occurrence of floods	Theoretical discussion

Author	Year	Country	Climate change threats	Methods
Hambira et al.	2013	Botswana	Increased temperatures, altered precipitation patterns, degradation of vegetation	In depth interviews with tourism operators
Saarinen et al.	2013	Botswana	Degradation of natural resources	Interviews with tourism operators
Sagoe-Addy and Addo	2013	Ghana	Sea level rise	Modelled sea level rise, interviews with tourism operators
Mbaiwa and Mmopelwa	2014	Botswana	Changing flooding patterns	Interviews with tour operators and lodge managers
Moswete and Dube	2014	Botswana	Theoretical impacts of climate change to nature-based Tourism	Theoretical discussion
Sajjad et al.	2014	Sub-Saharan Africa	Pollution	Multivariate regression analysis
Dillimono and Dickinson	2015	Nigeria	Rising temperatures, changes in precipitation patterns, Pollution	In depth interviews with tourists
Grant	2015	South Africa	Increasing temperatures, altered precipitation patterns,changing humidity, sea level rise, storm surges	TCI, digital elevation model sea level rise projections, interviews with tourists and tourism operators

Author	Year	Country	Climate change threats	Methods
Hambira and Saarinen	2015	Botswana	Changing water levels in dams, erratic rainfall, changing seasonality	In depth interviews with policy-makers
Fitchett et al.	2016	South Africa	Rising temperatures, changes in precipitation patterns, sea level rise	TCI, digital elevation model sea level rise projections
Fitchett et al.	2016	South Africa	Flooding related to tropical cyclones	Economic assessment of costs of flooding to tourism establishments
Hoogendoorn et al.	2016	South Africa	Increasing temperatures, sea level rise, increased storm Incidence	Interviews with tourists and tourism operators
Köberl et al.	2016	Tunisia	Increasing temperatures, altered precipitation	Sensitivity analysis and linear regression
Rogerson	2016	South Africa	Degradation of environmental resources, increase in vector borne diseases	Analysis of public statements, theoretical discussion
Amusan and Olutola	2017	South Africa	Pollution	Green theory
Pandy	2017	Southern Africa	Increasing temperatures, rainfall variability	Theoretical discussion

Author	Year	Country	Climate change threats	Methods
Serdeczny et al	2017	Sub-Saharan Africa	Sea level rise, aridity, temperature and rainfall changes, rural livelihood degradation	CMIP5, climate modelling
Sifilo, P. and Henama	2017	Africa	Pollution, droughts and flooding, theoretical impacts of climate change to various economies	Analysis of public statements, theoretical discussion
Hoogendoorn and Fitchett	2018	South Africa	Seal level rise, storm surges	TCI, DEMs, interviews
Pandy and Rogerson	2018	South Africa	Storms (hail and lightning), floods, drought	Interviews
Stockigt et al.	2018	Lesotho	Climatic sensitivity and snow-based tourism	TripAdvisor reviews and interviews
Fitchett and Hoogendoorn	2019	South Africa	Tourist sensitivity to climate change	TripAdvisor reviews, TCI data
Dube and Nhamo	2019	Zimbabwe	Increasing temperatures, rainfall variability	Survey, meteorological and hydrography data
Noome and Fitchett	2019	Lesotho	Snow tourism	TCI
Friedrich et al.	2020	South Africa	Tourist perceptions of climate and weather	Interviews

Sub-Saharan Africa is a rapidly emerging developing region (Dasgupta, 2018). Currently this region hosts thirteen percent of the world's total population, and it is estimated that three-quarters of the expected increase in population will be from sub-Saharan African which is estimated to be approximately 4 billion people by 2100 (Dasgupta, 2018). The sub-Saharan regions are considered some of the most vulnerable regions to climate change with expected temperature increases between 2 – 4°C (Hulme *et al.,* 2001; Schellnhuber *et al.,* 2016). This region has a wide range of outdoor tourism activities, including: ecosystem hiking trails (Hoogendoorn and Fitchett, 2016), beach or coastal tourism that includes fishing, water sports or leisure beach activities (Fitchett *et al.,* 2016), and adventure tourism (Giddy, 2018; Giddy and Webb, 2018; McKay, 2018). Adventure tourism is one of the fastest growing segments in the international sector (Rogerson, 2007). Typically, within the tourism sector in Africa, adventure tourism literature is underdeveloped (Rogerson 2004; McKay, 2013).

Within the Sub-Saharan context, there is a wealth of opportunities for countries to develop and profit from adventure tourism (Rogerson, 2007; Giddy, 2013). Adventure tourism is often confused with nature or eco-tourism, the separating difference between these types of tourism is that adventure-based tourism poses a level of risk to the tourist (Giddy, 2018; McKay, 2018). The level of risk depends on whether it is a hard or soft adventure activity, hard adventure tourism would include: river rafting, skiing, snowboarding, kayaking, bungee jumping, mountaineering, ice climbing, scuba or sky diving, horse-back riding, and surfing, while a family activity such as a game drive is considered a soft adventure tourism activity (McKay, 2018). Specific environments and climatic conditions are often required for adventure tourism as it enhances the value of the experience (Giddy, 2017; Hoogendoorn and Fitchett, 2018a). Climate influences the availability of tourist attractions and activities, the seasonality of the type of tourism, and the tourist selection process for a destination (Hoogendoorn and Fitchett, 2018a). The vast majority of the adventure tourism research focuses on the impacts tourists and adventure activities have on the environment (Hall, 2001; Lucrezi *et al.,* 2013; Giddy and Webb, 2018), including vegetation loss due to hiking and horseback riding and game viewing (Buckley, 2004); the destruction of coral reefs from diving operations (Doiron and Weissenberger, 2014); and the impact travelling to the often remote locations have on the environment through carbon emissions that contribute to climate change (Buckley, 2010).

Literature on the motivation for tourists to seek out adventure experiences have risen in recent years (Giddy, 2017). A large section of this research revolves around the influences on motivation for participation in adventure activities such as 'risk' and 'thrill' (Buckley, 2012; Buckley, 2015). Dann (1977) first introduced the factors of 'push' and 'pull' into tourism motivation, this approach looks at both the internal and external factors specific to tourism that attract tourists to these experiences and destinations (Buckley, 2012; Giddy and Webb, 2016). Push factors speak to the physiological research whereby individuals in highly urbanised environments seek out experiences in natural environments, while the pull factor provides an understanding into the draw of a particular environment to a specific destination (Mackenzie, 2011; Buckley, 2012; Giddy and Webb, 2018). However, identifying as an 'adventurer' has become questionable with the present commercially "manufactured" adventure activities (Giddy and Rogerson, 2018: 48). The views commercial adventure tourists hold about the environment compared to 'true' adventurists can have undesirable implications on the natural environments in which these activities take place as well as potentially negative impacts on the sustainability of the environment-dependent adventure tourism sector (Lucrezi *et al.,* 2013; Giddy, 2017; Giddy and Webb, 2018).

Therefore, a re-evaluation of the adventure tourism sector is required in the context of the new commercialisation of 'manufactured' adventure experiences. Giddy (2017) explored environmental attitudes and adventure tourism motivations which resulted in the knowledge that some adventure tourists appear to be less focused on the activity itself rather that a unique way to experience nature and escape everyday life was provided. Giddy and Webb (2018) analysed the motivation of adventure tourists for travel. The research used a fixed-response questionnaire based on existing literature on tourism travel motivation (Giddy and Webb, 2018). It was revealed that environmental aspects were the most important factor in drawing adventure tourism participants towards that specific destination and were correlated to overall satisfaction (Giddy and Webb, 2018). Conservation is crucial for the survival of the adventure tourism sector (Buckley, 2011; Steyn *et al.,* 2012). The significance of the natural environment in the experiences, demonstrated in the study's results, calls for an increased effort from the government, tourism operators, and the tourists towards mitigative action and sustainable practises to ensure the natural environment does not degrade due to adventure tourism operations (Giddy and Webb, 2018).

2.6. GROWING CLIMATE CHANGE AND TOURISM RESEARCH IN NAMIBIA

The tourism sector has grown, and is continuing to grow, in Namibia over the last few decades (Hoogendoorn and Fitchett, 2018a). Approximately 40% of the nature-based pursuits, including scenery and wildlife which are considered the main attractions (Barnes *et al.,* 2012).

Barnes et al. (2009) estimated that wildlife contributed almost half of the value of nature-based tourism using data from the Social Impact Assessment and Policy Analysis Corporation (2007) tourism survey. Nature-based tourism is approximately 80% non-consumptive, meaning that it is based in commercial or state land, lodges or camp accommodation, while the other 20% is made up of consumptive tourism and is dominated by trophy hunting—mostly on commercial lands but sometimes on commercial lands as well (Barnes *et al.,* 2012). Marine shore angling makes up a small percentage of the consumptive tourism (Barnes *et al.,* 2012). Tourism in Namibia is not reliant on the scarce and erratic rainfall of the region, the natural beauty is inherent in that natural landscape (Midgely *et al.,* 2005; Jokisch, 2009).

The Namibian government highlights the role of sustaining the growth of tourism for national development through investment and promotion strategies (MET, 2016; Government of the Republic of Namibia, 2015). These strategies present a valuable opportunity for local tourism growth through regional and international tour operators, it will create a broad awareness of the tourism offered in Namibia (MET, 2016). Various national documents, including: Vision 2030 developed in 2004, National Sustainable Tourism Growth and Development Strategy developed in 2016, and the National Development Plan 5 (NDP5), describe the future plans regarding the Namibian tourism sector (Green and Sheyapo, 2018). The NDP5 is the 5th National Development Plan in a seven-series strategy to implement achievable objectives for the long-term vision (Vision 2030) of Namibia (Green and Sheyapo, 2018). Growth in the tourism sector in Namibia is essential for the economy (Reid *et al.,* 2007). Currently, Namibia is facing an unemployment rate of around 34% (World Bank, 2019). One of the goals for the NDP5 is for tourism to create job opportunities for Namibian citizens; making the achievement of this goal important for significant economic development in the country

(Green and Sheyapo, 2018). Diversification of tourism activities is one step further for achieving the goal set by the NDP5 to attract more than 1.8 million visitors by 2022 (Republic of Namibia, 2017). Expanding the tourism market through creating awareness, marketing and promotion of Namibian tourist activities will ensure the sustainability of the sector (Republic of Namibia, 2017). One avenue the NDP5 considers is actively incorporating a cultural aspect into its tourism sector (MET, 2016). This new tourism niche of "creative tourism, ethical tourism and life-seeing tourism" are a distinctive way in which Namibia can diversify its tourism offering (Green and Sheyapo, 2018:183). Richards and Raymond (2000:19) coined the term "creative tourism". Creative tourism is described as:

> "tourism which offers visitors the opportunity to develop their creative potential through active participation in courses and learning experiences which are characteristic of the holiday destination where they are undertaken"
>
> [Richards and Raymond, 2000:19]

Ivanovic (2008:91) contributed to the 'creative tourism' definition by describing this type of tourism as "learning indigenous skills distinct of the destination visited and developing individual creativity while on holiday".

Furthermore, the NDP5 strategises to facilitate investment in infrastructure for improving growth in the tourism sector (Green and Sheyapo, 2018). A review of the evidence of anthropogenic climate change and its relation to Namibia reveals that much of the existing works are based on older generation climate change scenarios, dating from the early 2000s that correlates with the Third IPCC (Barnes *et al.,* 2012). For the more recent research, using the Fourth IPCC, key references are made to Midgley et al. (2005) and Turpie et al. (2010).

Midgley et al. (2005) used the Fourth IPCC scenarios in the context of Namibia for the development and analysis of land use enterprise models, such as a mechanistic modelling approach known as the dynamic global vegetation model (DGVM) to explore impacts of change on ecosystem structure and function.

No previous quantification assessment for risks of climate change to plant biodiversity had been undertaken for Namibia before this assessment by Midgley et al. (2005). As global and regional climate model projections for Namibia reveal that the region will become increasingly hotter leading to drier conditions over the course of the century and is expected to have devastating environmental consequences (Thuiller et al., 2006; Turpie et al., 2010; Engelbrecht and Engelbrecht, 2016). Rohdes et al. (2019) present historical vegetation and climate change empirical evidence for the hyper-arid Namib Desert and the arid Pro-Namib. The study used re-photographed landscape photography that matched the archival base of the late 19th century. The findings revealed an increasing trend in vegetation cover as a result of increased precipitation (in the form of fog and rain) along the coastal Fogbelt and inland Savanna (Rohdes *et al.,* 2019). The analysis concurs with the projected global warming effects on the Benguela upwelling system, however it diverts from the regional climate model predictions of increased aridification (Bakun *et al.,* 2015). Despite lacking long-term climate data, similar to that of this current research study, the research offers an important contribution to evidence-based knowledge of the relationship future climate change scenarios has with past climate trends.

Given the dire projections for warming and drying out in central and western regions in southern Africa, this topic needs urgent research to make informed action plans to remedy or mitigate this effect (Midgley *et al.,* 2005). The difficultly for tourism research with climate change is to link ecosystem integrity and tourism potential, current research indicates that climate warming and aridification may negatively influence the lucrative tourism that ecotourism offers in Namibia (Midgley *et al.,* 2005). A financial analysis was conducted to measure the profitability for investors or incentive to engage in this sector (Barnes *et al.,* 2012). This analysis measured the value these activities added to the national income, in other words the direct net change in gross national income. However, no account was taken of the indirect value associated with these activities nor the indirect use value (ecosystem service values) or non-use values (including, option and existence values; Barnes *et al.,* 2012).

Namibia has limited research regarding the climate change impacts affecting the profitability of the tourism sector. In a 1992 world-wide survey of tour operators, the visitor satisfaction of Namibian tourism was assessed (Weaver and Elliott, 1996). Another survey by Weaver and Elliot (1996) revealed that the visitors considered natural scenery and national parks were given an 'excellent' rating (receiving ratings of 98 and 91 per cent, respectively). Hospitality and personal safety followed with rating scores between 89 and 78 per cent. The lower ratings were given to infrastructure, including the accommodation establishments, with ratings of 64 per cent and services such as car rental received 62 per cent (Weaver and Elliott, 1996). From the score ratings it can be deduced that the provision of ecotourism opportunities had lagged behind the quality of the provided for the attractions (Weaver and Elliott, 1996).

Spatial patterns of the Namibian tourism sector and of tourist activity is another strategy used to understand how successful the tourism operation is in Namibia (Weaver and Elliott, 1996). By examining the distribution of accommodations and attractions, purposes of visit, and the limited amount of information on participation in specific activities and visits to particular attractions an understanding of the drives for tourism can be deduced. It is only in the study's discussion section that climate is referred to as a driver for tourism. The authors describe how the warm, dry and sunny climate of Namibia are assets for visitors and how the absence of a well-defined rainy season, except in the far north of the country , is suited for a year-round tourist season, in contrast to other African countries, such as Zambia (Weaver and Elliott, 1996). This study did not explicitly look at a type of tourism offered by the Namibian tourism sector, rather it provided an account of the infrastructure available for tourism. For specific tourist activity research a number of outputs centre around trophy hunting (Humavindu and Barnes, 2003). Trophy hunting involves guided visits for tourists that participate in quality game hunting with the aim to retain trophies from the game animals (Humavindu and Barnes, 2003). The revenue that results from trophy hunting is relatively high and is considered not only economically significant but also acts as an incentive for conservation (Humavindu and Barnes, 2003).

To test the profitability of trophy hunting for the GDP in Namibia, Humavindu and Barnes (2003) multiplied the number of hunting permits issued in 2000 by the permit price. To measure the actual direct expenditure of the trophy hunters and the daily rates, the average prices were multiplied by the number of trophies or total days hunted (Humavindu and Barnes, 2003). However, compared to Namibia's neighbouring countries, Botswana and South Africa, the economic significance of trophy hunting is diminished (Humavindu and Barnes, 2003). The trophy hunting market contribution to the GDP in South Africa was (at the time the research was published) 38 times more than the contribution of trophy hunting to the GDP in Namibia (Humavindu and Barnes, 2003).

According to the IPCC (2014), the mean surface temperature over southern Africa will likely exceed the global mean increase (Tervo-Kankare *et al.,* 2018). The projected global mean warming is 3.4 - 4.2 °C, which is expected to significantly affect semi-arid and arid regions of Namibia, causing a decrease in precipitation (Engelbrecht and Engelbrecht, 2016; Tervo-Kankare *et al.,* 2018). These changes are expected to have profound impacts on the natural resources and their utilisation (Reid *et al.,* 2007; Lendelvo *et al.,* 2018). The changes in climatic patterns will have an effect on the spatial distribution of agro-ecological zones, habitats, distribution of plant diseases and pests, and fish populations (Tervo-Kankare *et al.,* 2018). There is a concern for growth of the tourism sector in Namibia, in the light of changing climate (Midgely *et al.,* 2005; Reid *et al.,* 2008). There is very limited research-based knowledge available about the adaptive capacity of the Namibian tourism sector to respond to these predicted climatic changes (Spear *et al.,* 2018). Tervo-Kankare et al. (2018) carried out a study in Uis, Namibia, an old tin mining community situated next to the Brandberg, the highest mountain in the country. This work is similar to climate change studies elsewhere in southern Africa, including South Africa (Fitchett *et al.,* 2016a; Fitchett *et al.,* 2016b) and Botswana (Hambira *et al.,* 2013). Interviews were used to understand the perception of environmental change and tourism. The interviews were semi-structured research and all tourism-related businesses in the town were approached and asked to participate in the study, 9 out of the 10 approached businesses participated. The survey form included both open-ended and closed questions. Two-thirds of the business interviewed had main customers that were international tourists, the tourists arrived either by self-drive car or package tours. For wildlife management operators, the customers mostly consisted of local Namibian citizens. Majority of the participants demonstrated knowledge (through observations) of environmental changes occurring in Namibia (Saarinen, 2010; Tervo-Kankare *et al.,* 2018).

Namibia by nature and geography is a desert country, where lower level of precipitation may easily lead to drought and have severe implications. Therefore, the observational changes were mostly related to climate or weather conditions that include the presence or absence of rain (Tervo-Kankare *et al.,* 2018). The potential implications of drought are well-understood, maybe because of earlier experiences by those interviewed (Tervo-Kankare *et al.,* 2018).

However, few participants agreed that climate change would make the destination less attractive. This contradiction between the ideas of climate change impacting tourism in Namibia while not reducing the attractiveness of tourism products in the region reflects the "does not concern me directly" attitude of climate change (Tervo-Kankare *et al.,* 2018:279). This research provided insight into ongoing policy and decision-making in the tourism and other related sectors most likely to be on the vulnerable side of climate change and aims for future policy and decision-making to be thoroughly informed through growth in this research area.

2.7. THE TOURISM CLIMATE INDEX

Tourism-climate studies with a view to identify the climatic parameters that are most critical for tourism comfort and satisfaction levels are important for understanding the impact climate change will have on the attractiveness of geographical locations for tourism under a modified future climate (Mieczkowski, 1985; de Freitas *et al.,* 2008; Moreno and Amelung, 2009; Rutty and Scott, 2015; Dubois *et al.,* 2016; Georgopoulou *et al.,* 2019). Among these studies have been numerous empirical studies within the field of climatology with reference to tourism (Hewer *et al.,* 2017). These studies have been used in a wide range of locations including beach tourism (Morgan *et al.,* 2000; Moreno, 2010a; Martínez-Ibarra, 2011; Martínez-Ibarra and Gómez-Martín 2012; Rutty and Scott 2010, 2013, 2014, 2016; Fitchett *et al.,* 2017; Georgopoulou *et al.,* 2019), urban tourism (Scott *et al.,* 2008, 2016; Rutty and Scott 2010; McKercher *et al.,* 2015), mountain tourism (Scott *et al.,* 2008; Steiger *et al.,* 2016), ski tourism (Dawson *et al.,* 2013; Steiger *et al.,* 2013; Rutty *et al.,* 2015), golf participation (Scott and Jones 2006, 2007), zoo attendance (Aylen e*t al.,* 2014; Hewer and

Gough, 2016a,b,c; Perkins and Debbage, 2016) and park visitation (Hewer *et al.,* 2015, 2017). Furthermore, weather preferences and thresholds have been found to vary based on the specific tourist activity selected (de Freitas, 2015; Steiger *et al.,* 2016).

This study employs the most widespread and commonly used index, the Tourism Climatic Index (TCI) developed by Mieczkowski (1985; Scott *et al*., 2004; Amelung and Viner, 2006; Amelung *et al*., 2007; Tang, 2013; Amelung and Nicholls, 2014; Kovács and Unger, 2014; Fitchett *et al.,* 2016a; Hoogendoorn *et al.,* 2018). This index has achieved worldwide validation as it is applicable for multiple climatic environments providing a quantitative evaluation of climate for tourism (Brosy *et al.,* 2014). In this regard, the index can be referred to as a tourism comfort index as it indicates the climatic comfort levels for different types of tourism activities (Lorde *et al.,* 2016).

The TCI uses composite measurements to systematically assess the climatic elements most relevant in the climatic quality experienced of the 'average' tourist (Lorde *et al.,* 2016). Based on theoretical considerations in the bio-meteorological literature in relation to human comfort and tourist activities, a weighted scale for measuring the climatic elements most important to tourist satisfaction with a destination was devised (Mieczkowski, 1985; Bakhtiari and Bakhtiari, 2013; Tang, 2013). This includes mean maximum daily temperature, mean daily temperature, minimum daily relative humidity, mean daily relative humidity, total precipitation, total hours of sunshine, and average wind speed given in the formula (Mieczkowski, 1985):

$$\mathbf{TCI = 2(4CD - CA + 2\mathit{R} + 2\mathit{S} + \mathit{W}).}$$

This calculation accounts for both the push (climate of origin) and pull (climate of destination) dimensions of climate on tourism demand (Hamilton *et al.,* 2005; Amelung *et al.,* 2007; Eugenio-Martin and Campos-Soria, 2010; Gössling *et al.,* 2012; Goh 2012; Li *et al.,* 2018a). In the literature it is argued that the greater the positive difference between the climate of the source and the destination country or region, the greater the tourist flow will be from the source to the destination (Lorde *et al.,* 2016). In other words, tourists that prefer climatic attributes that will provide a tourism comfort better than their home country will be more inclined to travel to a destination with those attributes (Lorde *et al.,* 2016; Li *et al.,* 2018a).

Although the TCI has been applied by multiple authors over time (e.g. Scott *et al,* 2004; Amelung *et al.,* 2007; Nicholls and Amelung, 2008; Perch-Nielsen *et al.,* 2010; Olya and Alipour*,* 2015; Fitchett *et al.,* 2017), the TCI has a number of limitations (Georgopoulou *et al.,* 2019). These shortcomings include: 1) the rating and weighting schemes as they are claimed to be largely based on expert opinion and the existing biometeorological literature rather than revealed or stated tourist preferences, 2) the index neglects the overriding effect of physical climate parameters such as rain and wind on the TCI score, 3) that the TCI is insensitive to the large variety of weather requirements preferred by tourists engaging in various activities in tourism segments much like beach, city or winter tourism (Scott *et al.,* 2004; Amelung and Viner, 2006; de Freitas *et al.,* 2008; Farajzadeh and Matzarakis, 2009; Moreno and Amelung, 2009; Perch-Nielsen *et al.,* 2010; Steiger *et al.,* 2016; Öztürk and Göral, 2018). De Freitas et al. (2008) argue that a theoretically sound index must incorporate a multi-disciplinary research of climatology, tourism, geography, biometeorology, resource management, and psychology in order to improve the understanding of tourism-climate relationships as well as integrate all facets of climate and their effects on tourist satisfaction.

To overcome these shortcomings other researchers built on Mieczkowski's (1985) TCI with advancements to rectify the weighting system and provide empirical testing of the new indices (Scott *et al.,* 2016). Morgan et al. (2000) developed the Beach Climate Index (BCI) which used empirical testing to determine the thermal preferences of the beach users. However, it is emphasised in the research that the responses of the thermal preferences are specific to the various study sites in the UK and Mediterranean, and may not be applicable elsewhere (Morgan *et al.,* 2000). The Climate Index for Tourism (CIT), established by de Freitas et al. (2008:399), was also developed for beach tourism, specifically "sun, sea and beach" holidays. This index tested their rating systems using a survey where respondents rated the thermal (T), aesthetic (A) and physical (P) facets of weather. However, the index was only originally applied to one country with a relatively narrow survey segment. The Holiday Climate Index (HCI) developed by Scott et al. (2016) is used for general sight-seeing tourism in urban areas and is empirically validated through survey data from existing literature on the climatic preferences of tourists over the last decade. This validation is claimed to be a major advancement that overcomes the main TCI critique. However, a limitation for the comparative use of the HCI in other locations is that the index requires observed visitation pattern data to test the validity with tourists and the tourism sector's performance.

Although the original weighing scheme of the TCI was not empirically tested against climatic preferences of tourists, the option of tailoring the index to specific activities was as explicit part of the design by Mieczkowski (1985), however, the suggestion has yet to be widely implemented in practice. It must be noted that any alteration to the weighting scheme would impact the outcome of the index (Scott *et al.,* 2016; Georgopoulou *et al.,* 2019). Hoogendoorn and Fitchett (2018a) present an important intersection in the climate change and tourism discourse that incorporates climatic preferences for tourism that is found within the existing literature, for example: Hoogendoorn et al. (2016), with that of the TCI that has been applied to various localities in South Africa. The use of the TCI to model South Africa as a tourism destination has been critically reviewed by Fitchett et al. (2016a). Hoogendoorn and Fitchett (2018b) consider the potential impacts climate change could have on second homes throughout South Africa through a critical analysis of existing literature on tourism, climate change and second homes in South Africa. This research built on an existing study by Fitchett et al. (2017) that applied the TCI to various locations throughout South Africa, including Durban, Cape St Francis, Cape Town, St Francis Bay and St Lucia. These destinations represent the few second-home towns that the TCI has been applied (Hoogendoorn and Fitchett, 2018b). To overcome this limitation of the TCI, the intersection between climatic preference literature and the TCI are required.

However, what is evident in the literature is that the HCI is becoming frequently used as it was developed to more accurately assess the climatic suitability tourism destinations compared to the TCI (Table 2.4; Tang, 2013; Öztürk and Göral, 2018; Amiranashvili *et al.,* 2018). For this index, the word 'holiday' was chosen instead of 'tourism' used in the previous indices as it was thought that the word was misleading by having a broad definition, the index wanted to better reflect what the index was designed for; which is leisure tourism (Tang, 2013; Scott *et al.,* 2016). The HCI formula is given as (Scott *et al.,* 2016): **HCI: Urban = 4(TC) + 2(A) + (3(precipitation) + wind)**. And unlike the TCI, the HCI does not define any climatic condition as 'impossible' for tourism, this is due to some tourist activities requiring (what the TCI describes as) adverse weather conditions, such as high winds for wind surfing, or storm watching (Scott *et al.,* 2016). One of the differences between the HCI and the TCI is the rating scale and weighting system, the HCI combines precipitation and wind and weights them as 40%, which is an equal weighting to the thermal aspect. (Scott *et al.,* 2016; de Freitas, 2017; Öztürk and Göral, 2018). Due to the equal rating of the physical climatic conditions a more realistic representation of the climatic suitability of the destination for tourism is presented, if the physical conditions are 'weak' or unfavourable the thermal and aesthetic conditions will deteriorate as well in the HCI scores. However, the TCI is still a relevant index, with some studies published in 2019, as it can be applied to different climatic settings around the world, not like the BCI that is only aimed at beach tourism (Table 2.4; Li *et al.,* 2018a).

Table 2.4: Authors who have contributed to the use of the TCI spanning 1985 to present.

Author	Date	Journal	Location
Mieczkowski	1985	Canadian Geographer	Global
Matzarakis	1999	Proceedings of the First International Workshop on Climate, Tourism and Recreation	Greece
Scott et al.	2001	First International Workshop on Climate, Tourism and Recreation	North America
de Freitas	2001	Proceedings of the First International Workshop on Climate, Tourism and Recreation	Global
Matzarakis	2001	International Society of Biometeorology, Commission on Climate Tourism and Recreation	Greece
Perry	2001	Proceedings of the First International Workshop on Climate, Tourism and Recreation	Mediterranean
Scott et al.	2003	First International Conference on Climate Change and Tourism	North America
de Freitas	2003	International Journal of Biometeorology	Global
Scott et al.	2004	Climate Research	North America
de Freitas	2005	Tourism, Recreation and Climate Change: International Perspectives	Global
Perry	2005	Tourism, recreation and climate change	Mediterranean
Scott et al.	2005	Tourism, recreation and climate change	North America
Amelung and Viner	2006	Journal of Sustainable Tourism	Mediterranean
Matzarakis	2006	Tourism and Hospitality Planning & Development	Greece
Amelung et al.	2007	Journal of Travel research	Global
Matzarakis et al.	2007	Developments in Tourism Climatology	Global
Amelung and Viner	2007	Climate Change and Tourism – Assessment and Copying Strategies	Mediterranean
Amiranashvili et al.	2008	Transactions of the Georgian Institute of Hydrometeorology	Georgia
Mishev and Mochurova	2008	International conference “global environmental change: challenges to science and society in south-eastern Europe”,	Europe
Hain et al.	2009	Current Opinion in Environmental Sustainability	Spain
Farajzadeh and Matzarakis	2009	Meteorological Applications	Northwest Iran
Perry	2009	Journal of Sustainable Tourism	Mediterranean
Moreno and Amelung	2009	Coastal Management	Europe
Amiranashvili et al.	2010	Urban Climate	Batumi
Moore	2010	Current Issue in Tourism	Caribbean

Author	Date	Journal	Location
Farajzadeh and Ahmed	2010	Physical Geography Research Quarterly	Iran
Moreno	2010	Tourism and Hospitality Planning & Development	Mediterranean
Perch-Nielsen	2010	Climate Change	Global
Gandomkar	2010	Journal of Physical Geography	Isfahan
Eugenio-Martin and Campos-Soria	2010	Tourism Management	Global
Becken	2010	Research Archive Lincoln	Global
Shakoor	2011	International Journal of the Physical Sciences	Yazd Province
Lin and Matzarakis	2011	Tourism Management	Taiwan, Eastern China
Shiue and Matzarakis	2011	International Journal of Biometeorology	Australia
Gandomkar and Mohseni	2011	Economics and Tourism Management	Mazandaran Province
Roshan et al.	2012	Journal of Geography and Regional Planning	Tehran city
Cashman et al.	2012	Tourism Review	Barbados
Gourabi and Palic	2012	Acta Geographica Debrecina Landscape & Environment	Iran
Kulendran and Dwyer	2012	Tourism Analysis	Global
Bakhtiari and Bakhtiari	2013	Desert	Kerman province
Németh	2013	Journal of Environmental Geography	Hungary
Mailly et al.	2013	Journal of Multi-Criteria Decision Analysis	Global
Yazdanpanah et al.	2013	Geography and Environmental Planning	Iran
Omrani and Yazdanpanah	2013	Geographic Space	Iran
Rosselló-Nadal	2014	Tourism Management	Global
Amelung and Nicholls	2014	Tourism Management	Australia
Kovács and Unger	2014	Quarterly Journal of the Hungarian Meteorological Service	Central Europe
Amiranashvili et al.	2014	Journal of the Georgian Geophyscial Society	Baku, Tbilisi, Yerevan
Ghanbari and Karimi	2014	Journal of Regional Planning	Isfahan
Matzarakis	2014	Sustainable Envrionment	Global
Matzarakis et al.	2014	Global NEST Journal	Athens
Kubokawa et al.	2014	Journal of the Meteorological Society of Japan	Japan
Méndez-Lázaro et al.	2014	Ecology and Society	Puerto Rico

Author	Date	Journal	Location
Roson et al.	2014	International Journal of Climate Change Strategies and Management	Mediterranean
Kovács and Unger	2014	Acta Climatologica et Chorologic	Hungary
Olya and Alipour	2015	Tourism Management	North Cyprus
Amiranashvili et al.	2015	International Scientific Conference "Sustainable Mountain Regions: Make Them Work"	Georgia
Grillakis et al.	2015	International Journal of Biometeorology	Europe
Mokhtari and Anvari	2015	Journal of Novel Applied Sciences	Iran
Lorde et al.	2015	Journal of Travel Research	Caribbean
Kovác et al.	2015	Theoretical and Applied Climatology	Hungary
Olya and Alipour	2015	Fresenius Environmental Bulletin	Mediterranean
Scott et al .	2016	Atmosphere	Europe
Roshan et al.	2016	International Journal of Biometeorology	Iran
Fitchett et al.	2016	South African Journal of Science	South Africa
Fitchett et al.	2016	Tourism: an International Scientific-Professional Journal	South Africa
Mereu et al.	2016	Science of the Total Environment	Sardinia
Zhang and Kulendran	2016	Journal of Travel Research	Hong Kong
Köberl et al.	2016	Science of the Total Environment	Italy, Tunisia
Amiranashvili et al.	2016	Actual Problems of Pathology, Therapy and Medical Rehabilitation	Eastern Georgia
Li et al.	2017	Journal of Travel Research	Hong Kong, China
Fitchett et al.	2017	Journal of Sustainable Tourism	South Africa
Hoogendoorn and Fitchett	2018	Handbook of research methods for tourism and hospitality management	South Africa
Om et al.	2018	Asia Pacific Journal of Tourism Research	PDR Korea
Georgopoulou et al.	2019	Theoretical and Applied Climatology	Georgia
Ahmadi et al.	2018	Modeling Earth Systems and Environment	Iran
Amiranashvili et al.	2018	Journal of the Georgian Geophysical Society	Georgia
Huang et al.	2018	Theoretical and Applied Climatology	China
Heydari Alamdarloo et al.	2019	Scientific Journals Management System	Yazd Province (Iran)
Razzaq and Abbood	2019	Transylvanian Review	Iraq

Author	Date	Journal	Location
Mahmoud et al.	2019	GeoJournal of Tourism and Geosites	Egypt
Noome and Fitchett	2019	Journal of Mountian Science	Lesotho

To date, there has not been an academically agreed superior weighting system proposed (Amiranashvili *et al.,* 2018). Therefore, until a united bioclimatic index for tourism is developed, the use of the TCI, in spite of its limitations, is nevertheless the most widely used and it is useful for the possibility of multi-region comparison of the bioclimatic comfort level of the 'average tourist' in different destinations which can be used for decision-making and strategy planning for mass tourism (Figure 2.4; Amiranashvili *et al.,* 2018).

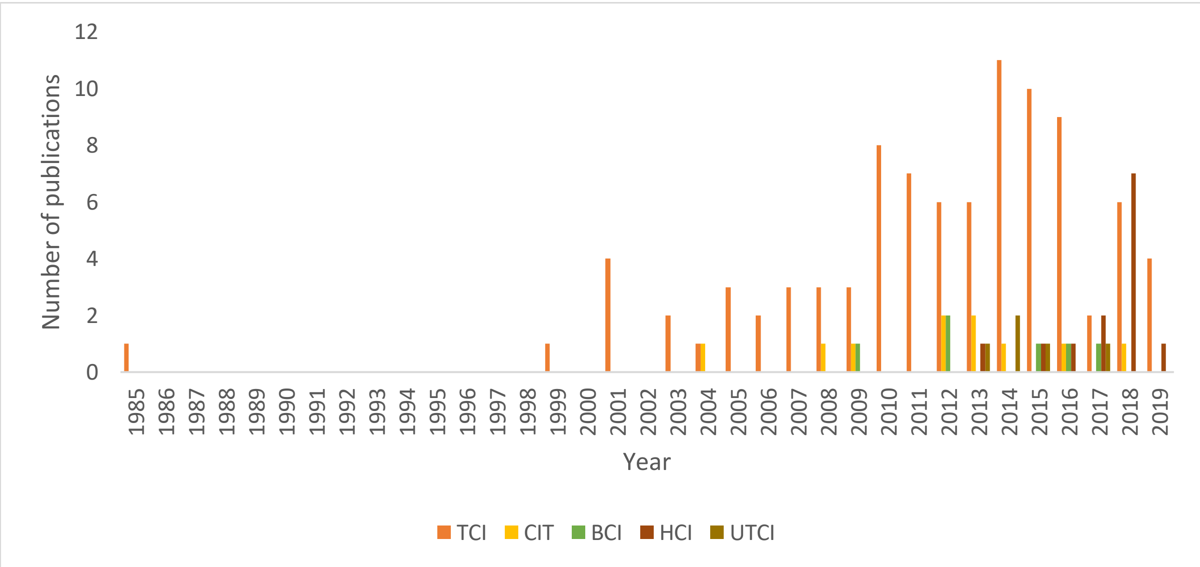


Figure 2.4: The amount of publications per index over the period 1985-2019.

Researchers have urged for a universally accepted climate index for tourism for the purpose of application to different kinds of climate conditions, regions and seasons of the year (Jendritzky *et al.*, 2001). This will facilitate improved destination comparisons as well as developing improved marketing strategies in the global tourism marketplace (Scott *et al.,* 2008).

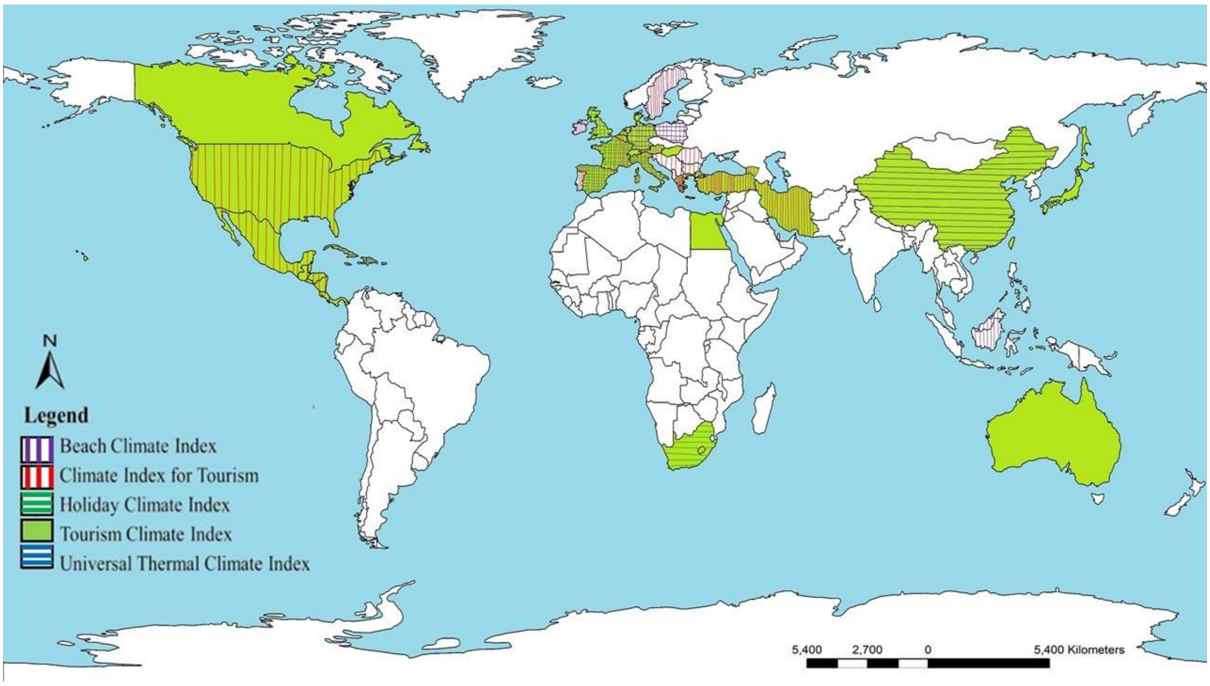


Figure 2.5: Spatial distribution showing the use of the BCI, CIT, HCI, TCI and UTCI around the globe.

The use of the various tourism climate indices is largely confined to the northern hemisphere, the need for the development of tourism climate indices that appropriately captures the tourism-climate relationship is particularly high considering southern regions are most likely to be affected by climate change (Figure 2.5; Hoogendoorn and Fitchett, 2018a). Currently, the activity-specific indices that have been developed (such as the BCI) have limited value for first-order assessments of the climate impact on tourism. As a first-order assessment tool the TCI is still very useful (Hamilton and Tol, 2007).

2.8. SYNOPSIS

As it is widely known in the literature the climate of a tourist destination is a prominent influencer on travel destination selection. Global climate change and tourism discourses highlight the natural environment for crucial for successful outdoor tourism, in many instances focusing on the extent to which climate change can alter the climatic suitability of tourism destinations. It is often the case that the tourism product offerings are destination specific meaning that without effective adaptative and mitigative action tailored to the specific climate change consequences at these destinations, their tourism market might face a decline due hazards or other risks associated with unfavourable climatic circumstances. Research into the role perception and mindfulness play towards adaptative action is relatively new in the literature but has shown a gap that can be filled towards more effective and long-term adaptative strategies. To comprehensively understand the influence changes to the climate will have on the tourism market as a whole, more comprehensive literature is required.

This literature needs to span a wide range of destinations across the globe to explore the similarities and discrepancies between destinations and how these destinations are or are planning to combat climate change. There have been many attempts to quantify the impacts of climate change on tourism at destinations around the world, however, these studies did not account for all aspects that are considered important to tourist satisfaction. The discourse surrounding the thermal comfort of tourists in the context of tourism and climate change, for example, has only become a fixture within the last few decades, and most prominently featured in the conception of the Tourism Climate Index (Maher *et al.,* 2011).

Still the most widely used index, the TCI has majorly been applied to the global north (predominantly the developed regions). Few studies have undertaken research into the climatic suitability of destinations in Namibia under climate change for tourism purposes. Therefore, the need for the quantification of climate for tourism purposes is important as it is predicted that Namibia will experience changes to its climate in the near future which may have serious implications for the region's tourism sector, which is a significant source of revenue for the country. As is evident in the literature section on climate change and Namibia in this thesis, the studies have small spatial and temporal scales due to limited temporal recorded meteorological data. There is a growing need for the quantification of climate in Namibia. Using the available meteorological data, this research provides a gap in the Namibian literature by providing a quantification of the climatic suitability of Namibia tourism using the TCI for the average tourist's satisfaction, as well as adding to the global literature on the understanding of the tourism-climate relationship.

CHAPTER 3: STUDY REGION

3.1. INTRODUCTION

This study focuses on assessing the climatic suitability of Namibia for tourism spanning the period 2008-2018, using the modified version of Mieczkowski's (1985) Tourism Climate Index (TCI), as adapted by Perch-Nielsen et al. (2010). For this research, the data used, collection of data and the locations of the weather stations are explored under *Chapter 4 (Data and Methodology)*. This chapter provides a description of the contemporary climate of the geographic location and topographic characteristics of the study region. The contemporary climate and the setting of tourism in Namibia are the primary focus of this chapter.

3.2. THE DESCRIPTIVE GEOGRAPHY OF NAMIBIA

Namibia is located on the south-western region of Africa between the coordinates of 22°95'76" S, 18°49'04" E (Figure 3, Jokish, 2009; Jänis, 2011). Windhoek is the capital city of the country, the TCI results of which is presented under *Chapter 5*. The country covers an area of roughly 824,268km^2, spanning 1,320km^2 along its longest axis and 1,440km^2 at its shortest (Mendelsohn *et al.,* 2002). It is roughly twice the size of Germany—one of the colonizers of the country (Mendelsohn *et al.,* 2002). Namibia shares borders with Angola to the north, Zambia and Zimbabwe in the north east, Botswana to the east and South Africa in the south (Figure 3, Lendelvo *et al.,* 2018; Gbagir *et al.,* 2019). Namibia is divided into four geographic regions; the Namib Desert, the Namib escarpment, the Central Plateau and the Kalahari sandveld (Imalwa, 2016).To the west, a coastline (which hosts the cold, north flowing Benguela current) spanning an estimated 1,570km^2 separates the land and the Atlantic Ocean

(Mendelsohn *et al.,* 2002). To the east, the region land is dissected by the Zambezi and the Kwando-Linyanti rivers (Dirkx *et al.,* 2008).

South of the Sahara Desert, Namibia is one of the driest countries and is classified as an arid zone (Angula, 2010). More than 90% of Namibian land area is estimated to be arid, semi-arid or hyper-arid (Tervo-Kankare *et al*., 2018). Geological processes over the last 2.6 million years (ma) have shaped this landscape and produced a variety of mineral deposits (Detay, 2017). Western Namibia hosts rugged escarpments, valleys and mountains in addition to large open plains (Mendelsohn *et al.,* 2002). Arguably the most distinguishable geological feature is the Namib Desert, bordering the Atlantic Ocean (Dowling and Grünert, 2018). The overall absence of moisture is due to the position of Namibia in the south-western part of the African continent and in the Tropic of Capricorn (Mendelsohn *et al.,* 2002).

The coastline has very different climate conditions compared to that of the interior regions of Namibia, largely these regions have lower temperatures and rainfall as a result of the Benguela Current brining in the cold water to the west coastline of southern Africa (David *et al.,* 2013). The northern regions of Namibia is straddled by two climate systems: the Intertropical Convergence Zone (ITCZ) that brings moist air from the north and the Subtropical High Pressure Zone that pushes back the moist air with dry air, which increases rainfall (Mendelsohn *et al.,* 2002; Spear *et al.,* 2018). In Namibia, the southern regions lie between the interface of the Intertropical Convergence Zone (ITCZ) and the temperate zone (David *et al.*, 2013). This results in drier climate conditions, especially during the winter season (Mendelsohn *et al.,* 2002). Namibia has an altitude range from sea level to 2,606m, with the mean altitude of the interior basin at 1,000m above sea level (masl, Barnard, 1998; MET, 2002). The Brandberg massif has the highest altitude of 2,579m above sea level (masl) which adds to the topographical features of Namibia (Mendelsohn *et al.,* 2002).

3.3. STUDY LOCATION JUSTIFICATION

The initial scope of this research was to evaluate 15 locations, namely Auas Mountains, Canon Roadhouse, Damara Mopane, Etosha Safari, Farm Skemerhoek, Hochfeld, Kalahari Farmhouse, Klein Aus Vista, Namib Desert, Olympia, Omuramba Hunting, Oranjemund, Oujo, Swakopmund, Windhoek. Due to limited availability of meteorological data, however, the study was reduced to seven study stations (Table 3.1) , as stated in the rationale in *1.2. Rationale* under *Chapter 1* . These seven weather stations are as follows, from the northern most position in Namibia: Etosha Safari, Hochfeld, Windhoek, Swakopmund, the Namib Desert, Kalahari Farmhouse and Klein Aus Vista (Figure 3.1; Table 3.1). The distribution of the weather stations is useful in this research in providing an overview of the climatic suitability of tourism in different regions of Namibia using the TCI and will provide an indication of the best season and location for travel for tourists and tourism providers.

Table 3.1: The latitude and longitude, elevation, average annual rainfall, and average maximum and minimum temperatures of the study sites.

Study sites	**Latitude**	**Longitude**	**Elevation (m.asl)**	**Mean monthly Rainfall (mm)**	**Mean monthly T_{max} (°C)**	**Mean monthly T_{min} (°C)**
Etosha Safari	19°24’30” E	15°55’04” S	1,184	33.96	35.12	11.08
Hochfeld	21°25’47” E	17°51’17” S	1,576	52.74	31.43	6.19
Kalahari Farmhouse	24°20’14” E	18°24’03” S	1,211	20.16	36.72	4.53
Klein Aus Vista	26°39’07” E	16°14’33” S	1,403	6.65	30.38	3.66
Namib desert	24°06’00” E	15°54’00” S	664	10.25	35.77	6.6.7
Swakopmund	22°40’44 E	14°31’52” S	90	2.32	27.87	10.29
Windhoek	22°34’36” E	17°04’32” S	1,673	40.63	31.29	8.89

Located in six of the 14 administrative regions of Namibia, the Kunene, Erongo, Otjozondjupa, Khomas, Hardap and Karas regions, these seven stations are subject to relatively distinct geomorphological agents that influence their climates (Figure 3.1). To some extent the distinct climate of these scattered locations has resulted in popular tourist attractions, making the assessment of climate impacts to these areas important in order to protect these tourist attractions from depreciating (Jokish, 2009; Naidoo *et al.,* 2016; Woyo and Amadhila, 2018; Koot *et al.,* 2019).

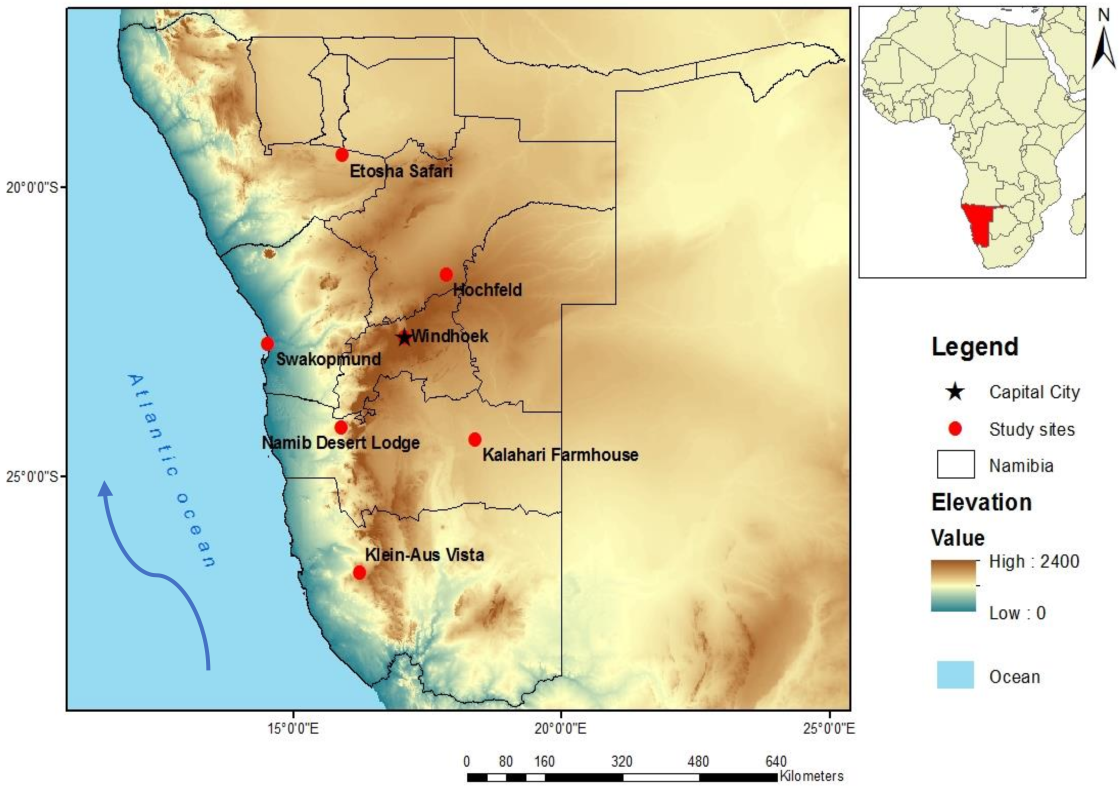


Figure 3.1: Map of the study region, Namibia. The depiction indicates the administrational borders within the country and the capital city, the study locations, topography, and the respective ocean current.

Specifically, outdoor attractions are expected to have a heightened awareness for the impacts of climate change to tourism flows (Fitchett *et al.,* 2017). The Global South, however, remains a region with proportionally limited research on the interrelationship of climate change and tourism (Noome and Fitchett, 2019). Namibia offers a heterogeneous array of outdoor tourist attractions, including wildlife and game tourism, trophy hunting, adventure attractions such as climbing and hiking, photography, cultural and heritage sites (African Geographic, 2018; Tervo-Kankare *et al.,* 2018; Woyo and Amadhila, 2018). Namibia presents a particularly valuable region to conduct an initial analysis of the climate change suitability for tourism using the long-established TCI. The future of nature and outdoor tourism in the study location is contingent on the adaptive capacity of the Namibia government, policy-makers, tourism operators and stakeholders in response to climate change (Davies *et al.,* 2020). This study will provide knowledge about tourism and tourism resources based on the climatic suitability of the region which will enable tourism planners, tourism operators, decision-makers to enhance their adaptive actions towards tourism under climate change. These actions may lead to economic growth and job creation, specifically in the tourism sector, in Namibia.

3.4. CLIMATE AND WEATHER OF NAMIBIA

Climate and weather characteristics across Namibia are not as well documented as some its neighbouring countries (Tyson and Preston-Whyte, 2000; David *et al.,* 2013; Ratnam *et al.,* 2013). Namibian climate is generally hot and dry with sparse or erratic rainfall (MET, 2010). As a result of the latitudinal position of Namibia, largely in the sub-tropics, the seasonal migration of the ITCZ and southern hemisphere Westerlies influence the climate of the country (Tervo-Kankare *et al.,* 2018). Characteristically, temperatures exhibited across Namibia follow a diurnal cycle, whereby daytime maximum temperatures are higher than daytime minimum temperatures (Spear *et al.,* 2018). In land, summer (December to February) experiences higher temperatures than coastal regions (Kuvare *et al.,* 2008; Spear *et al.,* 2018). The Kalahari Desert experiences the highest temperatures (Spear *et al.,* 2018). Throughout much of the year dry conditions persist, primarily due to the persistent high pressure along the coastline that is a result of the cool northward flowing Benguela Current (Dirkx *et al.,* 2008; Turpie *et al.,* 2010). Rainfall in Namibia has significant variance depending on the location in the country (Spear *et al.*, 2018). A single rainy season is present in Namibia, occurring from November to April and is associated with the southward migration of the ITCZ (Spear *et al.,* 2018). Northeast of Namibia receives approximately 600mm average annual total rainfall, however, the south and coastal regions can receive less than 50mm of average annual total rainfall (GRN, 2015). Thus, other sources of precipitation for desert flora and fauna have become important, for example fog (GRN, 2015). Coastal fog can provide up to five times the amount of moisture and water than rainfall in some coastal settings (Kaseke *et al.,* 2018).

Arguably one of the most important atmospheric patterns that the ITCZ interacts with around Namibia is the El Niño Southern Oscillation (ENSO; Spear *et al*., 2018). ENSO is a cyclical variation in the surface temperature of the tropical eastern Pacific Ocean (Spear *et al*., 2018). The El Niño event is present when ocean surface temperature in the Atlantic Ocean region is warmer than average, this is associated with below-normal rainfall in southern Africa but parts of South America and Australia as well (Meissner and Jacobs-Mata, 2016). The opposite conditions, where the ocean surface is cooler than average is called the La Niña event (Zaroug *et al.,* 2014). ENSO events vary temporarily but typically occur once every few years (Meissner and Jacobs-Mata, 2016). El Niño is associated with climate conditions that are drier and warmer than normal in southern Africa during the austral summer from December to

February (Gore *et al.,* 2020). The La Niña, on the other hand, is associated with wetter and cooler conditions (Gore *et al.,* 2020).

3.5. ANTICIPATED CHANGES TO NAMIBIAN CLIMATIC CONDITIONS

The relevance of weather and climate information is largely dependent on the ability of scientists to provide climatic information that is fit for the integrative purposes for decision-making processes towards climate change adaptation (Daron, 2015). For Namibia, and many African countries, adaptative strategies for weather and climate risks are intrinsically related to the socio-economic, pathways, socio-cultural context and differential vulnerability of the region (Ziervogel and Zermoglio, 2009; Singh *et al.,* 2018). However, as with many other developing countries, Namibia is faced with a mismatch between available information and what is needed to support on-the-ground decision-making for action against the anticipated impacts of climate change. To unpack the issues regarding the use of weather and climate information for decision-making, it is necessary to understand what type of information is relevant, and the relationship between the underpinning technical and scientific challenges associated with the production of such information (Singh *et al.,* 2018). This section summarises the range of available weather and climate information for Namibia and how this can be used to anticipate the effects and challenges climate change will pose to the country.

In the literature there have been noticeable changes in climate extremes and rainfall seasonality in the observed historic climate trends in Namibia since 1960 (Dirkx *et al.,* 2008). These changes are dominant in the hot extremes of increasing temperatures and the decreases in the cold extremes of daily temperatures (Spear *et al.,* 2018). The frequency of days with temperatures above 25°C and 35°C and days with minimum temperatures below 5°C clearly depicts increased climatic variability for Namibia, as well as increased length of the dry season and decreases in the number of consecutive wet days (Dirkx *et al.,* 2008). This is noted with a concomitant later start and earlier cessation of the rainy season in the northern regions of Namibia (Dirkx *et al.,* 2008). There are multiple websites that provide 'historical' climatic data for the use of modelling climatic futures for Namibia. Majority of the websites have temperature and rainfall records, some hold archives dating from 1900, however, only one data source offers climatic data other than temperature and rainfall, including: sunshine hours, wind speed. GCMs are another source of future weather and climate information (Singh *et al.,* 2018). Advances in the understanding and computational capacity of GCMs have improved the quality of the weather forecasts dramatically over recent decades (Lynch, 2008). Recently, there have been a number of strategic partnerships between national meteorological agencies between developed and developing countries for the sharing of skills in modelling and forecasting capabilities (Lynch, 2008).

Dissemination of information is vital for Namibia as much of the weather and climate information available for African regions comes from global data sets (for example: CMIP5) and projects with broad geographical coverage (Singh *et al.,* 2018) This process has improved in recent times with an increasing volume of climate data from online data portals becoming an important mode of communication (Daron *et al.,* 2015). However, a notable caution is placed on the use of information derived from downscaled simulations as they do not fully represent all sources of uncertainty (Daron *et al.,* 2015). Analyses of GCM simulations from

CMIP5 reveal high rates of warming and decreasing rainfall over Namibia in the coming decades (Figure 3.2; Daron *et al.,* 2015; Spear *et al.,* 2018).

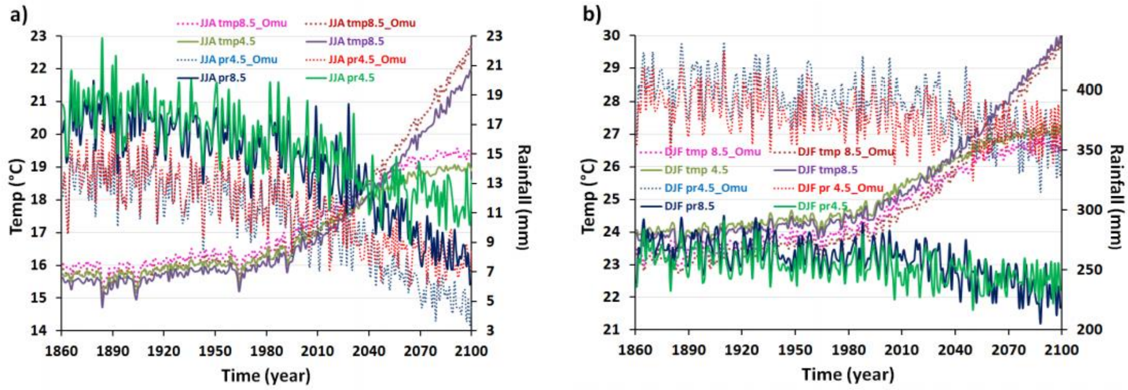


Figure 3.2: Time series of a) winter and b) summer precipitation and temperature from 1861 to 2100 from the CMIP5 multi-model mean averaged over Namibia and the Omusati climatic zone.

The Omusati climatic zone depicts a higher warming level compared to Namibia during the winter months of June, July and August (JJA) with a high warming rate and decreasing rainfall, and a lower rate during the summer months of December, January and February (DJF). CMIP5 shows that winter temperatures are projected to rise more quickly than summer temperatures, with temperature increases of between 2.5°C and 3.3°C expected in Namibia by 2050 and temperatures between 3.3°C and 5.8°C towards the end of the 21st century over Namibia (Dirkx *et al.,* 2008; Spear *et al.,* 2018). The Omusati climatic zone of northern Namibia shows high warming rates and decreasing rainfall during JJA and DJF. The warming level for both the RCP4.5 and RCP8.5 scenarios is higher compared to Namibia during JJA and lower during DJF. The projections show increases in the frequency of days with maximum temperatures above 35°C and significant decreases in the frequency of days with minimum temperatures below 5°C, which may lead to increased duration of heat waves (Dirkx et al. 2008).

Although some model projections show increasing precipitation for parts of Namibia, most models have a reasonable agreement that there is decreasing precipitation across much of Namibia over the next century (Davis, 2011; James and Washington, 2013). Thus, it is expected that there will be an extension of the dry season, with a delay in both the onset and cessation of rains over southern Africa (Mariotti *et al.,* 2014). Climate variability is expected to add to the rising concern of water resources and wetlands in Namibia (Mariotti *et al.,* 2014). Global warming will contribute to evaporation and evapotranspiration increases between 5-15% (Dirkx *et al.,* 2008). Changes in rainfall patterns over Namibia, Zambia and Angola will affect stormwater runoff and drainage in perennial rivers in northern Namibia (Dirkx *et al.,* 2008). Such changes increase the vulnerability of wetlands in Namibia, the most likely to be affected are the Kunene River, and the Cuvelai system. Other disruptions to the ecosystem characterised water retention, flood attenuation and water purification is the disruption of breeding and growth cycles of invertebrates, fish and flora—this may negatively affect rural livelihoods and tourism (Dirkx *et al.,* 2008).

3.6. TOURISM OF NAMIBIA

Namibia has a relatively small population base of approximately 2.6 million people, two-thirds of which live in rural areas (Dowling and Grünert, 2018). The remaining one-third of the population live in urban areas, mainly in Windhoek, the capital city, and coastal cities including Walvis Bay, Lüderitz and Swakopmund (Dowling and Grünert, 2018). One of the main economic drivers of Namibia, aside from agriculture and fishing, is tourism (Scott *et al.,* 2012; Dowling and Grünert, 2018). Nature-based tourism is the dominant form of tourism (Ashley, 2000; Saarinen, 2010). It is estimated that 70 percent of the tourist arrivals in Namibia are from other African countries, including South Africa, Angola, and Zambia (Dowling and Grünert, 2018).

Adaption responses

The majority of adaptation responses and measures is donor-driven (Davies *et al.,* 2020). Adaption capacity in Namibia Up-scaling the communities to be resilient to climate variability is a sustainable goal through community-based tourism initiatives, increased access to services such as drought relief, and improvement of infrastructure (Spear *et al*., 2018). The Ministry of Environment and Tourism is responsible for the measures put forward towards the climate change agenda, such as the implementation of the 2013 National Climate Change Strategy and Action Plan, supported by the Desert Research fund (MET, 2013). The multi-faceted strategy involves the development of programmes and initiatives by different institutions to reduce the exposure Namibia faces under climate change threats and improve adaptation measures (Lendelvo *et al.,* 2018).

Educational provisions to improve climate change understanding in local communities, preparedness for climatic events in the form of early warning systems, the promotion of drought and flood proof, and the use of low carbon (solar energy for example) infrastructure are avenues that promote sustainable adaption to climate change in Namibia (Lendelvo *et al.,* 2018). Adaptive capacity for natural resources is carried out in efforts to diversify land use practises to ensure that there is not a singular dependency on the land and functioning comprehensive land management schemes (Lendelvo *et al.,* 2018). However, poor channels for coordination within the government intersects for the improvement of sustainable responses towards climate change compounded by the existing barriers (limited access or existence of information, resource and technical capacity deficits) increases the gap to on-the-ground adaptation (Davies *et al.,* 2020).

Barriers to adaption

Adaptation efforts in sub-Saharan Africa tend to be inhibited by socio-cultural, institutional, financial, technological and knowledge-based deficits (Davies *et al*., 2020). Moser and Ekstrom (2010: 22027) explicate barriers as 'simply impediments that can stop, delay, or divert the adaptation process'. Without a comprehensive understanding of the barriers that delay interactions and interventions aimed at improving adaptation any action to eliminate these hurdles will become superficial (Davies *et al.,* 2020). Therefore, understanding the dynamics and intersecting relationships of barriers within the adaptation space in Namibia aids in the identification of where and in what form these barriers occupy adaptation space for decision makers (Pelling *et al.,* 2015).

Economic dependence on natural resources in Namibia, coupled with employment opportunity insufficiency, causes communities to become vulnerable to climate change if the correct avenues to superseding these barriers to adaption are not taken (*Davies et al.,* 2020). Insufficient infrastructure, including roads and bridges; hospitals; and stormwater drainage systems (particularly in informal settlements) and limited alternative means for livelihoods are barriers to equitable provisions against the effects of climate change (Davies *et al.,* 2020). Unequal access between the rurall communities and the established tourism businesses to technologies and climate change data and adaptation options further impede adaptation measures as the rural communities remain marginalised (Pelling *et al.,* 2015). To begin addressing the barriers to adaptation in Namibia, more integrated approaches to adaptation are needed (Dirkx *et al.,* 2008; Barnes *et al.,* 2012; David *et al.,* 2013). Avenues for integration should take form between different levels of government; the local, regional and national, by improving communication and cooperation between departments to align policies and strategies for more inclusive and collaborative planning processes (Davies *et al.,* 2020).

The study locations selected for this research are rich in tourist attractions for both local and international tourists The geographies of the regions play an important part in the tourist activity offerings for each destination Information regarding the tourism of these locations is unevenly distributed, Etosha Safari has a wealth of information about tourism in the area as it is a more popular tourist destination than compared to Hochfeld, for example.

Etosha Safari

Etosha is located in the north of Namibia and is characterised as semi-arid to arid savannah (Jokish, 2009). After Swakopmund and Windhoek, Etosha National Park is considered the most visited destination in Namibia, with landscape and wildlife the park's main tourist attractions (Kimaro *et al.,* 2015). The Etosha National park is considered the cornerstone of the growing wildlife tourism in Namibia (Mannetti, 2017). The farms of this region have various sources of income, some are known for their livestock farming but others have branched into wildlife tourism and trophy hunting (Jokish, 2009).

For a tourist destination such as Etosha Safari to remain in the competitive tourism market, the services and products the location offers requires quality on par or better than similar destinations (Kimaro *et al.,* 2015). Various visitor management techniques are employed in Etosha to improve or maintain quality offerings, including maintaining infrastructure such as roads, signage, and lodging; managing the number of kiosks and game drives, the presence of jackals at camp sites, noise and speeding, during peak season for conservation efforts (Kimaro *et al.,* 2015).

Hochfeld

Hochfeld is a German word meaning 'high 'field' referring to the altitude of the town, which is situated in the Otjozondjupa region and is known more for the agricultural offerings than tourism, including cattle and olive farming (Raper et al., 1989; Matengu and Ashekele, 2010). Hochfeld boasts a few tourist attractions such as bird and game hunting and landscape photography. However, this location is used more for its accommodation as it is en route to more popular destinations, such as the Waterberg (Expedia, 2019).

Kalahari Farmhouse

The involvement of the indigenous South Kalahari ≠Khomani has led to increased cultural (and educational) tourism interest in the Kalahari region of Namibia (Koot, 2016). This creates revenue that 'trickles down' to the communities that are involved in the tourist attraction, marginally helping alleviate poverty by creating create job opportunities (Koot *et al.*, 2019). The Kalahari Farmhouse, specifically, has tourism attractions to the farm lifestyle, bird watching and nature walks (Namibian, 2019).

Klein Aus Vita

Famed for its hiking, mountain biking trails and mountain bike challenge, Klein Aus Vista is situated in the Aus Mountains which provide tourists with landscape and nature photography along the trails in the Gondwana Sperrgebiet Rand Park or Farm Kubub (Gondwana, 2019). Historic transport routes now function as 4x4 trails with sporadic game viewing (Gondwana, 2019). Much like Hochfeld, this area is in need of continued research as there is a limited pool of information to draw from regarding this location.

The Namib Desert

Namibia hosts the oldest desert in the world, the Namib Desert (Baker and Mearns, 2017). Desert tourism is a niche tourist offering, with usually a minority of tourists (Woyo and Amadhila, 2018). The Namib Desert is considered a major tourist attraction on both a local and international scale, particularly among tourists from Germany who constitute 17% of the total number of tourists to this destination (MET, 2016). Unfortunately, little academic attention has been paid to the experiences of desert visitors, at least in the Namibian context (Woyo and Amadhila, 2018). The Namib Desert offers world-renowned attractions the world's highest sand dunes, horse-back riding, cycling and waking trails (National Geographic, 2013; Woyo and Amadhila, 2018).

Swakopmund

Fisheries are the main source of income for coastal towns (Simon and Ekobo, 2008). Swakopmund is a premier bird watching site in Africa (Hottola, 2009). Flanked by the ocean and desert, Swakopmund is a tourist sensation offering dolphin cruises, wildlife and nature photography, beach activity and off-road coastal sand dune driving for quad bike and 4x4 enthusiasts (Hottola, 2009; Saarinen, 2009).

Windhoek

Many international travellers start and end their visit to Namibia in Windhoek as it is home to the only international airport, Hosea Kutako International Airport, in the country (Steinbrink *et al.,* 2016). This boosts city tourism in Windhoek, to sites such as historical monuments and buildings, museums, shopping, handiworks and crafts, art and architecture (Saarinen, 2016). Initiatives to improve the cultural (township tours) and heritage sites in Windhoek have increase the popularity of the city as a travel destination (Steinbrink *et al.,* 2016). Bringing in the cultural aspects to tourism create sustainable and meaningful local benefits and employment in Windhoek (Saarinen, 2016).

CHAPTER 4: METHODS

4.1. INTRODUCTION

The primary aim of this research is to explore the manner in which climate variability and climate change influence Tourism Climate Index (TCI) scores in Namibia. The content of this desktop study will contribute to the existing literature on tourism and climate change, on both a local and international level, as research of this nature has not been previous undertaken for Namibia. This research was conducted in the period February 2019 to February 2020. The TCI model was selected as it provides the user with a method to place a numerical value on the climatic suitability of a destination for tourism.

Quantitative data is solely used for this desktop study. Meteorological data is required for the calculation of the TCI; which was sourced from online content, over the timeline of 2008 to 2018. This chapter outlines the process of sourcing meteorological data in a country where full records are not easily accessible, if at all. The methods detailing the calculation of the TCI scores for each of the seven locations will be explored as well as process of producing the overall and seasonal distribution of the final TCI scores through ArcGIS.

4.2. CLIMATIC DATA ACQUISITION

Paucity of climate data is one of the main obstacles in researching climate change in Namibia (Rohde *et al.,* 2019). In Central Namib, it was only in the last eight years that a permanent grid of climate stations (10) were installed (Rohde *et al.,* 2019). Because of the historical climate information being highly limited many studies have employed the use of satellite data and interpolated models to provide a basis for climate research (Rohde *et al.,* 2019). However, access to the use of the software and data is limited. Meteorological data for each of the seven locations was sourced from the Namibian Weather Network for the calculation of the TCI (Namibia Weather Network, 2019). This was the most reliable site. The climate data required for the calculation of the TCI input variables are monthly minimum and average relative humidity, the mean monthly maximum and average temperature, monthly average wind speed, average total monthly rainfall and monthly average sunshine hours.

The Namibian Weather Network had datasets that included all of the required climatic variables, namely total monthly rainfall, total monthly sunshine hours, maximum solar w/m^2, average, minimum and maximum temperatures, average dew point temperature and wind speed. However, various limitations were encountered during the collection of the meteorological data, over the study period 2008-2018. A number of locations were missing months to years of meteorological components for the TCI calculation, this resulted in some locations having more meteorological data over the study period than others (Table 4.1).

Table 4.1: Years with complete meteorological data required for the TCI calculation.

Location	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Etosha Safari											
Hochfeld						✓					
Kalahari Farmhouse											✓
Klein Aus Vista			✓								
Namib Desert							✓			✓	✓
Swakopmund		✓		✓	✓	✓	✓	✓	✓		✓
Windhoek	✓	✓	✓	✓	✓		✓		✓		

The difficulty in working with data in the Global South is that there is often a disjuncture or absent data in historical climatic records. However, there is still the pressing need for more research into the discourse surrounding climate in countries such as Namibia. Therefore, the decision to move forward with the research and provide a TCI output for local and international comparison of the locations with data was made.

Meteorological datasets containing temperature, precipitation, wind speed, and sunshine measurements for seven weather stations were obtained from the Namibian Weather Network climate database. Numerous limitations with the climate variables for the calculation of the TCI in the collected dataset were encountered. The result of the data gaps and outliers are that this project is unable to refer to climate change trends as it lacks the required 30-year data period (IPCC, 2007; WMO, 2013). Additionally, it is probable that inherent human and faulty equipment errors could transpire to cause outliers due to a number of reasons, for example rain gauge measurements do not represent a 'true' rainfall measurement (Schulze, 2007).

In this research, the final TCI scores are calculated for a 10-year data period. Interpolated values pose the risk of being misleading if there is intra-annual and inter-annual variability in the data. The limitation of climate data availability for TCI research, especially in developing countries, are not restricted to Namibia. Mieczkowski (1985) highlighted data availability as a limitation in his research. Initially, Mieczkowski (1985) intended to use 12 meteorological variables for the TCI, but the lack of widely available climate data led to a model that only included seven climate variables. Scott et al. (2016) developed an adapted version of the TCI, the HCI, to improve on the empirical limitations of the TCI.

The main criticism of the TCI is a lack of empirically validating through evaluating tourist preferences. However, the comprehensive metrics and integration of all three facets of climate namely, thermal comfort; aesthetic and physical components, still make the TCI a widely used index (Scott *et al.,* 2004; de Freitas *et al.,* 2008; Perch-Nielsen *et al.,* 2010; Scott *et al.,* 2016). A fundamental limitation is that this study is restricted to exploring tourism-climate suitability for a limited range of destinations, only seven weather stations, Etosha Safari, Hochfeld, Kalahari Farmhouse, Klein Aus Vista, the Namib Desert, Swakopmund and Windhoek, had data available on the Namibia Weather Network. Thus, the inability of the Namibia Weather Network to provide sufficient spatial and temporal meteorological data is a limitation as it restricts research regarding the consequences of climate change on tourist destinations in Namibia (Scott *et al.,* 2011). However, the limitations associated with the spatial distribution are minor as a fine-scale resolution was not necessary to address the objectives of this research project.

4.2.1. Climate data of Namibia

The longest available dataset from the Namibian weather stations was over the period 2008-2018. However, for a number of these weather stations, historic data recording does not start in 2008, including Etosha Safari, which has data from 2010, and Kalahari Farmhouse, Klein Aus Vista and the Namib Desert which have data available from 2009 (Table 4.2). There are no weather stations that contain meteorological data for all 12 months of the year within the study period (Table 4.2). Of the weather stations and the possible 132 months of data, Kalahari Farmhouse and Klein Aus Vista have data that is below half of the months in the study period with 60 and 57 months of available data, respectively. Kalahari Farmhouse is the second last in terms of weather stations with monthly data availability, and Klein Aus Vista has the least number of years with recorded climatic data. There are 20 months of the 132 months that have year-round data. The Namib desert, Etosha Safari and Hochfeld have climatic data for nine of the 11 years of the study period and most of the years have more than six months of recorded climatic data (Table 4.2). Swakopmund has the second most complete dataset, while Windhoek has the most complete dataset of the study locations. Swakopmund and Windhoek have 97.6% and 97.7% of the 132 possible months of data. Windhoek has seven of the 11 years having a full 12-month dataset and only three months missing data, while Swakopmund has four months of missing data (Table 4.2).

Table 4.2.: Availability of data for each location of the study over the period 2008-2018.

Year	January	February	March	April	May	June	July	August	September	October	November	December
Etosha Safari												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
Hochfeld												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												

Year	January	February	March	April	May	June	July	August	September	October	November	December
2016												
2017												
2018												
Kalahari Farmhouse												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
Klein Aus Vista												
2008												
2009												
2010												
2011												
2012												
2013												

Year	January	February	March	April	May	June	July	August	September	October	November	December
2014												
2015												
2016												
2017												
2018												
Namib Desert												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
Swakopmund												
2008												
2009												
2010												
2011												

Year	January	February	March	April	May	June	July	August	September	October	November	December
2012												
2013												
2014												
2015												
2016												
2017												
2018												
Windhoek												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												

	Data available
	No data available

The datasets required data sorting for the final calculation of the TCI. Mean monthly averages, maximum and minimum temperature, total monthly rainfall and mean monthly wind speed were calculated and input into an excel spreadsheet. Sunshine hour for Windhoek over the period 2011-2018 was not supplied in the required format for the TCI calculation. Mean monthly relative humidity and mean monthly minimum relative humidity, across the dataset for each location, were not included in the dataset retrieved from the Namibian Weather Network. Additional calculations were required for these components to produce a useable value as an input into the TCI calculation.

4.3. CALCULATION OF THE TCI

Quantifiable measurements on the year-round spatial and temporal distribution of the TCI are useful for resource management, including the adoption of alternative tourism products, strengthening of conservation of natural resources, control over the scale of tourism activity for the mitigation and adaption to the impacts of climate change on tourist destinations (Roshan *et al.,* 2016; Fitchett and Hoogendoorn, 2018; Noome and Fitchett, 2019; Zhong *et al.,* 2019). Ideally, an appropriate tourism climate index is simple to calculate, use and understand and can integrate the effects of all facets of climate (Tang, 2013). Thus, the TCI is an appropriate index for calculating the climatic suitability of Namibia for tourism as it meets these requirements.

The TCI used in this study was originally developed by Mieczkowski (1985) and was formulated to incorporate all three aspects of climate most relevant to tourism; namely, thermal comfort, physical and aesthetic components (Scott *et al.,* 2004; de Freitas *et al.,* 2008; Perch-Nielsen *et al.,* 2010; Scott *et al.,* 2016). Seven climatic factors are combined to produce the five components needed to calculate the TCI score, this value indicates the most suitable time of year (climatically) for tourists to visit a destination (Fitchett *et al.,* 2017). The formula incorporates different aspects of climate to allow for the quantification of the effects of climatic conditions on tourism (Mieczkowski, 1985; Amelung *et al*., 2007). The TCI was originally formulated to incorporate 12 climate variables, but due to restrictions in commonly available data the formula was reduced to seven climate variables (Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014). Thus, the climate variables needed for the calculation of the TCI are standard meteorological variables and are generally captured by all weather stations around the world. Since the original index by Mieczkowski (1985), there have been a number of different techniques created to measure climatic suitability for tourism, as stated in *The Tourism Climate Index* under *Chapter 2: Literature Review*. The TCI has been widely used in international studies, this prompted the use of the tourism-climate index for studying tourism and climate in Namibia (Scott *et al*., 2004; Amelung and Viner, 2006; Amelung *et al*., 2007; Amelung and Nicholls, 2014; Kovács and Unger, 2014; Fitchett *et al.,* 2016a; Hoogendoorn *et al.,* 2018).

This adapted version of the TCI has produced successful outputs in several recent studies (Roshan *et al.,* 2016; Noome and Fitchett, 2019). As such, the adapted version of the TCI by Perch-Nielsen *et al* (2010), based on the original version of TCI by Mieczkowski (1985), will be used for comparability with the resultant TCI outputs in the global North, and other locations that have used this formula:

$$\mathbf{TCI = 2(4CD - CA + 2\mathit{R} + 2\mathit{S} + \mathit{W}).}$$

The calculation includes five components that are essential for tourism satisfaction. According to the TCI, the outdoor climate of a travel destination is heavily influenced by: thermal comfort (CD), average thermal comfort (CA), mean monthly sunshine hour (S), total monthly rainfall (P) and mean monthly wind speed (W). *CD* is based on the mean monthly maximum daily temperature combined with minimum relative humidity. *CA* is the combination of mean monthly average temperature and mean monthly relative humidity. *S* is calculated by dividing the mean monthly daily sunshine hours by the number of days in the given month, in other words either a 30 or 31- day month. *R* is the recorded total amount of precipitation for the relevant month. *W* is calculated by averaging the wind speed values of a given month (Table 1; Mieczkowski, 1985; Perch-Nielsen et al., 2010; Roshan *et al.,* 2016; Fitchett *et al.,* 2017). In the calculation, these five components of the TCI are assigned weights according to their perceived importance to tourist satisfaction (Table 4.3). The end result score for each of the factors has the potential to either increase or decrease the mean annual TCI score for the study location.

Table 4.3: The assigned weighting to the five sub-indices of the TCI.

Sub-index	Required climatic Variable(s)	Weighting
Daytime thermal comfort (CD)	Mean monthly maximum temperature (°C)	40%
	Mean monthly minimum relative humidity (%)	
Average thermal comfort (CA)	Mean monthly temperature (°C)	10%
	Mean monthly relative humidity (%)	
Rainfall (P)	Total monthly rainfall (mm)	20%
Sunshine (S)	Daily sunshine (hr)	20%
Wind (W)	Monthly average wind speed (km/h)	10%

Sunshine data was not in the required format for the TCI calculation for Windhoek over the period 2011 to 2018. Over this period, sunshine data for Windhoek was recorded as maximum solar w/m^2, instead of a monthly average in hours. To rectify this for the degree of measurements to be in the same units to calculate the TCI, a monthly average was calculated based on previous the data of the previous years. *S*, along with R and *W*, are rated on a scale from 0 to 5, the value is input into the TCI calculation (Table 4.4; Mieczkowski 1985, Perch-Nielsen *et al.,* 2010).

Table 4.4: Ratings of P, S and W components of the TCI [after Mieczkowski (1985), sourced from Roshan *et al.,* 2016].

Rating	Mean monthly precipitation (mm)	Mean monthly sunshine hours (h/day)	Wind speed (km/h)
5.0	0.0-14.9	>10	>2.88-5.75
4.5	15.0-29.9	9	5.76-9.03
4.0	30.0-44.9	8	9.04-12.23
3.5	45.0-59.0	7	12.24-19.79
3.0	60.0-74.9	6	19.80-24.29
2.5	75.0-89.9	5	28.80-38.52
2.0	90.0-104.9	4	
1.5	105.0-119.9	3	
1.0	120.0-134.9	2	
0.5	135.0-149.9	1	
0	>150	<1	>38.52

Relative humidity was not included in the dataset. To calculate the monthly mean relative humidity the monthly average mean temperature was combined with the mean monthly dew point temperature. For minimum relative humidity, the value of the day with the lowest difference between the average temperature and the dew point temperature was used. To calculate CD and CA, the TCI uses a curved thermal rating system adapted from the ASHRAE (1972) standardised effective temperature method (Figure 4.1; Mieczkowski, 1985; de Freitas *et al.,* 2008; Perch-Nielsen *et al.,* 2010). *CD* was calculated by juxtaposing mean monthly maximum temperature (°C) for each available month of the seven locations which were plotted on the x-axis of the curved thermal rating system with mean monthly minimum relative humidity (%) on the y-axis. The resultant numerical value for *CD* is inserted into the TCI calculation for the final calculation over an overall monthly TCI score. Mean monthly temperature (°C) was measured along the x-axis against mean monthly relative humidity (%) along the y-axis to derive *CA* for the TCI calculation (Figure 4.1; Mieczkowski, 1985).

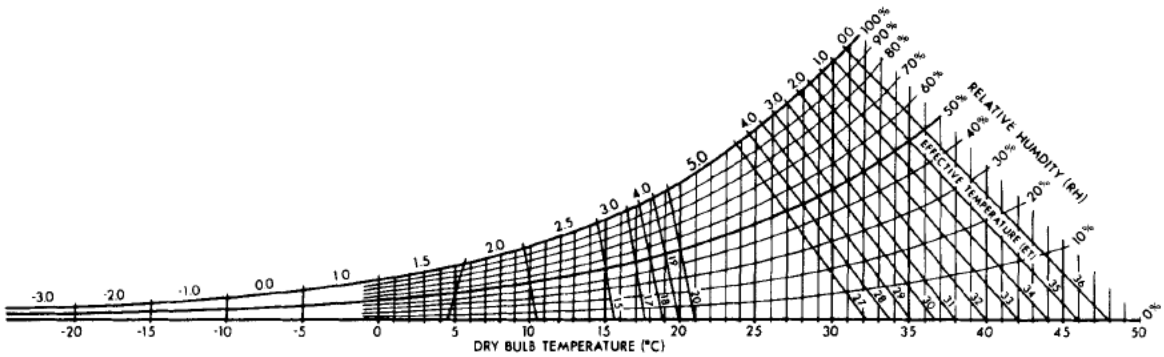


Figure 4.1: A modified version of the ASHRAE effective temperature rating system used by Mieczkowski (1895) to derive the CD and CA values for the TCI calculation.

The suitability of the climatic conditions for the seven study locations for tourism is classified by the resultant output value of the TCI calculation which is a score out of 100. The highest monthly TCI score, for instance, is February 2008 in Swakopmund with a score of 96: 2[(4x5) + 4 + (2x5) + (2x5) + 4) = 96. Thus, February in Swakopmund had 'ideal' climatic conditions for tourism in 2008 (Table 4.5). According to the TCI classification system rating, the minimal climate rating considered 'acceptable' for tourism are TCI scores between 50 and 59, climatic conditions that are considered 'good' are TCI scores between 60 and 69, 'very good' climate for tourism has conditions ranked 70 to 79, 'excellent' conditions receive scores for 80 until

89; after which the climatic conditions is classified as 'ideal' (Table 4.5; Perch-Nielsen *et al.,* 2010).

Table 4.5: Rating category classification system of the resultant output TCI score (after, Perch-Nielsen *et al*., 2010; Siedlecki, 2015).

TCI Score	Descriptive Category	Mapping Category
90-100	Ideal	Excellent
80-89	Excellent	
70-79	Very good	Very good
60-69	Good	
50-59	Acceptable	Acceptable
40-49	Marginal	
30-39	Unfavourable	Unfavourable
20-29	Very Unfavourable	
10-19	Extremely unfavourable	
>10	Impossible	

4.4. SPATIAL DISTRIBUTION OF THE TCI

Scott and McBoyle (2001) developed a system to classify tourist destinations into one of six annual climatic typology distributions. The six tourism-climate typologies; namely: year-round optimal, poor, summer peak, winter peak, bi-modal shoulder peak and dry season peak, describe the tourism climate resources of the chosen destination (Figure 4.2; Bakhtiari *et al.,* 2018). "Optimal' conditions relate to months of the year with TCI scores <80. Destinations with TCI scores >40 would be classified as having ‘poor’ year-round climate for tourism (Bakhtiari *et al.,* 2018). ‘Summer’ and ‘winter peak’ curves differ between the northern and southern hemisphere, where summer in the southern hemisphere is between December, January, February while the is considered winter in the northern hemisphere. If the spring and autumn months are revealed to be the more suitable time of year for tourism a ‘bi-modal’ or ‘shoulder peak’ distribution will manifest (Scott *et al.,* 2004). Tourism at destinations with wet and dry seasons is strongly influenced by precipitation (Scott et al., 2004). Mean monthly TCI scores and classifications for each study location over the study period were averaged to produce an annual TCI score and determine the classification for each study location.

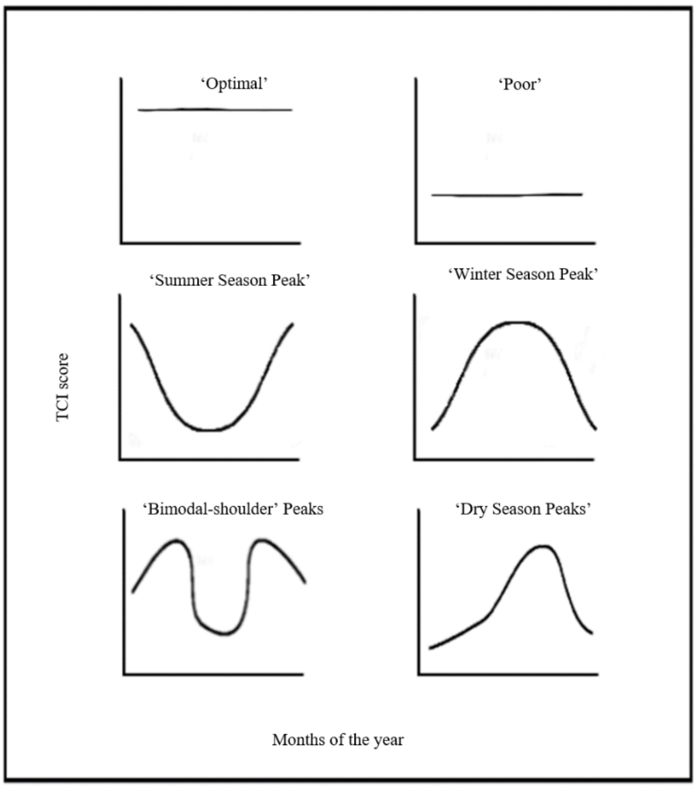


Figure 4.2: The annual TCI score distributions for bi-modal shoulder peak and summer and winter season peaks in southern Africa are inversed for those of the northern hemisphere (adapted from Scott and Boyle, 2001).

4.5. SEASONAL DISTRIBUTION MAPPING OF THE TCI USING ARCGIS

Providing climatological and meteorological data products covering a whole country in the form of maps or gridded datasets is an important task (Sluiter, 2009). Recent research on the interpolation of climatological and meteorological information using GIS has momentous potential for the development and improvement of prioritising implementation and decision-making within climatology and meteorology frameworks (Farajzadeh and Ahmad, 2010; Dobesch *et al.,* 2013; Fang and Yin, 2015). Interpolation is a method whereby surfaces are created, based on either the extent of similarity, from measured points (Apaydin *et al.,* 2004). Explicitly, this is the assumption that objects with a closer distance to one another are more similar than those that are farther apart (Apaydin *et al.,* 2004). Thus, IDW assumes that each measured point is weighted such that the local influence of one point relative to another diminishes with distance (Apaydin *et al.,* 2004).

Mapping the spatial distribution of the TCI scores within Namibia helps in the identification and analysis of climate suitability of a destination for tourism. First, the database was created in Excel with the seasonal TCI score mapping requiring sorting of the monthly TCI scores into spring, summer, autumn, and winter. An Inverse Distance Weighting (IDW) analysis was conducted for the TCI score by turning the points into interpolated raster cells through ArcGIS software. The shapefiles required for the Namibian borders and digital elevation were sourced from online website: DATADiva. Once the relevant TCI files for an overall and seasonal TCI distributions were prepared and exported into ArcGIS 10.4, an IDW interpolation was performed. This process of interpolation of the available data allows for an interpolated analysis possibility for the whole of Namibia.

4.6. SYNOPSIS

Weather and climate are valuable for a number of tourist activities, including beach and sight-seeing tourism (Rutty and Scott, 2010; Rutty, 2014). Without research into the relationship between tourism and climate, climate change is expected to have far-reaching consequences for the future of travel and tourism (Scott *et al.,* 2019a). Changes to climate resource availability and temporal distribution relevant for tourism can influence tourist responses to activity, demand and travel choices (Steiger *et al.,* 2019). Thus, it is therefore imperative that the relationship between climate change and tourism is explored in detail. This research uses a method that could assess changes to tourism suitability based on climatic changes through a numerical calculation. The TCI calculation will reveal the suitability of the study locations for tourism singularly as well as in relation to each other on an annual and seasonal scale, based on available climatic data over the period 2008-2018.

CHAPTER 5: RESULTS

5.1. INTRODUCTION

This study involves the use of seven aspects of climate, including mean monthly temperature and monthly total rainfall, mean monthly maximum and minimum temperature, mean and minimum relative humidity, wind speed and sunshine hour, from seven weather stations distributed across Namibia. Due to data restrictions, the study is conducted over a 10-year period from 2008—2018. The purpose of this research is to quantify the suitability of climate for outdoor tourism in Namibia. This chapter presents the results of a TCI analysis for all seven of the weather stations, starting with a description of the climate data availability in Namibia. Next, the results of the TCI calculation through a study period mean, annual mean, monthly mean and seasonal distribution of the TCI scores. Lastly, the results identifying the factors that influence the TCI, which components of the TCI decrease or increase the final TCI score. The interpretation of these results is presented under *Chapter 6 (Discussion).*

5.2. CLIMATIC COMPONENT RESULTS

The original TCI developed by Mieczkowski (1985) was formulated to incorporate all three aspects of climate that are considered relevant to tourist satisfaction (Amelung *et al.,* 2007). The calculation originally incorporated 12 climate variables which was reduced to seven variables due to a clack of commonly available climate data (Perch-Nielsen *et al.,* 2010). The dissemination of the importance of each component and the contributed weighting of the component for the final TCI score is explained in *4.3. Calculation of the TCI* under *Chapter 4: Methods.*

5.2.1. Temperature and rainfall

Mean monthly temperatures for the majority of the weather stations throughout the year follow the seasonal distribution of Namibia. The higher mean monthly temperatures are located between September and February, which are the spring and summer months of Namibia (Table 5.1). The starting month of summer (December) is revealed to be the hottest month of the year for four of the seven weather stations, namely Etosha Safari, Hochfeld, Kalahari Farmhouse and Windhoek (Figure 5.1). Maximum temperatures can reach >40°C for Etosha Safari, Kalahari Farmhouse and the Namib Desert during the summer months. Etosha Safari, Kalahari Farmhouse and the Namib Desert have mean monthly temperatures that range from upper 20°C to 9.8°C, 10.3°C and 13.1°C, respectively (Table 5.1).

The three weather stations located along the west and south-western coast of the country (Swakopmund, Namib Desert and Klein Aus Vista) experience their hottest month in February, the last conventional month of summer in Namibia (Figure 5.1). Each have a different month that has the coldest mean monthly temperature; Swakopmund, the Namib Desert and Klein Aus Vista experience the coldest mean monthly temperatures in August, June and July, respectively. The coldest mean monthly temperatures are displayed in the middle of the year (June, July and August) which are deemed the winter months of Namibia (Figure 5.1). Kalahari Farmhouse is the only weather station where mean minimum temperature reaches below 0°C.

Table 5.1: Monthly total rainfall, mean monthly and mean maximum and minimum temperatures of the weather stations over the period 2008—2018.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Etosha Safari												
2010												
T_{Max}			31.6					30.5	34.5	33.1		34.5
T_{Min}			19					12.2	15.6	13.6		18.6
Rainfall			130.8					0	0	22.4		70
2011												
T_{Max}	30.9	30.3	29.5	29.1			25.6	25.7				
T_{Min}	18.2	18.3	17.8	16.3			7.4	7.5				
Rainfall	129.8	166.3	6.6	7.6			0	0				
2012												
T_{Max}			30.5					30.7		37.3		34.8
T_{Min}			16.3					11.5		17.3		18.2
Rainfall			75.2					0		5		52.6
2013												
Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T_{Max}				33	29.9	28.4	27.9	30.5	34.5	36.8	36.4	33.6
T_{Min}				15.2	13.4	10.6	10.7	10.7	14.6	18.2	18.7	18
Rainfall				1	0	0.3	0	0	0	1.8	55.4	103
2014												
T_{Max}	34.5	32	29.5	29	29.9	27.2	27.9	31.8	34	37.1	35.2	
T_{Min}	17.4	18.9	17.2	16	13.5	10	9.5	11.8	15.7	17.1	18.2	
Rainfall	300.2	74.2	154.2	65.8	0	0	0	0	1.2	2.2	42.6	
2015												
T_{Max}		37.9		32.9	28.4		27.2	31.1		33.7		33.5
T_{Min}		18.6		17.5	14		13.4	17.7		23.1		20.2
Rainfall		6		11.4	0		0	0		0		0
2016												
T_{Max}	35.4	35.9	34.9	33.8	29.9	28.1	27	31.1	35	37.8	26.1	

T_{Min}	19.1	20.9	18.5	18.9	14.4	12.6	10	14	15	19.1	20.2	
Rainfall	21.8	53.2	38.8	25.4	0	0	0	0	0	3.2	25.2	
2017												
T_{Max}	32.2		31.2	27.1	28.6	27.2	27.3		36.9		36.2	36
T_{Min}	18.4		14.6	13.9	11.5	11.3	17.8		17.8		19.1	19.1
Rainfall	132.8		63.6	58.7	0	0	0		0.3		5.6	141.2
2018												
T_{Max}	37		29.1	30.3	30.1	27.2	29	31.4		33	33.9	33.4
T_{Min}	19.1		18.8	15.3	13	10.2	13.9	11.4		17.3	19.2	19.2
Rainfall	63		166.9	139	0	0	0	0		16.3	13.2	27.4
Hochfeld												
2008												
T_{Max}		23.1	25.8	25.7	25.5	23	22.2	26	31	32.9	31.1	30.2
T_{Min}		12.5	14.9	9.2	7	3.2	3.2	6.5	9.7	15.9	15.7	15.8
Rainfall		246.4	116	32	8	0	0.7	0.3	1.2	8	41	114
2009												
T_{Max}	30.3	26.4	28	26.6	25.1		20.1	26.1	30.1	30.8		33.2
T_{min}	16.5	16.1	12	10.1	7.2		2.7	5.5	11.3	12.6		16.6
Rainfall	98.3	187.1	202.9	25.1	30.9		0	0	0	11.2		121.8
2010												
T_{Max}	27.2	29.9		27			21	24.2		33.8		31.5
T_{min}	17.3	15.5		12.6			4.8	7.1		13.4		15
Rainfall	191.3	50.8		28.1			3.7	0		0		76.6
2011												
T_{Max}	27.4	27.6	27.5						29.8			29.7
T_{min}	16.4	15.9	16						9.5			17.5
Rainfall	388.9	155.1	204.4						2.4			115
2012												
T_{Max}	27.6		27.6	26.5	27.1	22.6	22.8	26.5	30.3		32.2	30.7
T_{min}	18.3		13.2	9.6	22.8	2.3	1.8	5.5	8.8		16.3	15.6
Rainfall	142.2		127.2	18.4	0	0	0	0	0		97.9	95.5

2013												
T_{Max}	32.4	33.3	31	28.5	25.9	24.1	23.4	25.9	29.8	32.4	32.8	28.9
T_{min}	17.4	16.4	15.2	10	7.5	4.4	4.2	4.7	10.6	15.6	15.7	16
Rainfall	65.9	45.3	58.9	0	1.1	0	0	0	4.6	19.5	24.8	210.4
2014												
T_{Max}	29.5	26.9	28.2	25.2				26.3	29.7			
T_{min}	14.9	16	14.9	10.8				7	10.1			
Rainfall	123.7	241.4	76	93.8				0	0			
2015												
T_{Max}				26.9	21.7	22	23.8	28	32.2	31.4	34.1	31.6
T_{min}				12.1	11.3	2.8	3.9	7.9	12	17.1	15.4	17.7
Rainfall				24.4	0	0	0	1.4	0	2	0.4	66.6
2016												
T_{Max}	31.8	32.7	29.5									
T_{min}	17.6	17.1	14.1									
Rainfall	93.2	50	25.2									
Kalahari Farmhouse												
2009												
T_{Max}											37.6	37.7
T_{min}											20.7	19.3
Rainfall											2.8	15
2010												
T_{Max}	32.9	33.5	34.3	30.9		16.9						
T_{min}	17.7	19.1	18.3	14.6		8						
Rainfall	141	42.5	14	10.1		0.6						
2011												
T_{Max}	33.1						22.3	30.1		32.9	35.1	36.1
T_{min}	20.2						-1.9	3.7		9.1	11.7	17
Rainfall	134.2						0	0		0	3.8	2.6
2013												

T_{Max}										34.3	36.3	33.7
T_{min}										10.9	14	18.5
Rainfall										0	2.8	15.4
2014												
T_{Max}	34.8	31.7	32.7	30	29.7	25.1	24.5	26.1	31.4	34.8	34.3	
T_{min}	18.3	17.6	14.4	9.8	5.8	1.3	-0.1	2.9	8.5	9.7	13	
Rainfall	5.6	73.6	77.8	0	0	0	0	0	0	0	2	
2015												
T_{Max}	35	31.7										37.9
T_{min}	18.7	16.5										20
Rainfall	0	0										14.8
2016												
T_{Max}			33.1	32.6		29.9	23.3		30.7	35.4	37.6	37.7
T_{min}			14.1	13.3		2.7	0		6.9	11.4	17.3	21
Rainfall			66	16.4		0.8	0		0	0	2.6	18.6
2017												
T_{Max}	34	33.9		28.8	27.6	26.4		28.1		32.6	35.4	36.8
T_{min}	18.8	19.3		13.8	7.1	4.4		3.7		12.4	14.9	17
Rainfall	78.6	43.6		27.4	0	0		0		8.2	2.2	3.6
2018												
T_{Max}	38	33.9	32.2	30.6	28	26.3	22.6	25.3	30.1	32.7	36.5	37.6
T_{min}	19.8	18.9	18.3	15.1	6.5	1.6	4.7	1.9	6.9	13.8	15.1	18.9
Rainfall	1	27	5.4	52.2	0.6	0	3.4	0	0	23.2	5.6	3.2
Klein Aus Vista												
2009												

T_{Max}			27.6	26.8	21.5	17.9	17.7	22	24.1	27.5	27.9	30
T_{min}			14.1	13.3	6.8	5.3	6.3	7.3	8.3	10.9	13.2	14.2
Rainfall			36.6	0.3	2.5	32.4	4.5	15.1	0	0	38	0
2010												
T_{Max}	30.6	30.8	29.2	24.5	18.2	16.8	23.8	26.1	25.6	29.7	27.9	
T_{min}	17.9	16.8	15.3	11.9	17	12.3	11.6	8	10.4	9.4	14	15.3
Rainfall	13.5	23	31.6	0	0.8	0.5	1.5	0	0.6	0	0	0
2011												
T_{Max}				22.2	20.1	17	16.9	21		26.8	25.1	29.4
T_{min}				9.8	8.1	7.6	6.1	6.6		10.7	10.2	13.6
Rainfall				5.6	38.2	2	2	15.6		0	0	0
2012												
T_{Max}	30.7	29.5			23.7	19.8	20.8	18	23.7	27.5	30	
T_{min}	4.9	4.7			9.2	5.4	5.8	8	7.1	11.4	13.6	
Rainfall	1.2	3.3			0	2.6	12.4	32.2	0	0	0	
2013												
T_{Max}		32.6	31.3	27.2		20.5	20.1	19.1	22.6	28	31	30.6
T_{min}		16.7	16.6	11.9		6.6	4.6	4.3	8.1	12.3	14.1	16
Rainfall		0	20.8	3.2		4.6	0.4	6.8	0	0	0	0
2014												
T_{Max}	30.1	31.6		26.2	24.2	18	17.7	20.2	26			
T_{min}	16.9	17.6		13.7	10	8.6	6.2	5.4	10.3			
Rainfall	13.8	13		0	0	0	0.4	0.2	0			
Namib desert												
2010												
T_{Max}	33.5	36		32.4	26.1		19.2		31.4	33.2	32.2	33.2

T_{min}	18.6	19.1		16.3	10.3		14.4		13.6	13.1	14	14.8
Rainfall	12	9.4		4	35.4		0		0	0	2.6	0.2
2011												
T_{Max}	30.8			29.7	26.1	23.9	24.6	28.6				35
T_{min}	17.5			14.7	9.6	3.7	5.4	7.6				13.7
Rainfall	68.6			246.8	42.8	3	0	6.6				0.2
2012												
T_{Max}					30.2		25.3	25.3	28.7	33.6	35.7	32.3
T_{min}					10.2		8.8	6.5	9.1	12.1	15.9	16
Rainfall					1		0.4	1.6	0	0	0	0.2
2013												
T_{Max}	33.3	35.1		31.8	29.8		24.1	26.6	29.7	33.1	33.2	34
T_{min}	16.9	19.9		13.5	11.7		9.5	6	15.5	14.7	14.3	17
Rainfall	1	0.8		0	0		0	0	11.2	0	0	25.6
2014												
T_{Max}	32.2	33.5	32.5	31.3	29.5	25.6	25.1	26.6	31.6	32.1	30.9	33.9
T_{min}	18.2	19	17.7	15.3	12.4	8.6	7.9	6.6	11.9	14.2	15.2	13.8
Rainfall	0.8	26.6	53.8	0	0	0	0	0	4.4	0	0	0
2016												
T_{Max}								29.5	29.4	34.1	34.8	36.3
T_{min}								10.9	11.4	15	16.9	17.8
Rainfall								0	0.2	0	2.2	2.2
2017												
T_{Max}	33.8	33.9	34.5	31.6	29.8	27.3	27.1	28.8	32.5	31.5	34.6	34.9
T_{min}	17	18.9	20.6	17.1	17.7	10.2	10.1	9.5	13.8	12.1	17.2	15.1
Rainfall	7.2	27.4	25.4	21.3	0	0	0	0	0	8.1	0	0
2018												
T_{Max}	34	33.6	32.7		26.5	26.8	25	24.7	29.8	34	34.4	35.8
T_{min}	16.3	17.3	16.1		12.7	9.3	11.5	16.4	10.3	17.2	17	16.2
Rainfall	0	0	13		28.8	0	0	0	0	63.8	0	0
Swakopmund												

2008												
T_{Max}		22.1	22.3	21.9	17	19.4	18.1	17.8	15.9	16.1	17.7	18
T_{min}		18.4	17.4	15.3	11.8	10.4	9.9	10.8	10.8	12.1	13.9	12.9
Rainfall		3.1	11.4	1.7	2.7	2.4	3.6	1.8	0.9	0.9	0.9	0
2009												
T_{Max}	19.9	22.7	22.7	21.3	14.5	14	24.5	16.5	16.9	16	19.7	20.4
T_{min}	15.6	18.9	16.9	15.1	12.5	11.4	13.2	10.3	11.6	13.1	14.6	15.6
Rainfall	1.2	11.2	0.3	0.3	2.4	2.4	0.6	2.5	1.4	1.5	0.6	0
2010												
T_{Max}	21.1		21.8	18.6	15.6	23.2	20.1	24.6	17.1	18.1	19.6	21
T_{min}	16.7		17	13.9	12.7	12.6	11	9.5	10.7	12.5	14.4	15.9
Rainfall	1.9		0	0.3	2	1.4	1.1	0	0	0.3	0	1.1
2011												
T_{Max}	21	23.3	23.3	22.1	19.8	18.7	22.6		18.1	18.7	19.6	20.4
T_{min}	15.9	17.8	18.3	16.4	13.3	9.8	11.8		11.7	12.6	13.2	15.3
Rainfall	1.1	9.3	2.8	43.7	18.3	2.4	1.1		1.9	2.2	0.5	0.5
2012												
T_{Max}	23.7	23.6	23.6	20.7	20.4	22	19.1	16.6	17.3	18.2	19.8	23
T_{min}	17.9	17.8	16.6	14.1	12.3	11.3	10.2	10	10.3	12.3	14.8	16.8
Rainfall	1.8	4.8	3.3	1	2.8	1.3	1.1	1.8	1.6	0.3	0.3	0.3
2013												
T_{Max}	23.1	23.3	23.3	20.9	20.2	18.3	19.5	17.2	17.6	18.3	20.2	22.8
T_{min}	17.1	18.4	16	13.5	12.8	10.4	9.9	9.4	10.9	12.6	13.8	16.7
Rainfall	0.5	1.3	13.2	0	0	0	0	0	12.4	0	1	0.5
2014												
T_{Max}	24.1	24	24	23.9	19.6	21.8	17.5	17.2	17.6	19.2	20.9	20.7
T_{min}	17.9	15.9	15.8	15.9	11.9	12.1	9.1	9.9	11.5	13.1	14.2	15
Rainfall	0	10.2	0.3	0	0	0	0	0	1.3	0	0.3	0
2015												
T_{Max}	23.7	22.2	22.2	23.9	19.6	21.8	17.5	17.2	17.6	19.2	20.9	20.7
T_{min}	18.8	17.7	15.1	14.1	15.5	9.1	9.1	10.5	11.9	13	13.8	16.2

Rainfall	3.8	0	1	0	0.3	0	0	0	0.8	1.3	0	3.3
2016												
T_{Max}	25.5	23.7	23.7	27.7	22.2	23.8	21.2	18.9	18.4	19.1	19.9	20.3
T_{min}	16.9	16.9	16	15.3	12.7	11.4	11.4	10.6	11.9	13.3	14.3	16.6
Rainfall	0	0	3.8	0	0	10.7	2.3	2.3	1.5	0.5	3.8	0
2017												
T_{Max}		21.8	21.8	15.9	16.4	16.9	19.1	15.6	17.2	17.8	19.9	20.3
T_{min}		17.2	17.4	15.6	14.1	12.6	10.6	9.9	12.5	12.6	14.3	15.5
Rainfall		1	0.3	0.5	1.5	2.3	3	3.8	1.5	0	1	0
2018												
T_{Max}	21.7	21.8	21.8	19.7	19	19.9	25.7	16.6	16.5	19.8	19.5	20.3
T_{min}	16.9	16.9	16.2	14.7	12.9	11	13.8	9.4	10.3	14.3	14.2	15.5
Rainfall	0.8	1.3	0	13	16.3	5.1	1	1.8	1.8	1.5	0	0.3
Windhoek												
2008												
T_{Max}	31.6	28.3	26.4	25.8	24.9	22.2	21.4	24.9	29.7	31.7	30	29.9
T_{min}	18.2	17	14.8	11.6	9.3	5.6	5	8.7	11.4	16.1	17.1	17.1
Rainfall	72.6	194.9	191.3	10.7	2.9	0	0	0	0	33.2	65.6	43.1
2009												
T_{Max}	31.6	27	28.1	27.4	24.5	22	19.3	25.6	31.2	30.7	31.1	34.1
T_{min}	16.7	16.8	14.3	13.4	9.2	6.4	5.3	8.9	16.9	15.7	15.8	18.6
Rainfall	77.1	302.7	69.6	8.1	29.3	0.6	0	0	12.6	3.1	5.9	32.9
2010												
T_{Max}	28.6	30.9	29.2	22.3	17.9	17.1	21.8	26.3	33.7	32	31.7	31.7
T_{min}	17.1	17.4	17.4	17.3	12.5	11	7.1	9.7	17.3	16.3	13.1	16.7
Rainfall	25.1	25.6	50.2	37.7	11.4	0	0	0	25.4	0	110.2	20.5
2011												
T_{Max}	28.2	27.8	26.9	25.5	23.5	21.8	21.1	25.7	30.1	30.1	31.8	31.6
T_{min}	17	16.6	16.3	13.3	10.1	4.5	5.2	8.8	13.4	13.8	15.8	18.6
Rainfall	383.6	175	296.1	231.7	67.3	0	0.2	0	9.4	0	12.6	45

2012												
T_{Max}	31.3	28	28.2	26.5	25.5	22	22	24.9	29.4	33.1	29.5	31.9
T_{min}	18.1	16.5	14.8	12	10	5.2	5.6	8.8	11.1	17.8	17.8	17.4
Rainfall	59.2	180.6	113.6	14.2	0	0	0	0	0.6	1.2	19	43.8
2013												
T_{Max}	33.9	34	31.3	27.9	25.5	23.7	22.7		27.5	32.2	31.1	30.3
T_{min}	19.7	19.1	17.6	12.9	10.7	7.6	7		12	15.5	19.3	17.3
Rainfall	21.6	31.2	79.4	0.8	0	0	0		12	1.6	2.8	98
2014												
T_{Max}	30.2	27.9	27.9	25.8		22.1	22.7	25.3	29.4	31.8	30.9	33.2
T_{min}	16.7	17.5	15.6	12.7		7	6	8.7	13.5	15.1	15.6	17.9
Rainfall	108.6	154.2	127.4	16.61		0	0	0.2	1.6	1	21	44.2
2015												
T_{Max}	32.2	33.2	27.3	26.8		21.7	22.6	27.4	28.8		32.8	31.8
T_{min}	18.7	17	15.5	13.4		4.7	5.9	10.9	15.8		16.8	19.8
Rainfall	81.8	2.2	65.2	70.6		0	0	2.4	0.2		10.6	83.6
2016												
T_{Max}	32.6	33.5	30.2	29.8	25.4	24.1	21.1	26.8	29.5	33.2	33.4	32.7
T_{min}	18.6	19.8	15.7	16.1	11.3	8.6	3.9	10.7	12.8	18.1	18.4	18.2
Rainfall	124.8	68.8	47.2	16.2	0	16.2	0	0	0	2.8	26.2	13.8
2017												
T_{Max}	30.1	29.1	28.2	26	20.5	23.5	24	26	31.9	30.9	31.5	33.2
T_{min}	18.5	19.1	16.6	13	12.2	8.3	8.2	9.3	16.1	13.7	16.9	18.6
Rainfall	96	89.6	79.6	71	0	0	0	0	1.4	26.8	3.4	45.6
2018												
T_{Max}	33.6	32	29.8	27.1	25.1	23.9	21.2	25.6		31.3	34.1	33.2
T_{min}	19.3	18.4	16.9	14.2	10.6	7.7	7.7	7.9		17.1	19.3	18.9
Rainfall	6.2	33	77.6	99.8	11	0	0.4	0		11.4	3.4	53

Additionally, these three weather stations also divert from the rainfall seasonality of the other stations and receive highest rainfall in the autumn months of Namibia, rather than the summer months (Figure 5.1). Swakopmund and the Namib Desert have the most rainfall in April, while Klein Aus Vista experiences the most rainfall in March. Swakopmund and Klein Aus vista receive notably less rainfall than any of the other weather stations with the highest total rainfall of the dataset measured at 43.7mm and 38.2mm, respectively (Table 5.1). Etosha Safari, Hochfeld, Kalahari Farmhouse and Windhoek have peak rainfall in the summer months, January for Etosha Safari, Hochfeld and Kalahari Farmhouse, and February for Windhoek (Figure 5.1). Hochfeld receives the highest total rainfall in January 2011 with 388.9mm (Table 5.1). Windhoek was the second highest with 383.6mm of total rainfall of the same year and month, January 2011 (Table 4.2).

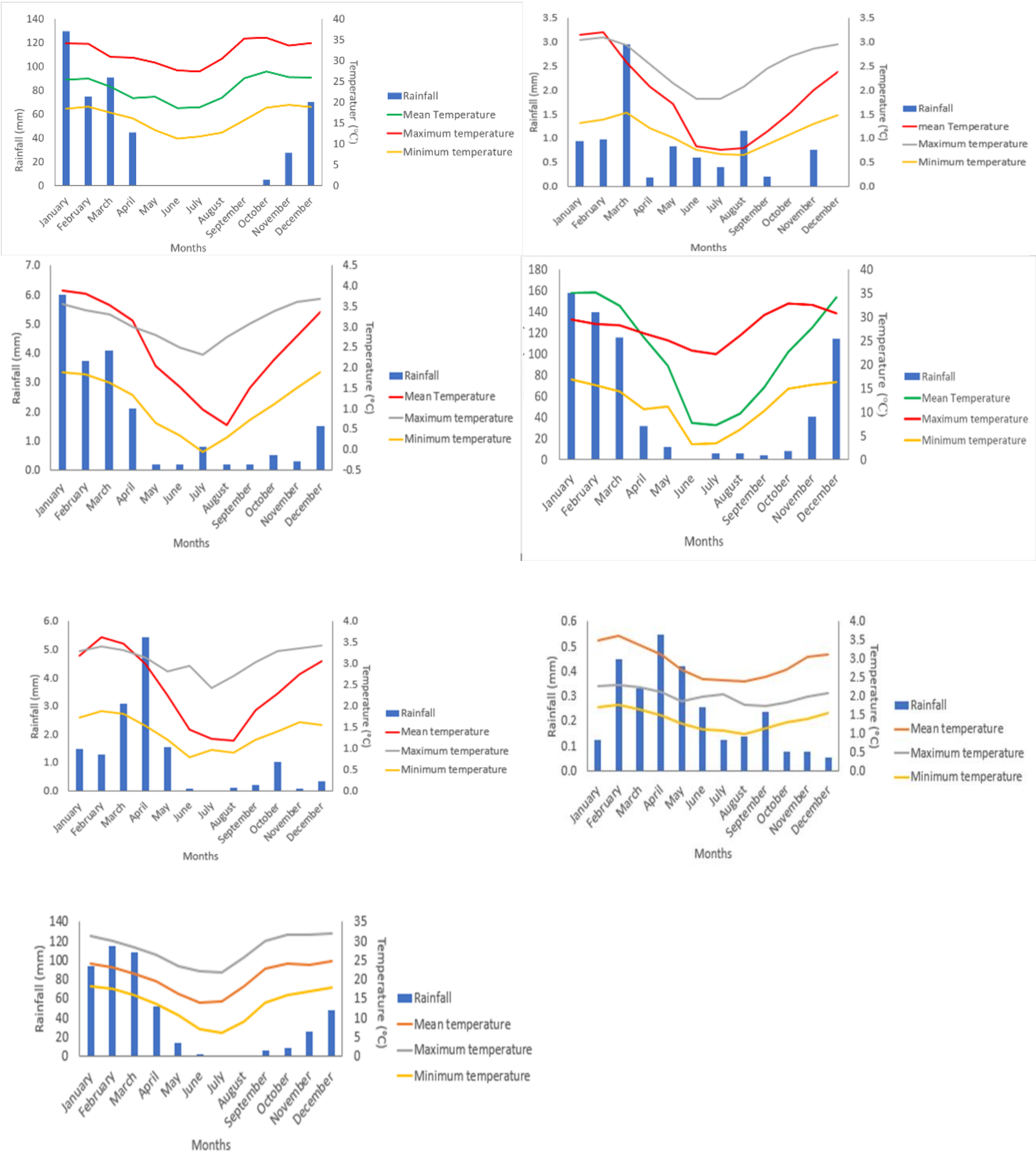


Figure 5.1: Monthly rainfall totals and mean monthly temperature and mean monthly maximum and minimum temperature for individual weather stations (from top left): a) Etosha Safari, b) Hochfeld, c) Kalahari Farmhouse, d) Klein Aus Vista, e) the Namib Desert, f) Swakopmund, and g) Windhoek.

5.2.1. Relative humidity

Mean monthly relative humidity for Namibia follows the distribution evident in majority of the weather stations regarding monthly total rainfall pattern, mean monthly temperature, and mean monthly maximum and minimum temperatures over the period 2008—2018 (Figure 5.2.). February and December have the highest mean monthly relative humidity readings throughout the study period, these months fall within the summer months of Namibia. This corresponds to the main peak in monthly total rainfall, mean and maximum temperature, for the majority of the weather stations. The winter months experience low mean relative humidity during the same time that the mean monthly rainfall, average, maximum and minimum temperatures decrease. The mean monthly relative humidity starts to rise from September, the beginning of spring in Namibia.

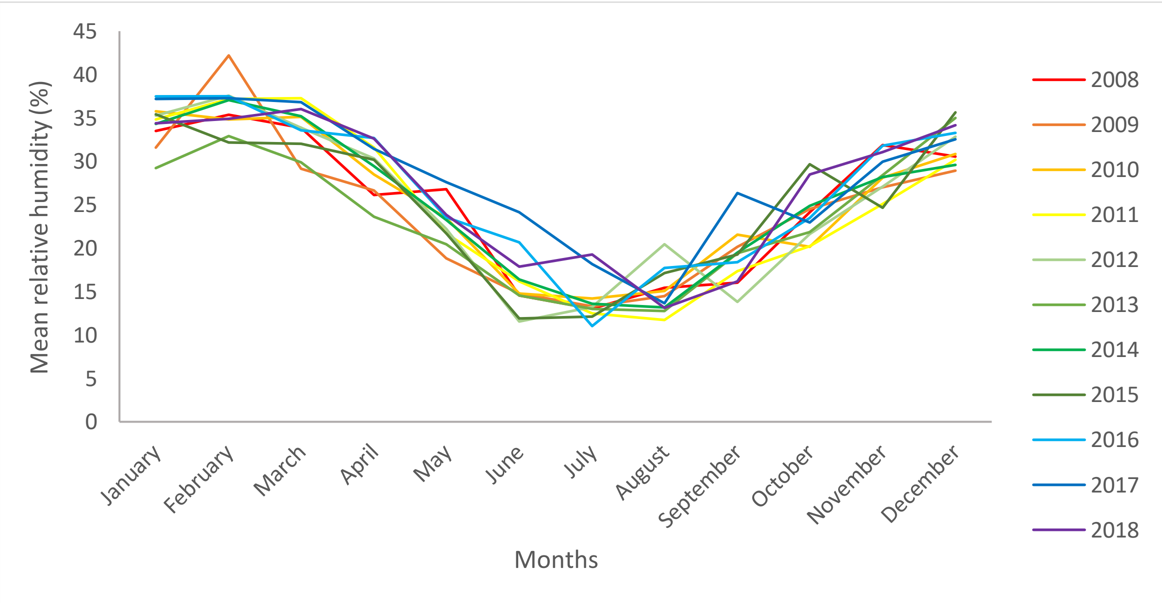
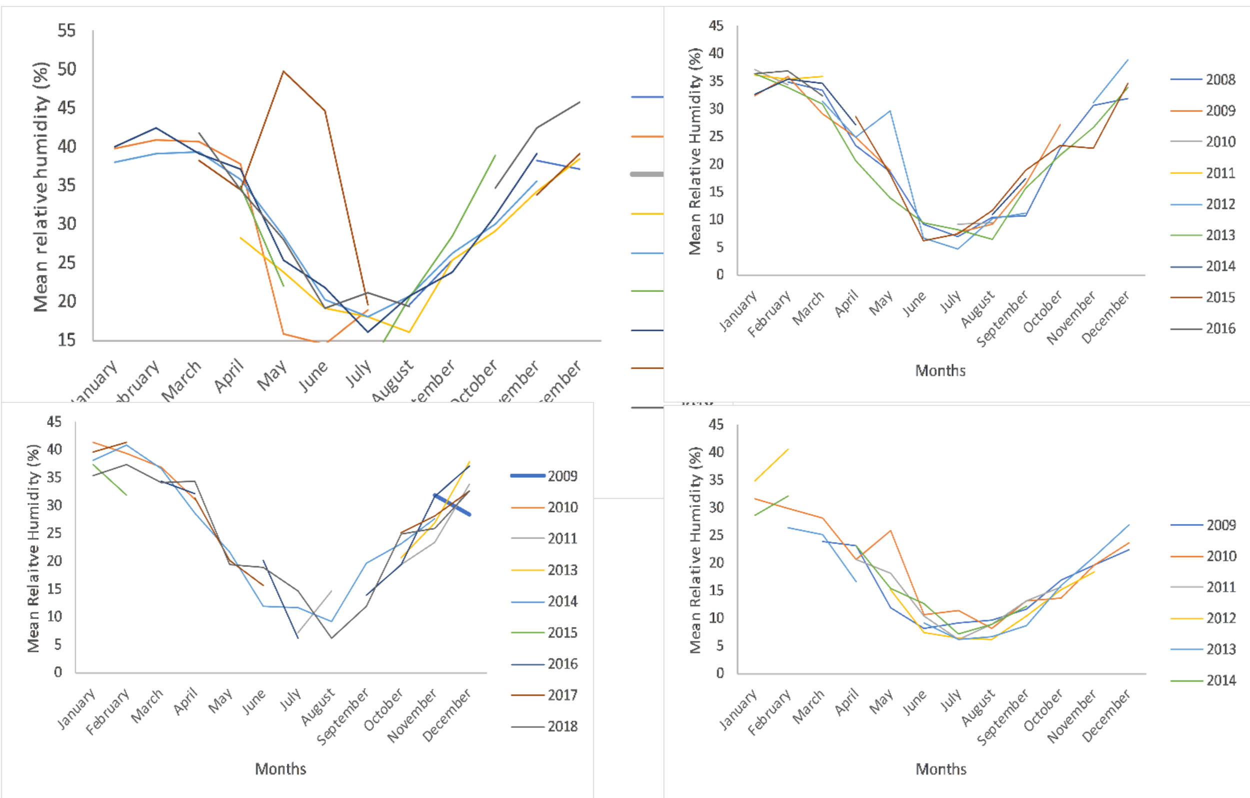


Figure 5.2: Mean monthly relative humidity distribution of all seven weather stations for each month of the year in Namibia, over the period 2008—2018.

Individual weather stations reveal a general distribution of higher mean monthly relative humidity is found in the summer months of the year; this falls into the summer peak category (Figure 5.3). Hochfeld, Kalahari Farmhouse, Klein Aus Vista, the Namib Desert and Swakopmund have bi-modal mean monthly relative humidity peaks, that also resembles a summer mean monthly relative humidity peak (Figure 5.3). Although Etosha Safari and

Windhoek loosely resemble the distribution of the other weather stations, these two stations have outliers. Etosha Safari reveals a sharp peak in mean monthly relative humidity in May (2017) that slowly decreases until July where it rapidly descends. Aside from this arbitrary peak, the other months and years resemble the general distribution of the overall study mean monthly relative humidity (Figure 5.3). Windhoek, on the other hand, has three peaks, in three different months, over three different years. There are sharp peaks in mean monthly relative humidity in February (2009), May (2008) and most noticeably in August (2012; Figure 5.3).



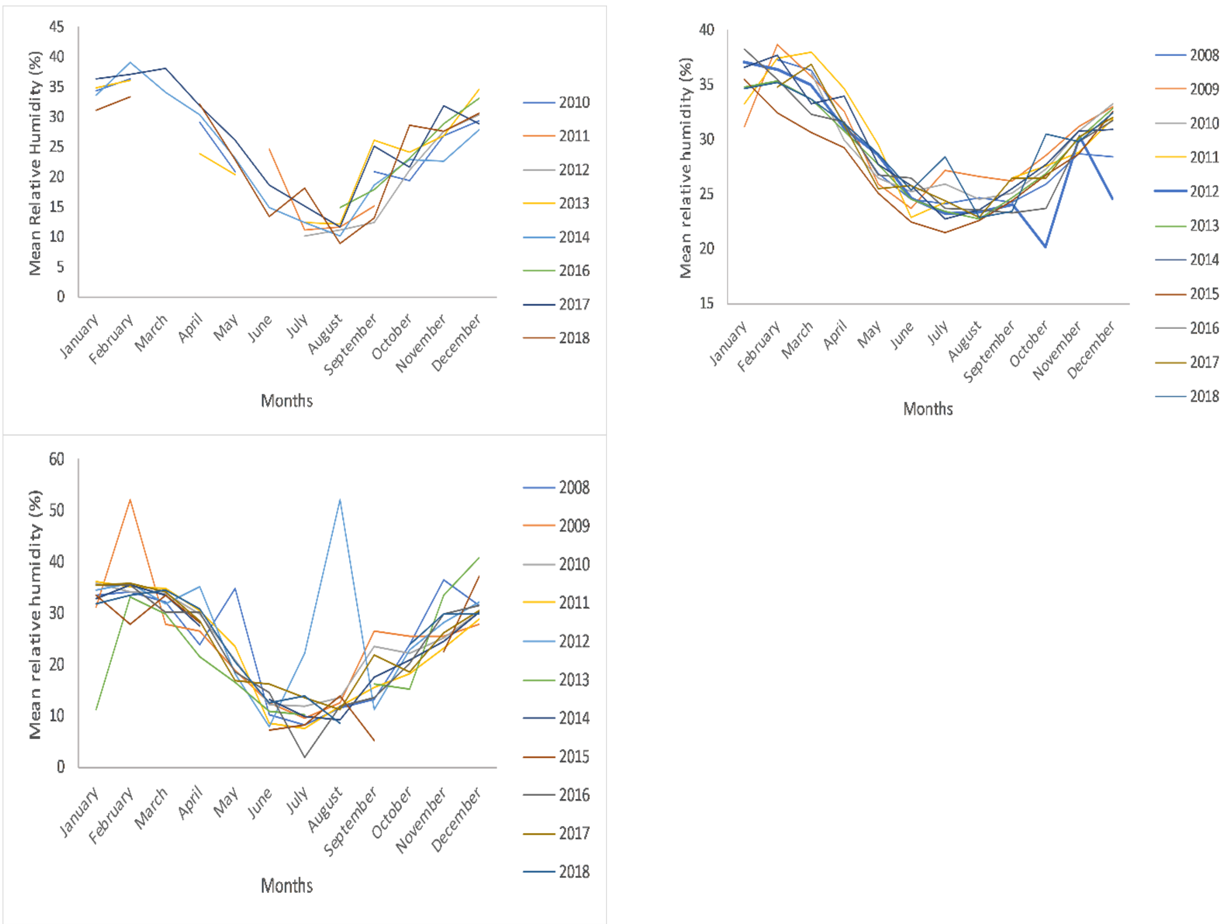


Figure 5.3: Mean monthly relative humidity of the individual weather stations over the study period 2008—2018.

5.2.2. Sunshine hour

Sunshine hours appear to be consistent throughout the year, with no steady increases in one season over another for the weather stations over the period 2008 to 2018. There is a slight curve that seems to favour the autumn and winter months (April to July), in terms of higher sunshine hours. January, February, March and October appear to have more decreases in sunshine hours, this may be due to precipitation, for example rain or fog. Most notable are a number of outliers that are evident in the dataset, namely January to June of 2008 and July of 2010 (Figure 5.4). Sharp increases in sunshine hours can be seen for these months. This is not consistent with the patterns seen in mean temperature, rainfall, and relative humidity which clearly fit into a seasonal pattern and distribution—specifically, winter as a suitable climate for tourism, according to the TCI. This suggests that 2008 and 2010 do not fit into the sunshine per day distribution in Namibia. However, sunshine throughout the year in Namibia is, for the majority, consistent with the literature under *Chapter 3: Study Region*.

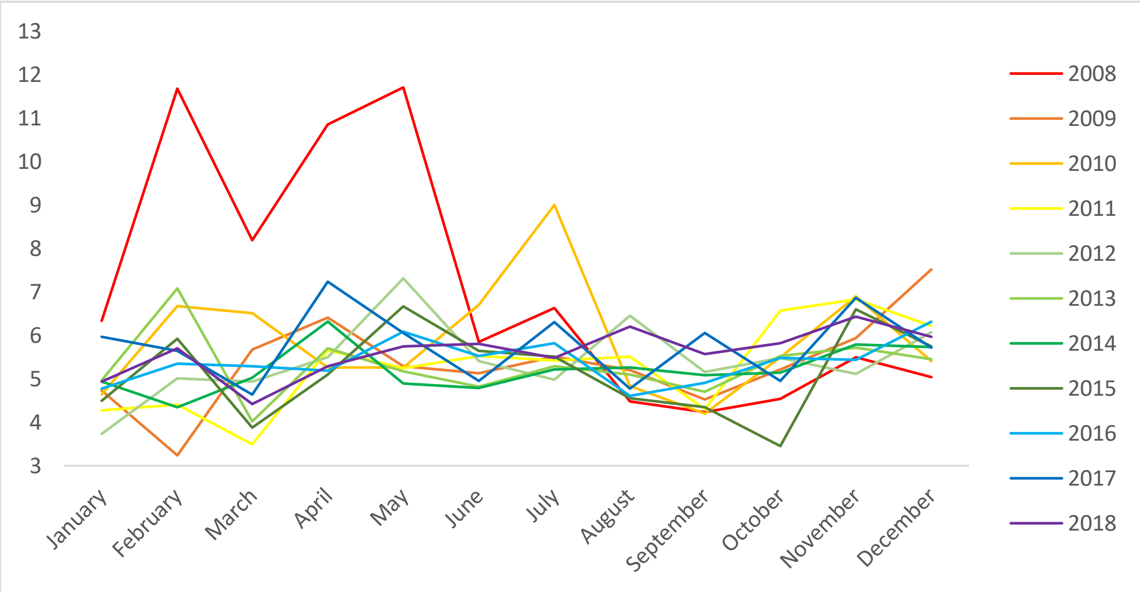


Figure 5.4: Mean daily sunshine hour for the overall study period 2008—2018.

5.2.3. Wind

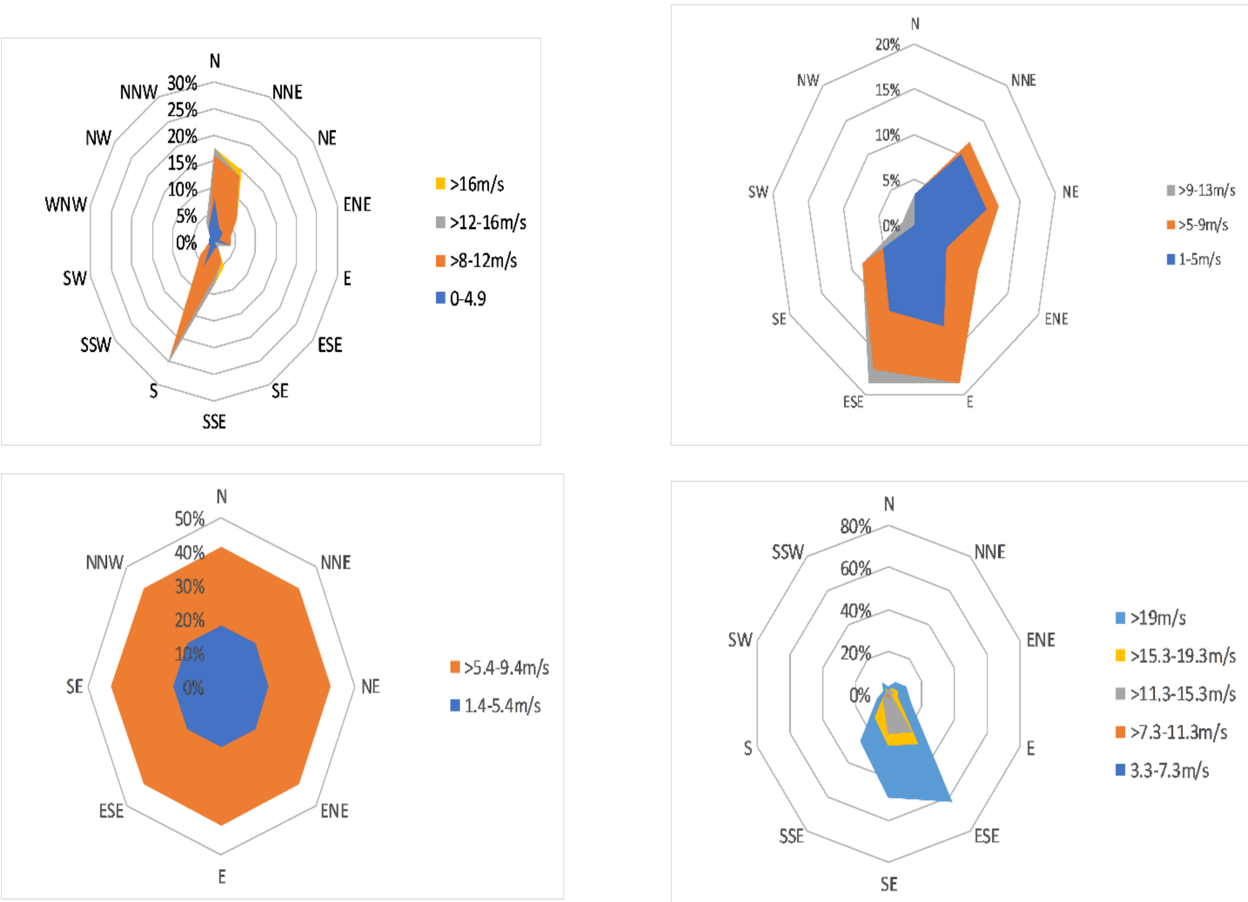
Over the period 2008 to 2018, May is recorded as having the lowest mean monthly wind speed with 5.9km/h (Table 5.2). November has the highest mean monthly wind speed of 8.3, with October a close second with mean wind speeds of 8 km/h (Table 5.2). Additionally, November has the highest wind speed measurement for the study period in 2010 with an average of 18.4km/h. July, August and September have increased wind speeds in 2010, compared to other recorded years (Table 5.2). The wind speeds evidently decrease from January to June before rising in July and cresting in November (Table 5.2).

Table 5.2: Mean windspeed for each month over the study period 2008—2018.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Mean Ws (km/h)
January	7.5	7.3	8.6	10.6	7.6	6.1	6.5	6.2	7.0	6.1	7.1	7.3
February	6.6	7.2	9.1	6.6	6.4	7.7	4.6	6.2	6.4	5.9	5.5	6.6
March	7.4	7.9	8.8	5.6	4.9	8.1	3.0	5.0	4.9	7.1	5.6	6.2
April	6.2	8.2	7.9	7.2	4.7	6.6	5.1	4.4	6.2	6.1	4.6	6.1
May	5.4	7.0	8.8	6.6	6.4	6.0	5.7	3.6	5.8	5.1	4.7	5.9
June	5.4	8.9	8.8	6.0	6.8	7.7	6.0	3.5	5.5	5.4	3.9	6.1
July	6.4	10.6	10.1	8.7	5.9	7.5	5.5	4.5	6.0	6.5	5.1	7.0
August	7.0	7.4	14.4	8.1	6.8	8.0	5.8	5.6	6.4	4.9	5.3	7.2
September	7.7	9.8	11.0	7.6	6.9	9.0	7.7	7.1	6.5	7.5	5.6	7.8
October	8.3	10.4	8.8	8.4	7.9	8.3	6.5	10.2	5.9	6.4	6.9	8.0
November	8.0	9.2	18.4	6.2	8.8	8.1	5.8	7.7	5.1	7.2	6.8	8.3
December	8.5	9.4	10.0	7.6	5.8	7.1	5.8	6.4	4.5	7.2	7.1	7.2

Wind direction is ultimately different for each of the seven weather stations due to their varying geographical location and topography governing various parts of Namibia as explained in *3.2.1. Descriptive geography of Namibia: location and topography* under *Chapter 3*. Klein Aus Vista, the Namib Desert and Swakopmund clearly have a dominant direction in wind (Figures 5.5). The Namib Desert had relatively low wind speeds, below 19m/s, over the period 2008-2018 and has the clearest indication of the direction mostly affecting the region of all seven weather locations (Figure 5.5). It is apparent that wind direction is predominately from west-north-west. Dominant wind direction of Klein Aus Vista is from east-south-east with wind speeds that reached over 19m/s most of the time over the period 2008-2018 (Figure 5.5). As the only coastal region, Swakopmund has wind that is mainly brought in from a south westerly direction (Figure 5.5). Wind speeds were predominantly below 10m/s between 2008 and 2018.

Etosha Safari has clear multi-directional incoming winds, from the south and from the north and north-north-east (Figure 5.5). Predominantly over the period 2008-2018, wind speeds don't exceed 16m/s. Similar to Etosha Safari, Kalahari Farmhouse has multi-directional incoming wind, but mainly from the east-south-east and east as well as a north-north-eastern direction (Figure 5.5). Wind speeds for Kalahari Farmhouse do not exceed 13m/s for the period 2008-2018 and are predominantly in the 5-9m/s range (Figure 5.5). A key role in the direction of incoming wind for Windhoek is the location of the weather station, as explained in *3.2.2. Study locations* under *Chapter 3.* The major wind direction is from an easterly direction, including north-north-east, east-north-east, east, and south east. Wind speeds below 10m/s were a common occurrence over the period 2008-2018 (Figure 5.5). Hochfeld appears to have wind incoming from all directions equally (Figure 5.5). The dominant wind speed for Hochfeld was within the range of 5m/s to 9.4m/s over the period 2008-2018.



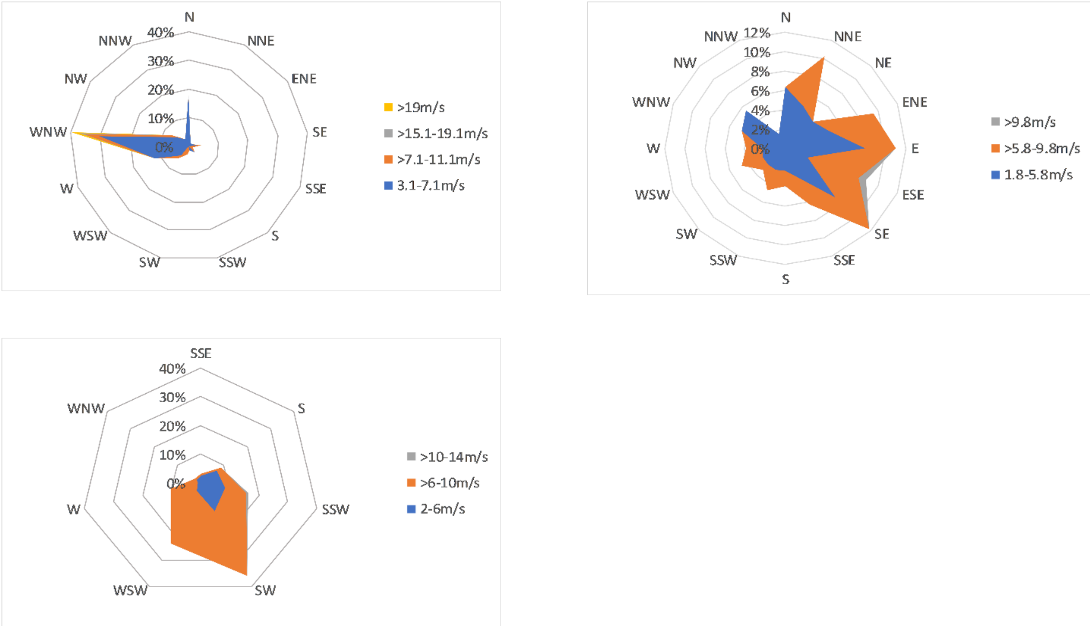


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Figure 5.5: The direction and wind speeds of the seven weather stations in Namibia (from top left): a) Etosha Safari, b) Hochfeld, c) Kalahari Farmhouse. d) Klein Aus Vista, e) Namib Desert, f) Swakopmund and g) Windhoek.

5.3. TOURISM CLIMATE INDEX RESULTS

The TCI results have been divided into four subsections: mean TCI scores based on 1) study period mean TCI scores and 2) annual mean TCI scores; 3) the typologies that result from the annual TCI score distribution; and 4) mapping the seasonal distribution of the mean TCI scores.

5.3.1. Study period mean TCI score

The mean monthly TCI scores for the respective study sites range from 39 (unfavourable) in December for Hochfeld to 90 (ideal) in February for Swakopmund, over the period 2008 to 2018 (Table 5.3). This would suggest that tourist seeking beach tourism and adventure tourism would benefit from the ideal climatic conditions at Swakopmund, in February (Table 5.3). The majority of the locations produced mean monthly TCI scores in the 'very good' climatic suitability rating category, with 32 of the 84 of the study falling into this category.

The very good climate months for tourism are closely followed by the 'excellent' climatic suitability rating category, which has 28 of the 84 months under this rating. In comparison to the very good rating, which is more sporadic and is found throughout the year, the bulk of the months that have the excellent rating fall within the winter months of the year; June, July and August. Tourists would have the excellent climate conditions for taking part in nature-based or adventure tourism during this time. Etosha Safari and Hochfeld are the only two locations that feature 'acceptable' (50-59), 'marginal' (40-49) and 'unfavourable' (30-39) climatic conditions for tourism (Table 5.3).

This is demonstrated in the spring and summer months, while spring and summer months of the other five locations demonstrate mainly 'good' but also very good and excellent climatic conditions for tourism. This may be due to the geographical location of these two locations, which is situated further north than the other locations. The mean annual TCI scores for the study sites produced a range of 62 'good' for Etosha Safari and Hochfeld and 84 'excellent' for Klein Aus Vista over the period 2008—2018 (Table 5.3). Etosha Safari, Hochfeld and the Namib desert have years that range from good to very good, as well as Kalahari farmhouse which consistently has climatic conditions that fall into the very good category. Klein Aus Vista, Swakopmund and Windhoek have climatic conditions that range from very good to excellent (Table 5.3).

Table 5.3: Mean monthly TCI scores for the period 2008-2018.

Study location	January	February	March	April	May	June	July	August	September	October	November	December
Etosha Safari	52	56	63	75	81	80	75	72	66	60	66	58
Hochfeld	42	52	58	74	84	84	87	81	68	57	48	39
Kalahari Farmhouse	61	71	74	81	83	86	87	77	66	64	66	69
Klein Aus Vista	74	76	72	85	85	82	82	83	84	78	77	78
Namib Desert	65	69	77	75	84	85	87	80	76	69	69	70
Swakopmund	83	90	80	77	75	72	73	74	78	79	81	75
Windhoek	70	73	75	84	86	88	87	86	78	78	78	75

	Ideal (90-100)
	Excellent (80-89)
	Very good (70-79)
	Good (60-69)
	Acceptable (50-59)
	Marginal (40-49)
	Unfavourable (30-39)

5.3.2. Annual mean TCI scores

All of the overall mean TCI scores for the study sites range from 62 ‘good’ for Hochfeld to 81 ‘excellent’ for Klein Aus Vista over the study period 2008-2018 (Table 5.4). Most of the locations fall within the ‘very good’ climate rating, with three of the seven locations having rating between 70-79. The tourist seeking beach tourism, nature-based and adventure tourism will have very good conditions if they visit Kalahari Farmhouse, the Namib desert and Swakopmund. For the tourist visiting Klein Aus Vista and Windhoek, they will have excellent conditions for general tourism. Tourists visiting Etosha Safari and Hochfeld will experience good climatic conditions.

Table 5.4: Mean overall TCI scores for seven weather stations in Namibia over the period 2008-2018.

Location	Mean TCI score	Classification
Etosha Safari	67	Good
Hochfeld	62	Good
Kalahari Farmhouse	71	Very good
Klein Aus Vista	81	Excellent
Namib Desert	75	Very good
Swakopmund	78	Very good
Windhoek	80	Excellent

5.3.3. Tourism Climate typologies

Scott and McBoyle (2001) developed a theory, based on their argument that tourism-climate resources for any destination will fall into an annual TCI distribution category, that there are six tourism-climatic typologies which can be used to determine the climatic suitability distribution of a destination throughout the year for general tourism (Fitchett and Hoogendoorn, 2018). The annual TCI distributions are; dry season peak conditions, bimodal-shoulder peaks, winter season peaks, summer season peaks, year-round poor conditions and year-round optimal conditions (Roshan *et al*., 2016). Climatic typologies are not universal between the northern and southern hemisphere as the seasons are do not occur at the same time of year. In other words, the summer and winter season peaks are inverted in the climatic typology distribution (Figure 5.6). For Namibia, none of the selected locations in this study fall into dry season peak conditions, year-round optimal conditions or year-round poor conditions tourism-climate typology categories.

Namibia falls into two categories; 'winter peak' and 'bimodal-shoulder peak' (see Figure 4.2 for six conceptual tourism climate distributions) when rated by the TCI (Table 4.5). The winter peak distribution accounts for 71% of the locations, including: Etosha Safari, Hochfeld, Kalahari Farmhouse, Namib desert and Windhoek. The distribution indicates that the climatic conditions in winter are the most conducive for general tourism in Namibia. Notably, these locations are all situated inland. It is presumed that these locations may experience greater differences between summer and winter temperatures as a result of continentality.

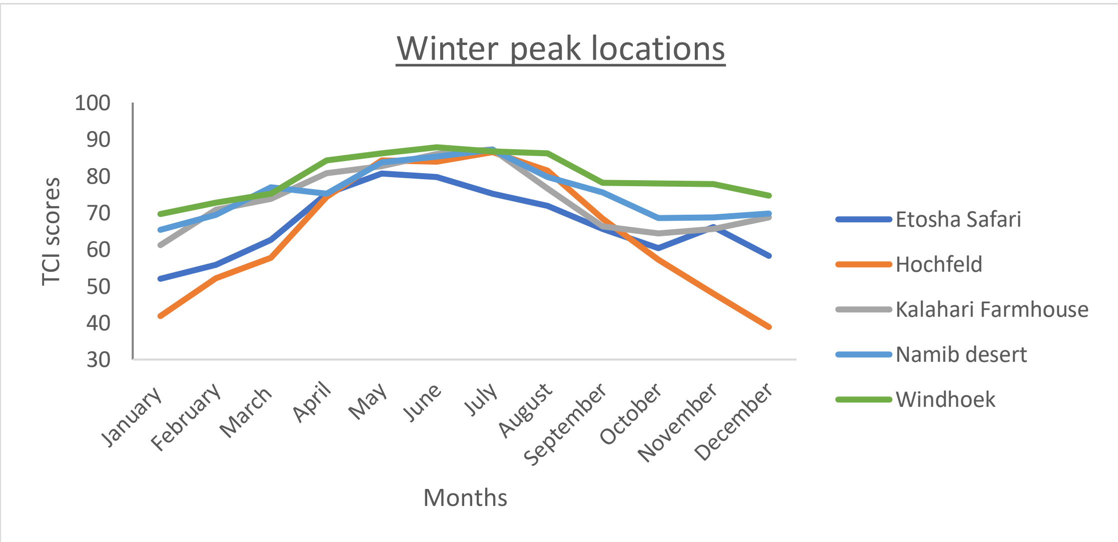

Figure 5.6: The 'winter peak' distribution is present for five of the weather stations over the study period 2008—2018.

Only Klein Aus Vista and Swakopmund fall into the bimodal-shoulder peak category. Bimodal-shoulder peaks are observed for summer and spring months at Swakopmund, and autumn and spring months at Klein Aus Vista, not the spring and winter months that is typical of the northern hemisphere (Figure 5.7). The distribution within the mean monthly TCI scores at Klein Aus Vista depicts a bimodal-shoulder peak for in the months of May and September, as May has a score of 85 and September has a score of 84 which categorises the two locations as having 'excellent' climatic conditions (Figure 5.7). Swakopmund has a mean monthly TCI score distribution in February and November for the bimodal-shoulder peak, where February has a score of 90 which is considered 'ideal' and November has a score of 81 which is categorised as 'excellent' climatic conditions (Figure 5.7). Swakopmund being a coastal town, while Klein Aus Vista is located in a mountainous region. This may explain why the regions are both classified as having 'bimodal shoulder peak' distributions but 'shoulder peak' months differ.

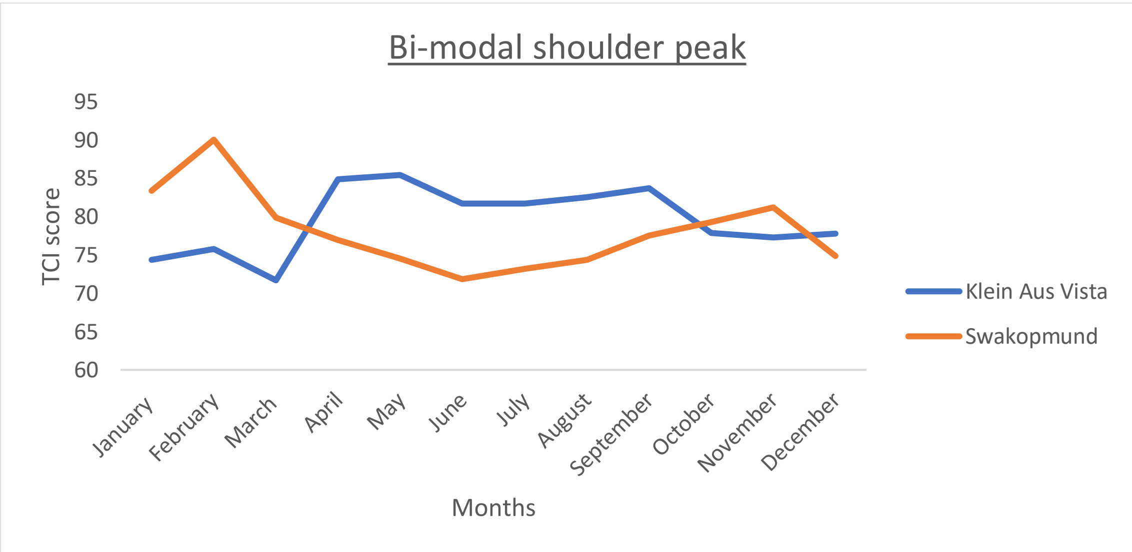

Figure 5.7: The 'bimodal-shoulder peak' distribution is present only for Klein Aus Vista and Swakopmund over the study period 2008—2018.

5.3.4. Inverse Distance Weighting seasonal distribution of the TCI

Climatic conditions (2008-2018) of 7 weather station destinations were rated using the TCI. The range of all the TCI scores over the study period are 39-88, classifying the country as having climatic conditions of 'unfavourable' (30-39) to 'excellent' (80-89). The destination with the highest mean TCI score over the study period (2008-2018) is Windhoek with a score of 80, categorising Windhoek as having an 'excellent' climate for tourism (Figure 5.8). The year with the highest TCI scores is 2014 with an 'excellent' score of 84 for Klein-Aus Vista. Overall, the location that frequently has the lowest score is Hochfeld. It is the only location that has TCI scores that fall below 50, which is considered 'acceptable' in terms of suitability of the climate for tourism. Over the study period (2008-2018) Hochfeld has a mean TCI score of 62 (Figure 5.8). The mean pattern of the TCI scores for the destinations across Namibia reveal that the higher scores are found along the coastline of Namibia and towards the southern inland regions with the lower scores found higher up in the northern regions of the country.

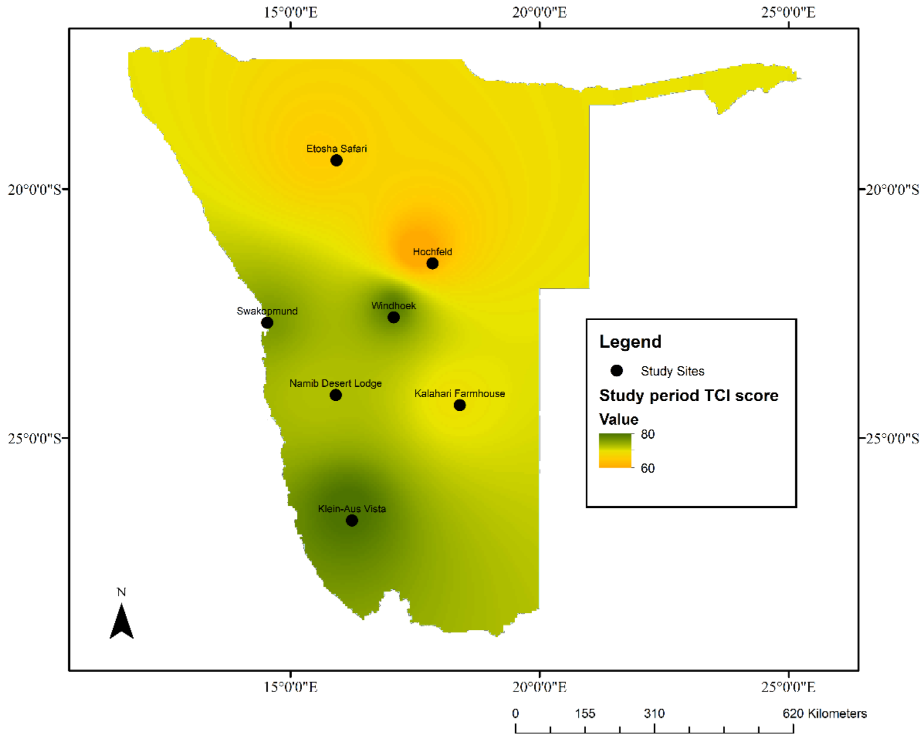

Figure 5.8: Mean annual TCI scores for the entirety of the study period.

Spring has the lowest mean TCI scores out of all the seasons, with a range of 58-80, which is classified as ‘acceptable’ to ‘excellent’. This is lower than the mean annual TCI scores of the study period. Similar to the mean annual TCI score distribution, the regions with the highest scores are Windhoek, Klein-Aus Vista and Swakopmund (Figure 5.9). Again, Hochfeld has the lowest mean TCI score with a score of 58 classifying Hochfeld as a destination with an ‘acceptable’ climate for tourism. Etosha Safari and Kalahari Farmhouse have low TCI scores as well, with scores of 64 and 65, respectively, both having a ‘good’ climate for tourism (Figure 5.9).

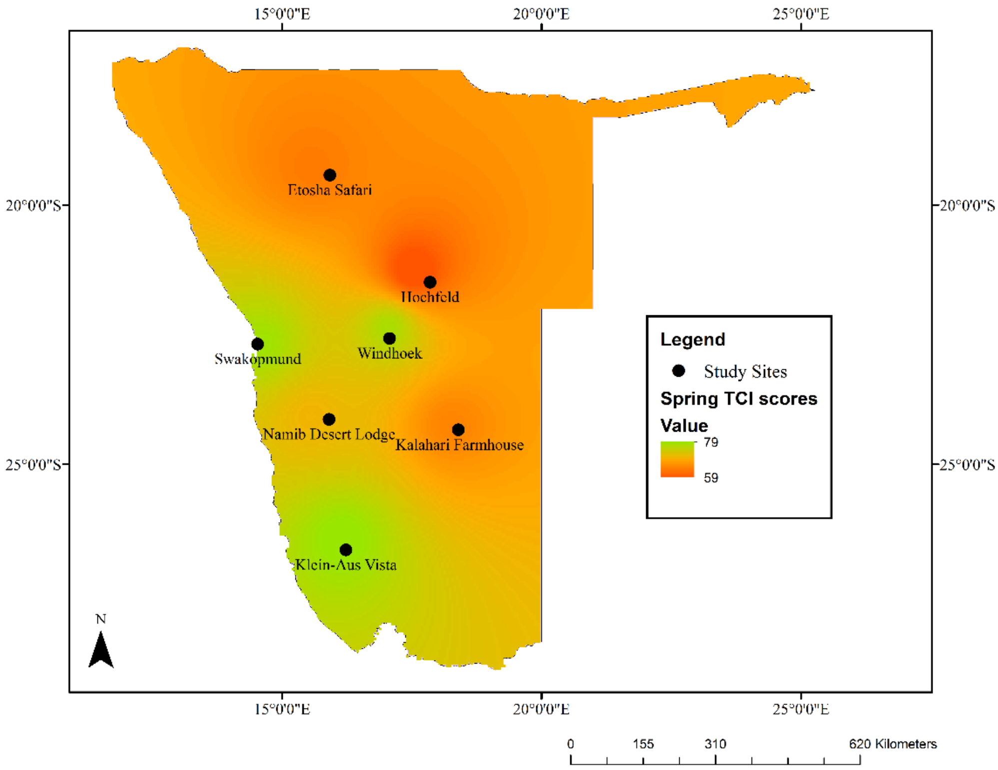

Figure 5.9: Spring is the least climatically suitable destination for tourism compared to the other regions.

Compared to the mean TCI scores for the study period, summer has average climatic conditions for tourism. The summer months have a range of 65 to 80, which is classified as 'good' to 'excellent'. This is similar to the mean spring and stusy period TCI score distribution, the regions with the highest scores are Windhoek, Klein-Aus Vista and Swakopmund (Figure 5.10). Hochfeld has the lowest mean TCI score along with Etosha Safari with 'good' scores of 65 and 67, respectively. The Namib Desert and Kalahari Farmhouse have mean TCI scores of 75 and 71, classifying the destinations as having 'very good' climatic conditions for tourism (Figure 5.10).

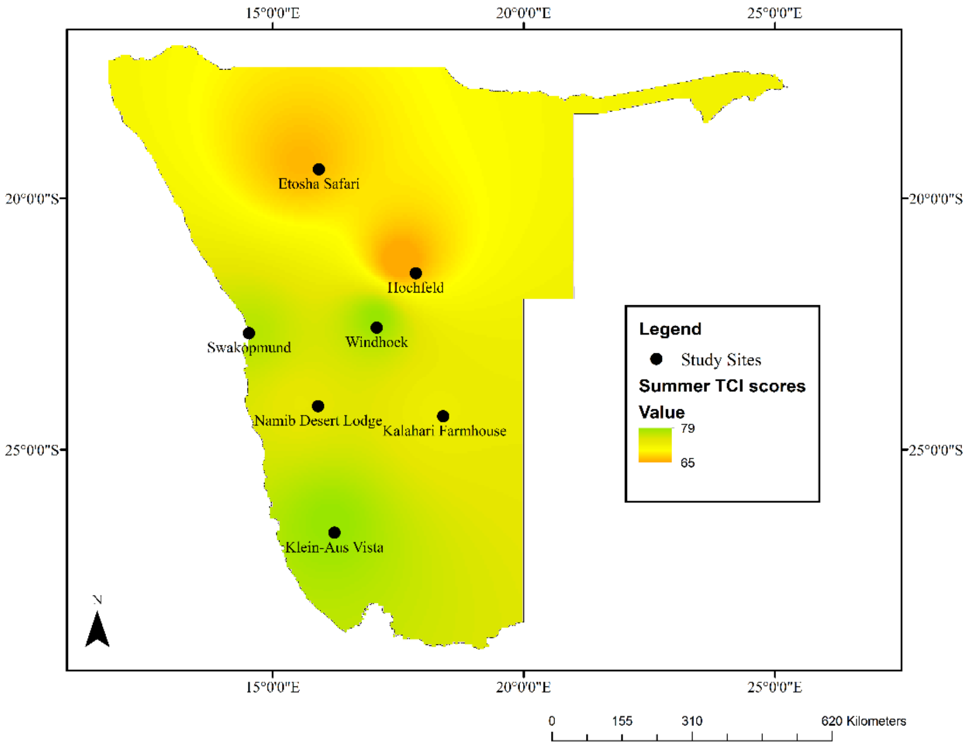

Figure 5.10: Summer conditions are 'very good' to 'excellent' for the majority of the destinations.

Similar to the mean annual TCI score outcome, autumn produced higher TCI scores located in the southern inland and coastal regions and the lower scores found in the northern parts of the country (Figure 5.11). Autumn has relatively high climatic conditions for tourism compared to the spring and summer seasons. The autumn months have a range of 72 to 82, which is classified as 'very good' to 'excellent'. This is slightly higher than the mean annual TCI scores of the study period. Windhoek has markedly higher mean TCI scores throughout the year compared to other destinations. In Autumn Windhoek has the highest mean TCI score with a score of 82, classifying the region as having 'excellent' climatic conditions (Figure 5.11). Klein-Aus Vista is a close second with a mean TCI score for autumn of 81. Swakopmund has a decreased TCI mean compared to the study period, spring and summer mean TIC scores.

This is the only season where it is not in the same category as Windhoek and Klein-Aus Vista; instead it falls under the 'very good' classification with a score of 77 (Figure 5.11). Hochfeld has the lowest mean TCI score of 72, classifying the region as having 'very good' climatic conditions during autumn. Etosha Safari still has a mean TCI score higher than Hochfeld with a score of 73. Namib Desert and Kalahari Farmhouse have the same mean TCI score of 79, classifying the destinations as having 'very good' climatic conditions for tourism in autumn (Figure 5.11).

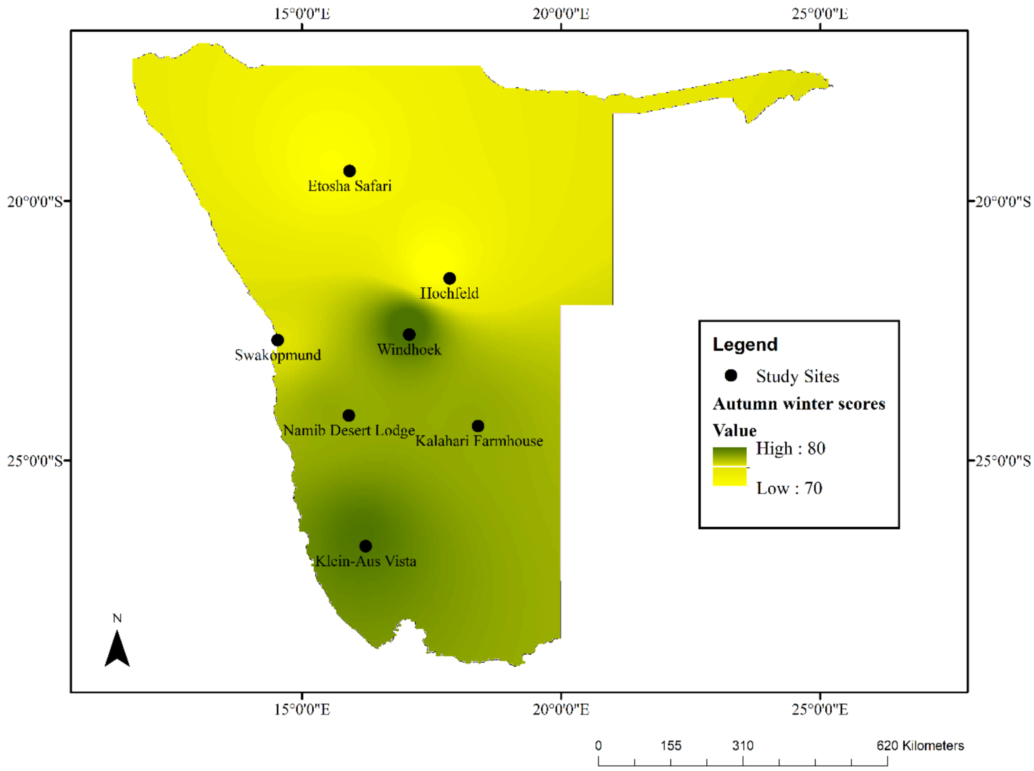

Figure 5.11: Autumn has higher mean TCI scores than the study period, spring and summer.

Winter has a different mean TCI spatial pattern compared to that of the study period, as well as the summer and autumn seasons. Previously, the coastal and southern inland regions have higher mean TCI scores, but in winter the majority of the country has 'excellent' climatic conditions for tourism, including Hochfeld, and the north west regions (Hochfeld and Swakopmund) of the country have lower scores (Figure 5.12). Swakopmund has a reduced score similar to what is seen in autumn, compared to the destination having a score similar to Windhoek and Klein-Aus Vista. The biggest difference between winter and the other seasons and the study period is that Hochfeld is no longer the destination with the lowest mean TCI score. Hochfeld has a score of 84, classifying the region as having 'excellent' climatic conditions for tourism in winter which raises the suitability of the climatic conditions of the destination significantly compared to that of summer and spring. Winter has relatively high climatic conditions for tourism in all destinations compared to spring and summer, except Swakopmund. The winter months have a range of 73 to 87, which is classified as 'very good' to 'excellent'.

This is higher than the mean annual TCI scores of the study period but is similar to the autumn distribution. Windhoek has the highest mean TCI scores of 87 in winter classifying the region as having 'excellent' climatic conditions for tourism (Figure 5.12). Windhoek maintains the highest mean TCI score throughout the study. Klein-Aus Vista is not the second highest mean TCI score location in winter compared to the other seasons and study period, with a mean TCI score of 82. Hochfeld and the Namib Desert have the next highest mean TCI scores after Windhoek with equal scores of 84, placing these two regions in the 'excellent' climatic zone for tourism. For the first time, Hochfeld does not have the lowest mean TCI score. Swakopmund has the lowest mean TCI score, with a score of 73 classifying the destination as having 'very good' climatic conditions for tourism (Figure 5.12).

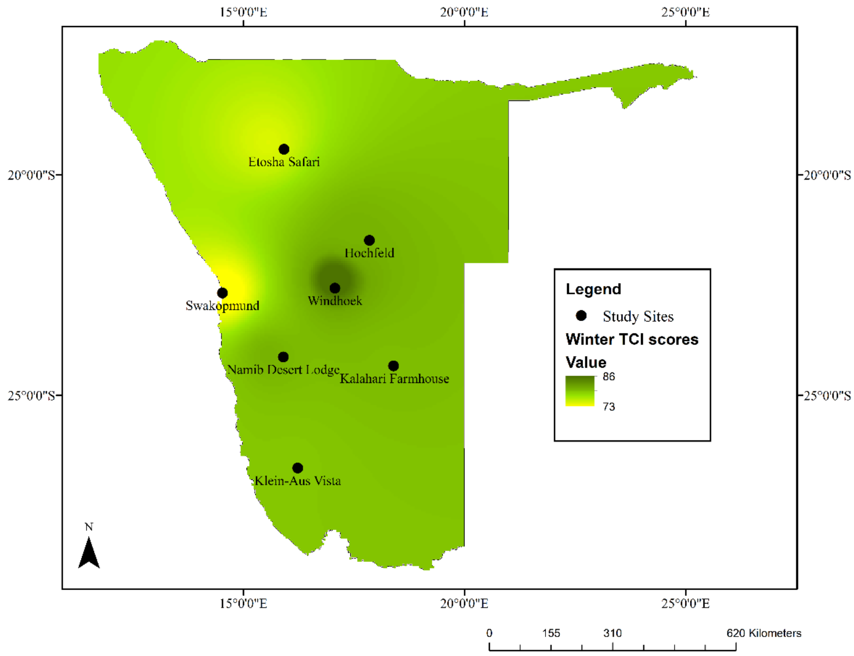

Figure 5.12: Winter has the highest mean TCI scores.

In summary, according to the mean TCI scores, winter months (June, July, and August) are climatically the most suitable time of year for general tourism. This is followed by autumn, then summer and lastly, spring. The winter season does not conform to the spatial distribution of the other seasons or the study period mean TCI scores. Instead of the most climatically suitable regions being found along the coast and in the southern regions, nearly all of Namibia is considered to have ‘excellent’ climatic conditions except for two north-western regions: Etosha Safari and Swakopmund. The winter months have a mean TCI score above 73 and range up to 87, which classifies winter in Namibia in the categories of ‘very good’ (70-79) to ‘excellent’ (80-89) for general tourism.

These ratings demonstrate that winter months in all of the study destinations are suitable for the average tourist experience. The summer months (December, January and February) have mean TCI scores which reveal that all selected destinations as having a score above 65, and the scores range from 65 to 80 which means summer months in these regions are 'good' (60-69) to 'excellent' (80-89) for general tourism activities. Throughout the study period, Windhoek is climatically the most suitable destination for tourism.

5.4. FACTORS INFLUENCING THE TCI SCORE

The TCI is influenced in various ways through five climatic phenomena; including temperature, humidity, rainfall, sunshine, and wind speed. The end result score for each of the factors has the potential to either increase or decrease the mean annual TCI score for the study location.

5.4.1. Factors increasing the TCI score

The most frequent highest rated TCI component, according to the results from the TCI calculation, that increases the TCI scores are wind (W) and rainfall (P), whilst sunshine (S) and daytime thermal comfort (CD) decrease the TCI score (Figure 5.13). Wind speed is a positive factor for the TCI scores of Hochfeld, Kalahari Farmhouse, the Namib desert, Swakopmund and Windhoek (Figure 5.13). Majority of the scores are above 4 for wind speed, which means that these study areas experience wind speeds that range from >2,88-12.23 km/h. Rainfall is the second highest factor to positively influence the TCI scores in Namibia with Klein Aus Vista and Swakopmund producing scores ranging from >4-5, this means that these study sites experience mean monthly precipitation between 0.0 - ≥44.9 mm. Etosha Safari was the only location that identified average thermal comfort (CA) as the factor that most positively influenced the TCI score (Figure 5.13). The TCI scores in the summer months were most positively influenced by wind, influenced by the lack of strong winds that could impact the experience of a tourist while participating in an activity in the region during this time, followed by average thermal comfort. The TCI scores increased in the winter months, equally, through the influence of precipitation and wind speed (Figure 5.13).

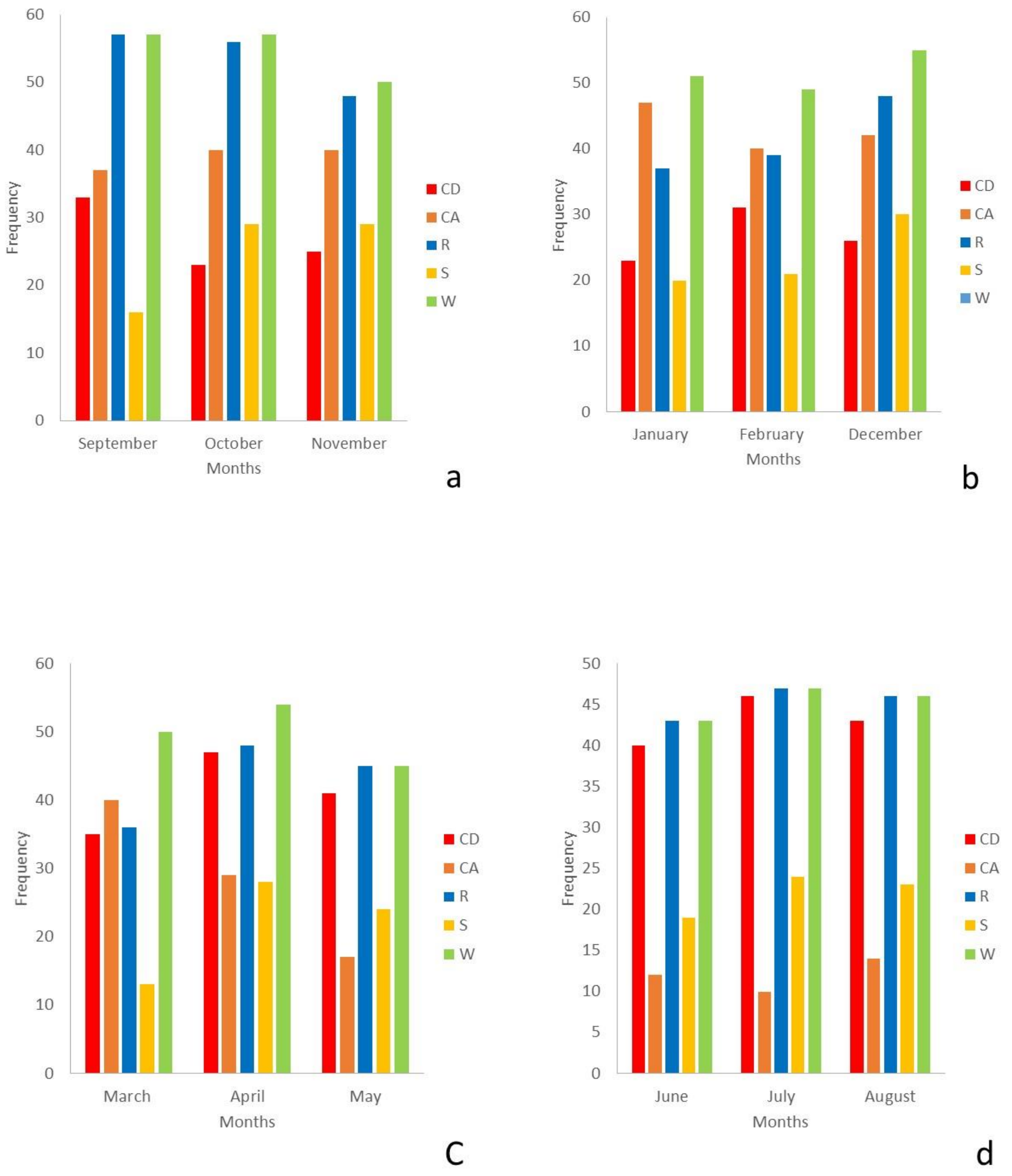

Figure 5.13: Factors positively influencing the TCI scores for the study locations. From top left: a) spring, b) summer, C, autumn, and d) winter.

If the temperatures continue to rise the suitability classification for this region, based on tourist comfort, will continue to decrease (Scott *et al.,* 2004; Amelung and Moreno, 2009; Perch-Nielsen *et al.,* 2010; Hoogendoorn and Fitchett, 2018b). Future projections in the period 2046-2065, that predict with a high degree of certainty that Namibia will become a hotter region, predict temperature increases of 1.8°C to 3.5°C in the summer season and between 1.8°C to 4.8°C in winter (Dirkx *et al.,* 2008). Results of these climate model projections for southern Africa indicate that the Cuvelai Etosha basin area, as well as upper catchment areas in Angola, will experience significantly increased dry climatic conditions (David *et al.,* 2013). Thus, increasing temperatures inherently influence seasonality of tourism (Hoogendoorn and Fitchett, 2018a).

Increasing temperatures are proportionately more damaging to the regions that rely predominantly on summer tourism for economic income (Fitchett *et al.,* 2017). Autumn has a better TCI outcome than spring with all of the weather stations classified as having 'very good' to 'excellent' climate conditions for tourism compared to the spring conditions of 'acceptable' to 'excellent'. Supported by the peak in tourist arrivals, the dry season (April to October) is the best time of year for tourism in Namibia (Tervo-Kankare *et al.,* 2018). Namibia has a relatively year-round climate for tourism, as seen in the IDW mapping.

5.4.2. Factors that decrease the TCI scores

The TCI components that most frequently decreases the TCI score is S, with Etosha Safari, Hochfeld, Klein Aus Vista, the Namib desert, Swakopmund and Windhoek experiencing >6 hours sunshine per day. Day time thermal comfort was highlighted as the most negatively influential impact on the TCI score for Kalahari Farmhouse and the Namib desert with scores

>3. Climatic factors that negatively affected the TCI scores for the summer months during the study period is sunshine (Figure 5.14). Winter TCI scores, on the other hand, decreased due to average thermal comfort (Figure 5.14). Daytime thermal comfort is the second highest factor that negatively influences the TCI scores in Namibia, this means that these study sites experience relatively low mean monthly maximum temperature (between 10-15°C) and minimum relative humidity. Etosha Safari was the only location that identified S and W, as factors that negatively influenced the TCI score (Figure 5.14).

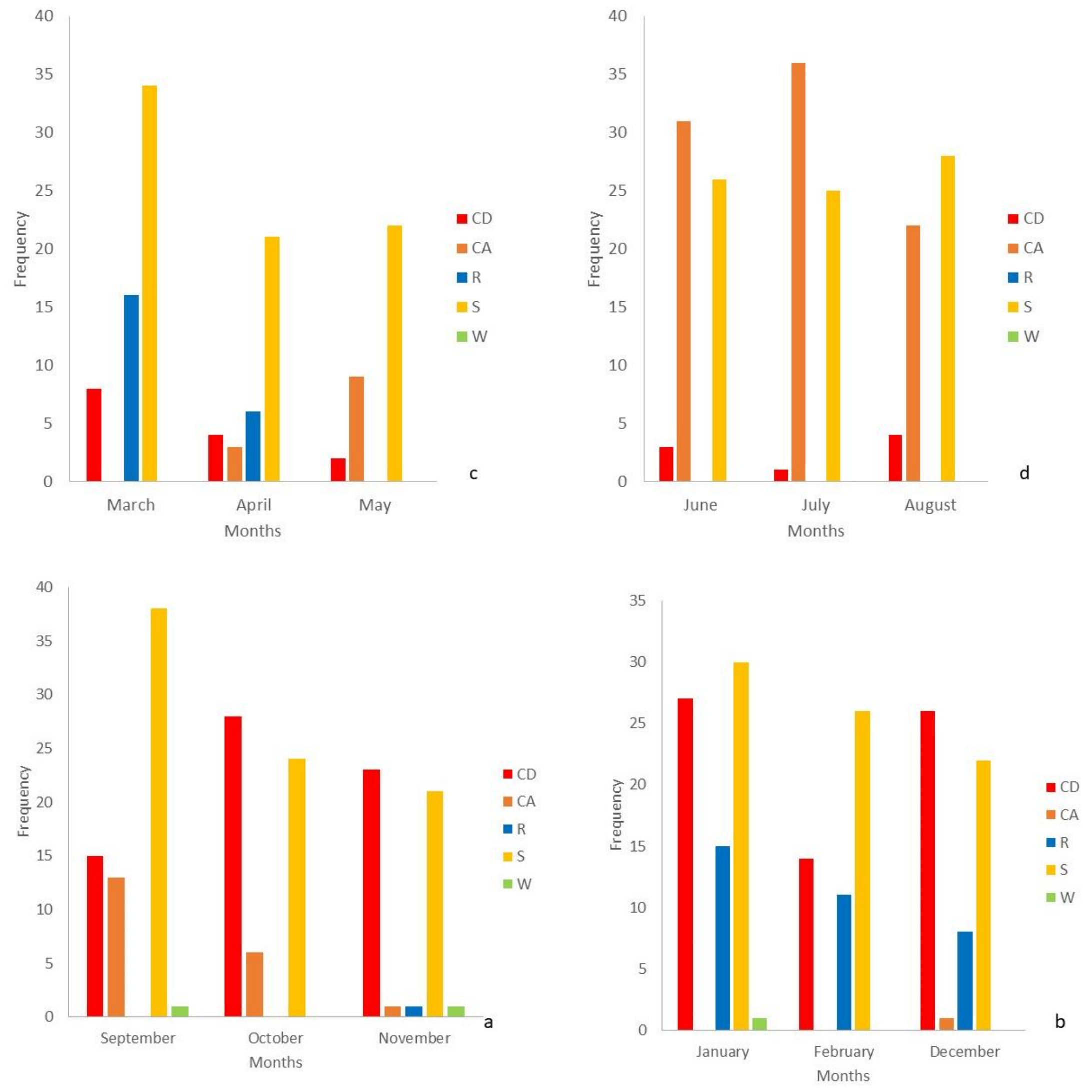

Figure 5.14: Factors negatively influencing the TCI scores for the study locations. From top left: a) spring, b) summer, C, autumn, and d) winter.

Spring (September, October and November) has notably the lowest mean monthly TCI scores out of all the seasons. Projected warming expected to take place in arid and semi-arid regions of Namibia will have a parallel decrease in precipitation (Tervo-Kankare *et al.,* 2018). Temperature uncertainties, however, are small relative to the rainfall uncertainties that Namibia is facing, although low or absent rainfall is seen as a positive factor by the TCI for spring (Perch-Nielsen *et al.,* 2010; MET, 2010). Namibia has a more subtle shift in climatic suitability but similarly displays higher TCI scores located from south to north. The summer fog season across the Namib desert explains the decrease in TCI score compared to the higher score it receives in winter where sunshine hours increase (Kaseke et al., 2018). While Swakopmund has an inverted relationship with the frequency of fog occurrence, the summer TCI scores at Swakopmund increase as the fog peak season is in winter (mainly June and July) along the coast (Kaseke et al., 2018).

For Windhoek, the highest TCI scores are calculated for winter. This city holds the largest share of tourism establishments in Namibia, most of the tour operators, travel agencies and car rental companies are located in Windhoek (Jänis, 2011). Research into the expected impacts of changes to the climate, both positive and negative, using the TCI is important for planning and management of tourism resources, in order reduce the impact of the negative effects and to take advantage of any positive opportunities as a result of those changes (Mahmoud *et al.,* 2019).

5.5. IMPLICATION OF MISSING DATA AND VALIDATION OF RESULTS

One of the fundamental limitations of the TCI is the subjectivity of its rating due to a lack of empirical verification (Perch-Nielsen et al*.,* 2010). Despite this, the TCI is the most widespread index in the global North, with only a handful of studies conducted on the African continent, as discussed in 2*.7. The Tourism Climate Index* under *Chapter 2: Literature Review*. The implications for the limited available data for determining the multi-faceted aspects of tourism must be considered (Fitchett *et al.,* 2016b). 'Missing data' is problematic as it hinders the capacity for suitability comparisons between tourist destinations on not just a local scale but a global scale as well (Amelung et al., 2007).

The greatest challenge of this research in the application of the TCI to Namibia is the climate data shortfalls. Although there are 15 weather stations on the Namibian Weather Service website none recorded the required 30-year historical climate data to complete this research of assessing the climatic suitability of the TCI for tourism in Namibia. Large data gaps impeded time trend analysis in mean monthly TCI scores and the data that is available has changes in measuring instrumentation which need to be remedied. Fitchett et al. (2016b) concedes that poor availability of climate data will pose limitations on the calculation of the TCI scores in southern Africa but argues that these challenges can be circumvented, as has been done in this research. Similar to the problems present in the works of Fitchett et al. (2017), as described in *2.7. The Tourism Climate Index* under *Chapter 2: Literature Review*, the primary limitation in the expansion of the TCI to other destinations of Namibia is data challenges. It is shown that data limitations are a key challenge in conducting a TCI study in other developing countries, particularly in Africa, as these countries lack the infrastructure and continuity of climate data (Fitchett *et al.,* 2016b; Fitchett *et al.,* 2017; Noome and Fitchett, 2019). Although this limitation reduces the capacity to easily differentiate between the climatic suitability of the study locations within Namibia, the validity of the use of the TCI in this research is due to the benefit of comparison of these destinations with global studies using the TCI.

5.6. SYNOPSIS

The TCI is a valuable yardstick for climate regime comparisons between locations (Fitchett et al., 2016b). This study demonstrated the capacity to quantify climatic suitability for tourism using the TCI in Namibia. Determining the sensitivity of the Namibian tourism sector requires significant future research and an important component for the future works is to assess the changes in climatic suitability over time (Fitchett *et al., 2017*; Hoogendoorn and Fitchett, 2018b). The results of this research contribute to the calculated TCI scores for other regions in southern Africa, including South Africa and Lesotho (Fitchett *et al.,* 2017; Noome and Fitchett, 2019). Much like Namibia, South Africa and Lesotho are dominated by outdoor attractions but progress in these countries are impeded by relatively low adaptive capacities to climate change (Hoogendoorn and Fitchett, 2018b). This research in important for facilitating improved understanding of climate change impacts to tourism sectors in southern Africa by contributing to the understanding of regional variability in TCI scores.

CHAPTER 6: DISCUSSION

6.1. INTRODUCTION

The primary aim of this research is to assess the climatic suitability of Namibian tourism using the adapted version of Mieczkowski's (1985) Tourism Climate Index (TCI), the adapted version by Perch-Nielsen et al. (2010), over the period 2008-2018. The current research gaps highlight the need for this research, which have been identified under *Chapter 2 (Literature Review).* The validity of the Tourism Climate Index is presented, to determine the appropriateness of the selected index in quantifying the climatic suitability of Namibia for tourism.

This chapter will discuss the application of these results in understanding climate resources in Namibia, the interpretations and implications of the results captured in *Chapter 5 (Results),* can be used to understand the climate resources in Namibia and how the TCI scores of Namibia relate to other destinations that have TCI scores around the globe. Firstly, the validity of the TCI in current tourism-climate research is discussed through the existing literature reviewed in *2.4. The Tourism Climate Index* under *Chapter 2 (Literature Review).* Secondly, the spatial and seasonal distribution of climatic suitability that is found within Namibia using the results from the TCI calculation, detailed in *5.3. Tourism Climate Index* under *Chapter 5 (Results),* and the classification of the locations across Namibia are discussed and compared internationally with TCI destinations. Following this, the impact of these changes over time on tourism are assessed to understand the vicissitudes to natural resources that tourist activities are reliant on and the action that is needed to mitigate these impacts. Lastly, a critical analysis of the limitations associated with this research are explored.

6.2. VALIDITY OF THE TCI IN TOURISM CLIMATE RESEARCH

Climate has a strong influence on the tourism and recreation sector (Tang, 2013; Hewer *et al.,* 2017; Om *et al.,* 2018). In some regions, climate represents the natural resource base of outdoor tourism (Scott and McBoyle, 2001; Scott *et al.,* 2004; Perch-Nielsen *et al.,* 2010; Grillakis *et al.,* 2016; Georgopoulou *et al.,* 2019). In this work, the determination of the climatic potential of tourism of seven locations in Namibia using a calculation frequently utilised in other countries, the Tourism Climate Index (TCI), is carried out. Scholars have highlighted the importance of climatic suitability classification of travel, however a standard tourism-climate index has yet to be established (Scott *et al.,* 2004; 2016; de Freitas *et al.,* 2008; Perch-Nielsen *et al.,* 2010). There is significant contention amongst the scholars as to which version of the TCI has the greatest validity as a tourism-climate index (de Freitas *et al.,* 2008; Scott *et al.,* 2008; Perch-Nielsen *et al.,* 2010). Although scholars found the original climate-tourism index to be subjective, as it lacked empirical testing (Scott *et al.,* 2016), all future indices were adapted from the original TCI.

The TCI, frequently together with other bioclimatic indices, has been successfully used in many countries around the world (Scott and McBoyle, 2001; Matzarakis and de Freitas, 2001; de Freitas *et al.,* 2008; Cengiz *et al.,* 2008; Scott *et al.,* 2016) over the decades. In the last several years, many studies have been executed using the TCI (Roshan *et al.*, 2016; Nasabpour *et al.,* 2017; Fitchett *et al.,* 2017; Mihăilă and Bistricean, 2018; Amiranashvili *et al.,* 2018). The question of validity of the TCI in tourism-climate research compared to other tourism-climate indices raised by scholars is mainly regarding the methodological issues, constructed around the rating system and the weighting system (Mieczkowski, 1985). Until a consensus on which used bioclimatic index to use is revealed for the tourism, use of the TCI in tourism-climate research, in spite of the four deficiencies of the index (as referred to in *Chapter 2*), is nevertheless useful for the comparison of bioclimatic comfort levels for the 'average tourist' in countries that have TCI scores (Mieczkowski, 1985; Matzarakis *et al.*, 2010; Javan, 2017; Amiranashvili *et al.,* 2018).

The literature (reviewed in *Chapter 2*) suggests that developing countries have a lower adaptive capacity compared to developed countries (Rogerson, 2017; Hoogendoorn and Fitchett, 2018b; Gannon *et al.,* 2020). Methods for localised adaptation and development planning should draw on the lessons within the literature which have highlighted previous challenges of ensuring equitable participation in local institutional arrangements and the potential adaptation strategies in response to existing exclusion and vulnerability (Eriksen *et al.,* 2015). Yet, these strategies need to be unique to each region to an extent as developing countries in Africa have adaptation requirements (due to high vulnerability and lowered adaptivity) that differ from the stressors of the global North (Hoogendoorn and Fitchett, 2018b). Namibia for example has high rainfall variability which, combined with the various climatic zones of the country, hinder prediction and detection strategies used in the global North (Tervo-Kankare *et al.,* 2018). If climatic information is to be useful in decision-making, it needs to be presented in a form appropriate to the problem (Scott *et al.,* 2012).

6.3. SPATIAL DISTRIBUTION OF CLIMATE SUITABILITY OF MEAN ANNUAL TCI SCORES IN NAMIBIA

The spatial distribution of the mean annual TCI scores for the period 2008-2018 reveals that central, southern and south-western regions of Namibia have climatic factors that are most suitable to tourism than other parts of the country for the majority of the year. The TCI and the results of this study are not a predictive tool for tourist arrival, rather the TCI provides a quantified values that are used to determine the climatic suitability of destinations and climatically the best time of year to visit these destinations (Amelung *et al*., 2007; Amelung and Nicholls, 2014; Fang and Yin, 2015). Over the period of 2008-2018, regions in the central to coastal and south-west of Namibia, including Windhoek, Swakopmund, the Namib Desert, Kalahari Farmhouse and Klein Aus Vista, are calculated to have 'very good' to 'excellent' climatic conditions for tourism. Overall, for all destinations, the arid conditions of Namibia contribute positively to the final TCI output. Namibia has a short and intense rainy season (Orti and Negussie, 2019). The south west regions are drier than the eastern regions of the country (Reason, 2019). Minimal precipitation is favoured by the TCI for tourism satisfaction and comfort (Scott *et al.,* 2004; Gómez-Martín, 2005; Fitchett *et al.,* 2016b; R-Toubes *et al.,* 2020). However, the TCI cannot distinguish drought and other extreme events from the data as the suitability is purely based on set climatic criteria (Yu *et al.*, 2009).

Inter-annual variability in rainfall patterns and extreme climatic events such as a severe drought potentially poses a risk of water scarcity, increased risk of disease impacting tourism businesses, landscape scenery and wildlife populations and the migration of game, as well as veld fires (Lendelvo *et al.,* 2018; Orti and Negussie, 2019). These consequences may lead to cancellation or reduced bookings, making unfavourable climate a main cause of declining tourist visitation (Amelung and Viner, 2006; Lendelvo *et al.,* 2018; Hoogendoorn and Fitchett, 2018a). The decrease in austral summer rainfall has been projected and observed over the interior of Namibia, this may result in higher TCI scores but the adaptive capacity of the region to a rainfall decrease is critical for tourist satisfaction (Scott *et al.,* 2004). The variability of rainfall requires higher resolution data than the coarse spatial resolution of the GCMs used in the IPCC AR5 for predicting future change in precipitation patterns (Lu *et al.,* 2016). Drastic increases in surface temperature are set to occur in the future (Engelbrecht *et al.,* 2015). By 2100, within most of the southern African region temperatures are projected to increase between 4°C and 6°C (Engelbrecht *et al.,* 2015). Most of Namibia is projected to experience a decrease in precipitation of up to 0.4 mm day^{-1} (Maúre *et al.,* 2018). The northern and eastern regions are projected to be the worst impacted by future temperature projections, particularly over the September, October and November season (Maúre *et al.,* 2018). Spring has the lowest TCI scores for the study period, with some of the TCI scores outputs that are lower than the study period average TCI scores. Thus, destinations with higher TCI climate suitability for tourism in Namibia are more probable to continue in the south-western regions of the country (Engelbrecht *et al.,* 2015; Maúre *et al.,* 2018; Mihăilă and Bistricean, 2018).

On an international scale, the mean annual TCI scores calculated for other regions of the world can now be compared to Namibia. These results contribute to the premise that no two locations have identical TCI outputs (Fitchett *et al.,* 2017), and that even within the same suitability category the comparison between destinations should be carried out based on the difference between the scores themselves for absolute climate suitability between two or more locations of interest. In Namibia, the lower latitudes, the southern region of the country, have the highest TCI scores throughout the year due to low rainfall. Nasir et al. (2020) determined that the relative importance of environmental attributes to destination selection. The results reveal that tourist 'loyalty' or willingness to repeat visitation was highly correlated with their satisfaction with the destination (Nasir *et al.,* 2020). Changes to the climate of these regions will affect the spatial distribution of tourism flow and impact the duration and quality of climate-sensitive tourism seasons, which has consequences for national and international spending (Rutty and Scott, 2016). These changes to the spatial distribution of climate resources require continual reassessment over time (Perch-Nielsen *et al.,* 2010).

6.4. SEASONAL DISTRIBUTION OF CLIMATE SUITABILITY FOR MEAN MONTHLY TCI SCORES IN NAMIBIA

Tourism seasonality has attracted a wealth of research over the last several decades, but it is one of the most problematic factors for tourism and yet one of the least understood (Amelung *et al.,* 2007). In China, seasonal distribution maps of TCI scores indicate that the climatic conditions of most regions during spring and autumn are the most suitable time for visitation, as it ranks higher in terms of tourist comfort. Summer and winter, on the other hand, have climate conditions that differ greatly (Fang and Yin, 2015). The climatic suitability ratings of "excellent", "good", "acceptable" and "unfavourable" appear to exist by a latitudinal gradation, similar to that of the seasonal distribution of the TCI scores for Namibia whereby the higher the latitudinal gradient the lower the TCI output and the lower the gradient the higher the TCI output. Namibia can be classified as having a winter and bi-modal shoulder peak for the destinations of this study. Climate suitability for destinations according to the TCI are mainly based in North America and Europe (Scott and McBolye, 2001; Scott *et al.,* 2004; Amelung *et al.,* 2007; Tang, 2013; Scott *et al.,* 2016; Amiranashvili *et al.,* 2018).

Windhoek, Swakopmund, Kalahari Farmhouse, Klein Aus Vista and the Namib Desert indicate very good to excellent climate conditions for tourism, with relatively low precipitation which makes it arguably 'open' to tourism year-round. However, this does not necessarily mean that these destinations will have high levels of tourists visiting those destinations (Scott *et al.,* 2004; Mihăilă and Bistricean, 2018). Aridification and extreme drought conditions can potentially alter the spatial distribution of national parks and game reserves in Namibia (Hoogendoorn and Fitchett, 2018b). This may have severe consequences for national parks and may undermine the future of tourism operations and activities across Namibia as 75% of the tourism sector relies on game viewing and trophy hunting for economic income (Reid et al., 2007; Hoogendoorn and Fitchett, 2018a; Dube and Nhamo, 2019). Tourist arrivals throughout the year are greatly influenced by climate (Moreno, 2010b; Scott and Lemieux, 2010). The results of this study demonstrate that the climate suitability across Namibia varies according to geographical location, which means that under a changing climate each destination will be impacted differently (Scott and Mc Boyle, 2001; Roshan *et al.,* 2017; Mihăilă and Bistricean, 2018; Amiranashvili *et al.,* 2018). In previous studies, the TCI has been applied on a global scale (Figure 6.1. and 6.2; Mieczkowski, 1985; Scott *et al.,* 2004; Amelung *et al.,* 2007).

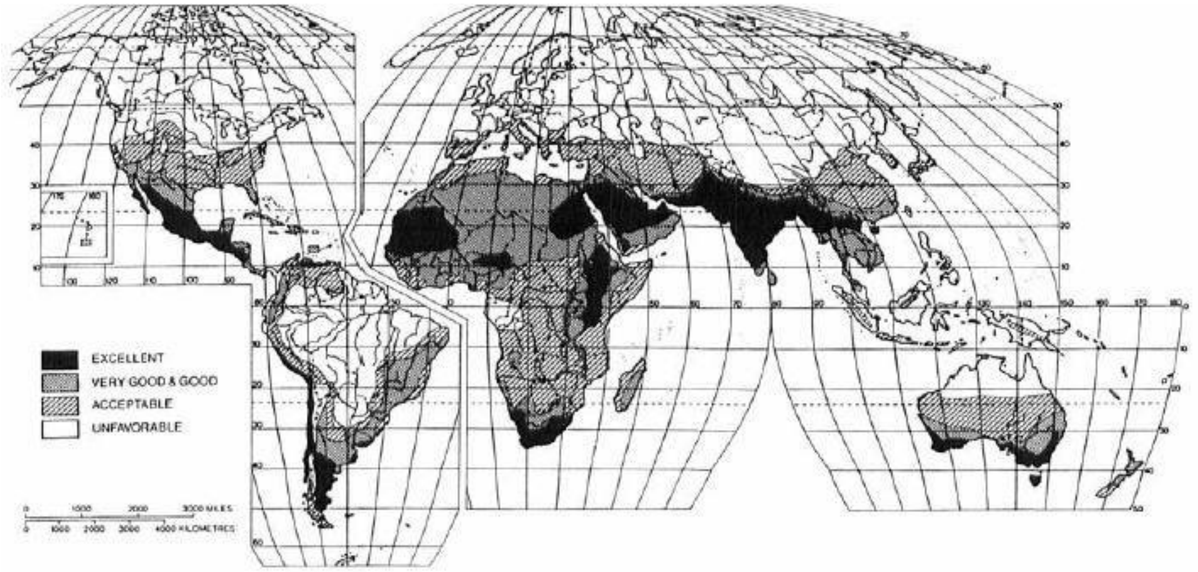

Figure 6.1: Suitability of climatic conditions for tourism around the globe, using January as an example (after Mieczkowski, 1985).

Amelung et al. (2007) applied the TCI to represent the general suitability of climatic conditions around the world (Figure 6.2). The results depict the whole of Namibia as having 'excellent' conditions for tourism in the winter months of the southern hemisphere, June, July and August (Figure 6.2). However, the results of this research dispute that claim. The low resolution of the TCI results cannot accurately depict variability of climate conditions on a regional scale. Etosha Safari and Swakopmund, for example, are classified as having 'good' climatic conditions for tourism during this time of the year. This is misleading to tourists who expect 'excellent' climatic conditions for tourist comfort and may have serious consequences for repeat visitation of the destination (Rutty and Scott, 2016).

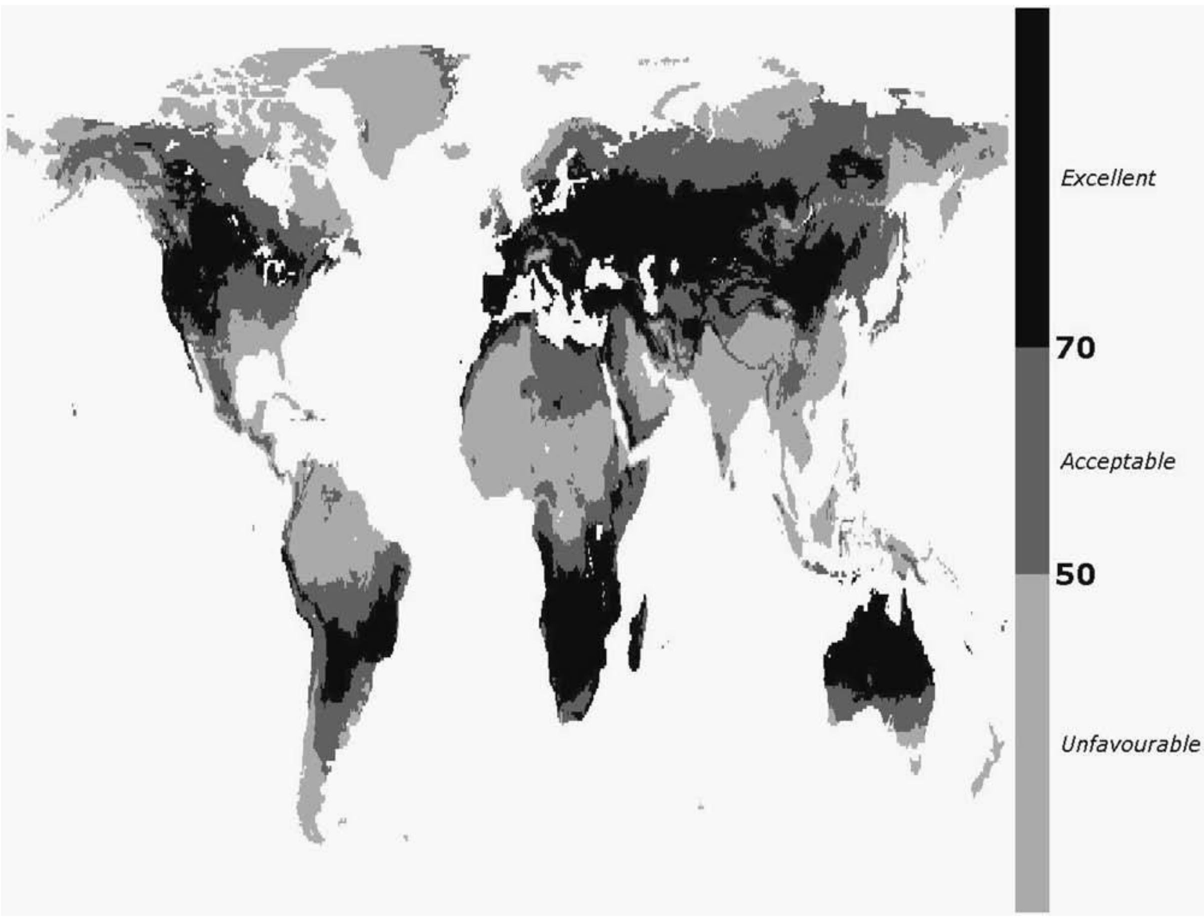

Figure 6.2: TCI scores for winter months over the 1970s.

Although five of the seven locations for which a TCI score has been calculated fall within the 'very good' to 'excellent' climatic classification over the study period 2008-2018, the magnitude of impacts under a changing climate can only be fully evaluated by tourist and tourism stakeholders for decision-making and planning with specific data. Therefore, the globally aggregated results provided by Mieczkowski (1985) and Amelung et al. (2007) present a distorted view of the climatic conditions and potential tourism at different destinations which can affect the perception of impacts due to climate change (Atzori *et al.,* 2018). The TCI results of this research has greater resolution. The distribution of climatic resources at the seven destinations are clearly visible through the final TCI score results and the IDW mapping (in *Chapter 5*).

6.4.1. Spring

These expected conditions will impact the natural resources of Namibia and the spatial distribution of tourism (Tervo-Kankare *et al.,* 2018). Etosha National Park, for example, experiences very hot weather from September, the onset of spring, to March, the beginning of autumn and has the second lowest TCI rating with a 'good' score of 64 (Jokisch, 2009; MET, 2010). If the temperatures continue to rise the suitability classification for this region, based on tourist comfort, will continue to decrease (Scott *et al.,* 2004; Amelung and Moreno, 2009; Perch-Nielsen *et al.,* 2010; Hoogendoorn and Fitchett, 2018b). Future projections in the period 2046-2065, that predict with a high degree of certainty that Namibia will become a hotter region, predict temperature increases of 1.8°C to 3.5°C in the summer season and between 1.8°C to 4.8°C in winter (Dirkx *et al.,* 2008). Results of these climate model projections for southern Africa indicate that the Cuvelai Etosha basin area, as well as upper catchment areas in Angola, will experience significantly increased dry climatic conditions (David *et al.,* 2013). With the potential further aridification of Namibia and extreme drought conditions under climate change Namibia may see worsening conditions during spring months, but improved autumn and winter TCI scores.

Research on the spatial distribution of climate suitability for tourism destinations is beneficial, especially for international tourists not familiar with the climate conditions of a region (Huang *et al.,* 2018). The low rainfall and wind speeds during spring in Namibia, for example, allows for better sightseeing tourism (Liu *et al.,* 2007). The results from Namibia differ considerably from the shift in climatic suitability seen in many cities around the world (Om *et al.,* 2018).

Given the importance of the tourism sector to the GDP in Namibia, this research is crucial for the identification of the most climatically suitable spatial distribution for tourism for the future to guide strategic planning and investment (Moreno, 2010b; Hoogendoorn and Fitchett, 2018a; Mueller *et al.,* 2020). Extreme climatic events have the potential to negatively influence the experience of the tourist as it could prevent them from taking part in offered tourist activities at a given destination (Fitchett *et al.,* 2016b; Hoogendoorn and Fitchett, 2018a).

6.4.2. Summer

Pronounced seasonal differences in rainfall exists in Namibia (Reason *et al.,* 2006). Although it is highly variable and multi-year droughts are common (Reason *et al.,* 2006; Jokisch, 2009). Summer has relatively good climatic conditions for tourism with the lowest TCI score, at Hochfeld, falling into the ‘good’ classification for tourism climate suitability. Although not as pronounced as destinations in Iran, which demonstrates a major shift of south to north in terms of climatic suitability for tourism due to the subtropical high pressure that causes cities in the south to be considered too hot for tourist comfort (Roshan *et al*., 2016). Namibia has a more subtle shift in climatic suitability but similarly displays higher TCI scores located from south to north. Sunshine and temperature are the two most frequent factors that negatively affect tourism in summer. Low daily sunshine hours are the highest factor that negatively influences the tourist comfort level. Increasing temperatures are proportionately more damaging to the regions that rely predominantly on summer tourism for economic income (Fitchett *et al.,* 2017). Increased temperatures during the summer tourism season are threatening to eliminate a key tourist attraction: wildlife, as these changes will induce wildlife migration in the Okavango Delta, Tanzania and Kenya (Agnew and Viner, 2001; Hambira *et al.,* 2013).

Most of Namibia is most positively influenced by average thermal comfort and low wind speedsAlthough, daytime thermal comfort is among the lowest positive factor for tourist comfort level at present, with increasing temperatures it may play a more significant role in influencing the TCI scores of Namibia. Coastal regions, such as Swakopmund, may find increasing temperatures beneficial for year-round tourism (Moreno and Amelung, 2009; Moreno, 2010a), while inland regions are expected to suffer under increased temperatures as they rely mostly on scenic attractions for tourism (March *et al.,* 2014).

Much like the spatial distribution of climate in South Africa, a southern neighbouring country to Namibia, the TCI scores form the southern weather stations are higher than the northern weather station TCI score (Fitchett *et al.,* 2017). Cape Town, a southern destination in South Africa, was calculated as having as ‘ideal’ climate for tourism, while in Namibia the highest

TCI scores were Windhoek (located in the central plateau) and Klein Aus Vista that is furthermost southern weather station used in this research (Fitchett *et al.,* 2017). These results are important for anticipating and managing the needs of tourists in summer (Fitchett *et al.,* 2017).

6.4.3. Autumn

Conditions in autumn (March, April and May) over Namibia are characterised by low wind speeds, low rainfall and relatively warm temperatures Therefore, it is not surprising that Namibia does not have a TCI score below 70 during autumn. In *Chapter 5*, autumn is highlighted as the second-best month after winter for tourism in Namibia with ‘good’ to ‘excellent’ climate conditions. The coastal and southern most region of Namibia have bi-modal shoulder peaks; however, autumn has a better TCI outcome than spring with all of the weather stations classified as having ‘very good’ to ‘excellent’ climate conditions for tourism compared to the spring conditions of ‘acceptable’ to ‘excellent’. Bi-modal shoulder peak distribution is likewise observed for interior regions of South Africa with most of the climate conditions classified as ‘excellent’ to ‘ideal’.

Rainfall is the second factor that negatively influences the TCI scores in autumn. The rainy season is highest in the northern and central parts of Namibia compared to southern regions (Spear *et al.,* 2018). The rainy season begins around January (summer) but continue into the beginning of autumn and is associated with the southward migration of the Inter-Tropical Convergence Zone (ITCZ; Spear *et al.,* 2018). Spring and autumn are expected to benefit from increasing temperatures in other parts of the world, including northern and central North America and Europe, that are witnessing a slow decline in summer climate resources

(Amelung and Viner 2006, Hamilton and Tol 2007, Amelung and Moreno 2012). Research into the expected impacts of changes to the climate, both positive and negative, using the TCI is important for planning and management of tourism resources, in order reduce the impact of the negative effects and to take advantage of any positive opportunities as a result of those changes (Mahmoud *et al.,* 2019).

6.4.4. Winter

Climatically, the dry season (April to October) is the best time of year for tourism in Namibia and is supported by the peak in tourist arrivals (Tervo-Kankare *et al.,* 2018). Although, as seen in the IDW mapping in *Chapter 5*, Namibia has a relatively year-round climate for tourism. In winter months, excellent tourism climate conditions are present in the southern parts of the country that toward northern parts, these conditions decreased. Namibia is positively influenced by a number of climate factors, including moderate temperatures, and low wind speeds and rainfall A 'winter peak' for tourism usually occurs in equatorial and lower-latitude locations where cooler temperatures and lower humidity generates conditions that are more comfortable for tourists (Bakhtiari and Bakhtiari, 2013).

For Windhoek, the highest TCI scores are calculated for winter. This city holds the largest share of tourism establishments in Namibia, most of the tour operators, travel agencies and car rental companies are located in Windhoek (Jänis, 2011). Distinct seasonality is important to tourism management (Fitchett *et al.,* 2017; Mahmoud *et al.,* 2019). TCI scores show seasonal variation, this is crucial for the management of outdoor and nature-based tourist attractions that may face declining attendance due to less suitable climate conditions (Fitchett *et al.,* 2017).

Winter TCI scores reveal that Namibia has 'very good' to 'excellent' climate conditions for tourism, with the central and southern regions continuing to have the highest TCI scores. However, compared to the other seasonal distributions, the coastal region of Swakopmund has the lowest TCI score of 73, classifying the destination as having 'very good' climate conditions for tourism in June, July and August. Average thermal comfort is the most negative climate factor that influences the TCI score in winter, followed closely by low sunshine hours.

Several outdoor tourism activities, including hiking, rafting, golf, hunting, fishing, and mountaineering, are dependent on climatic conditions (Gomez-Martin, 2005). Climate variability can potentially impact the number of tourists visiting a destination which will consequently influence on tourism expenditures (Shih *et al.,* 2009 A changing climate may be beneficial for winter tourism in Namibia. It is expected that a deterioration of summer climatic resources will result in increased winter tourism particularly in southern tropical and subtropical areas (Mihăilă and Bistricean, 2018).

6.5. CLIMATE FACTORS INFLUENCING THE MEAN MONTHLY TCI SCORES

Classifying the seasonal distributions of a destination in terms of climatic attractiveness is important for tourism but identifying which climatic factor has the greatest influence on climate attractiveness will assist in the understating of the potential impacts of climate change on climate suitability of destinations for tourism in the future (Fitchett *et al.,* 2017). The mean annual TCI score has a similar spatial distribution to the mean monthly TCI score, where the destinations in central and southern Namibia are ranked higher than northern weather stations.

Temperature increases are not uniform, with some regions experiencing greater effects of climate change than others (Davis *et al.,* 2017). Scott et al. (2008) suggest that tourists' climate preferences are related to their origins, the study emphasized that tourists from different nationalities have different climatic preferences (Tang, 2013). Engelbrecht et al. (2015) suggest that there will be drastic increases in surface temperature in the future. By 2100, destinations with 'excellent' climate suitability for tourism in Namibia are more probable in the south-western regions of the country. In other words, the 'very good' destinations are predicted to have 'good' conditions for tourism and the regions with 'good' tourism climate conditions in the northern parts of the country will become 'acceptable'.

The most notable positive climate factor for the TCI calculation, that is present across the study sites, is low wind speed Rainfall is the second factor that positively influences the TCI scores. Decreases in summer rainfall over the interior of Namibia may mean higher TCI scores in the future, however, the adaptive capacity of the region to a rainfall decrease is critical for tourist satisfaction (Agnew and Viner, 2001; Reddy, 2012). Looking at the meteorological factors that most negatively influence the mean monthly TCI for the climate suitability of tourism in Namibia, it is clear that low sunshine hours most negatively affect the TCI score for Namibia—especially during spring and autumn.

Much like South Africa, Namibia demonstrates high mean monthly TCI score variability (Fitchett *et al.,* 2017). The TCI scores range from 'unfavourable' 39 in December to 'ideal' 90 in February. The seasonal distribution of the weather stations according to the climate typologies of Scott and McBoyle (2001) reveal that the winter peak distribution accounts for

71% of the locations while the bi-modal shoulder peak accounts for the other two locations. The seasonal distribution of Namibia indicates that suitable tourism can be found year-round in Namibia between the seven study locations.

6.6. IMPLICATIONS OF CLIMATE CHANGE ON TOURISM IN NAMIBIA

Climate change is not equally distributed around the world (Agnew and Viner, 2001; Perch-Nielsen *et al.,* 2010; Demiroglu *et al.,* 2018; Zhong *et al.,* 2019). Tourism has been described as the greatest economic driver for Namibia, and potentially the most economically and socially sustainable sector for the future of the country (MET, 2010). The occurrence and focus of extreme events, including floods and droughts, have increased across Namibia. Wilhelm (2012) estimated that annual losses as a result of climate change impacts on natural resource range from 1% to 6% of the Namibian GDP. Floods, centred mostly in the northern regions of Namibia, have severe consequences on socio-economic factors, including the relocation of houses, schools and businesses; some of which temporarily close down due to flood damage (Wilhelm, 2012).

Current climate change models for Namibia generally predict a decrease in rainfall or an increase in rainfall variability or both. Namibia has a high degree of temporal and spatial variability. Thus, even in the absence of climate change, demand in water supply surpassed the installed capacity in Namibia (Dirkx *et al.,* 2008). Droughts, on the other hand, are often accompanied by high temperatures and pose a danger with an increase in veld fire risk (Lendelvo *et al.,* 2018). Southern Africa has many regions that are particularly susceptible to dry conditions and the frequency of droughts (Masih *et al.,* 2014). Severe droughts (including 1982-1983, 1991-1992, 1997-1998 and 2014-2015) have been linked to the El Niño-Southern Oscillation (ENSO) phenomenon in southern Africa (Rouault and Richard, 2005). However, the interdecadal South Atlantic Mode most prominently impacting rainfall is the Benguela Niño (Reason *et al.,* 2006). Extreme El Niño events do not necessarily result in a larger impact as other factors such as land-surface temperatures, availability of food, political stability among others that affect the vulnerability of a region to drought (Giddy *et al.*, 2016; Moreno, 2017). Schultze et al. (2005) presents a 'present' (1975-2005) and 'future' (2070-2100) climate scenario. The scenarios reveal that increasing temperatures and projected climate change in southern Africa will result in land use changes, increased veld fires, increased rainfall intensity but variability in rainfall patterns, soil erosion (MET, 2010). It is estimated that an annual average of 43,615km^2 (mostly in the savanna biome) of land burns as a result of uncontrolled fires (Figure 6.3; MET, 2010).

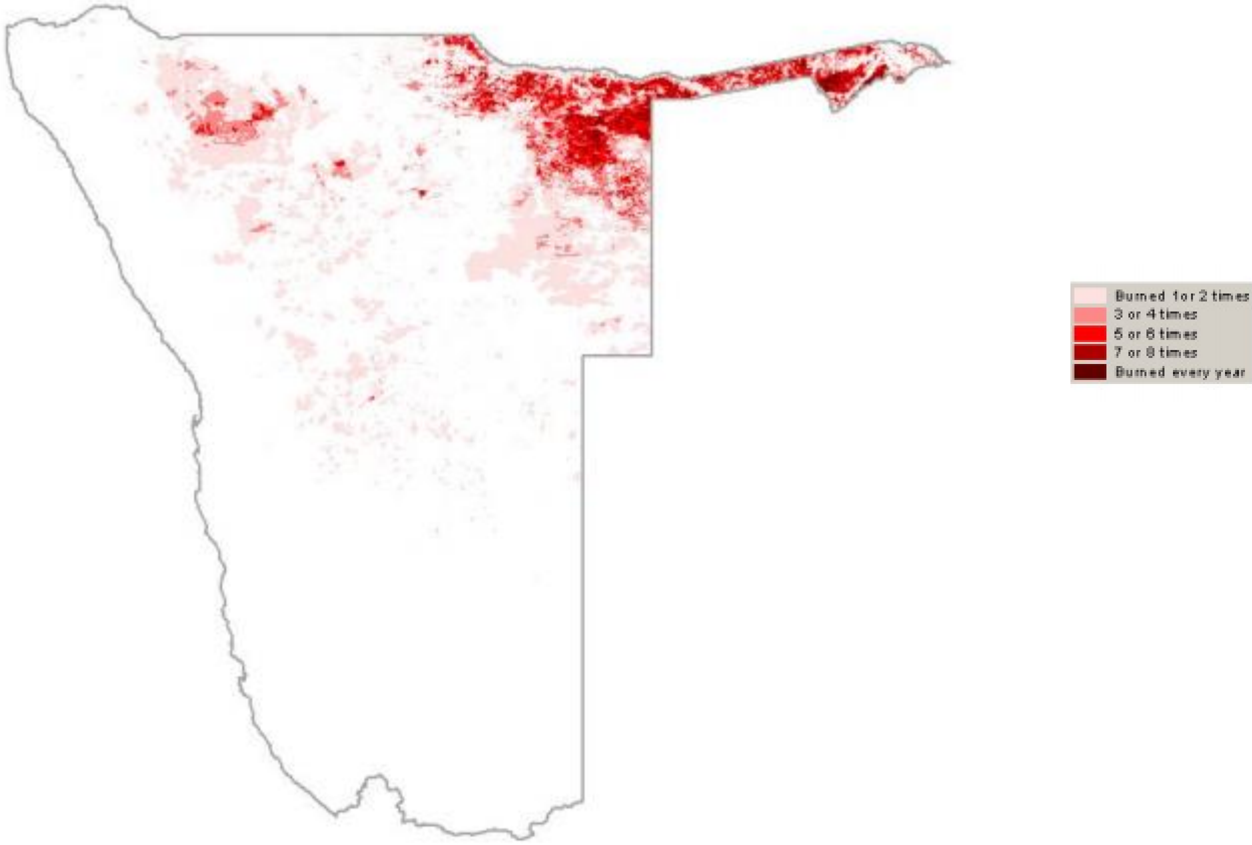

Figure 6.3: Veld fires are predominant in the savanna biome, or the northern parts of Namibia (MET, 2010).

The coastal fog system is a key climate feature in Namibia and is an important element of biodiversity in the region, but there are currently no credible climate change projections for this system (Kaseke *et al.,* 2018). Coastal towns and settlements are important centres for tourism in Namibia as they provide cultural and leisure tourism, which are two key aspects of the rapidly growing tourism sector in Namibia (MET, 2010; Saarinen, 2016). Leisure tourism makes up some 40% of the tourism offered in Namibia (MET, 2010). Many African countries, much like Namibia, are desirable for their abundance of wildlife species and diverse cultural heritage (Saarinen, 2016). Namibia tourism, which is promoted as a wildlife and open landscape destination, has identified cultural heritage tourism as a key area for development.

However, there are concerns centred around the sustainability of long-term cultural heritage tourism (Green and Sheyapo, 2018). Thus, the concept of a long-term cultural-tourism market has been heavily debated in the literature (Kavita *et al.,* 2017).

Concerns that have been expressed revolve around growing tourist numbers, the capacity to fulfil tourist demands, as well as the proficiency to provide and maintain cultural heritage resources and facilities (Shackley, 2006). Windhoek and Etosha Safari National Park both include cultural-based tourism into their tourism strategy. Etosha has the Hai//om 'bushmen' who hunt around the park and are used as a tourist attraction for travel groups to experience 'African authenticity' (Van Beek and Schmidt, 2012). Thus, culture has become a major "pull factor" for tourism in various parts of the region (Manwa, 2007; Rogerson and Visser, 2011; Monaheng, 2016; Saarinen, 2016). Etosha Safari is considered to have an 'acceptable' climate for tourism with a mean TCI score of 55.3 over the study period. According to the TCI scores and the IDW mapping, tourism in this region is best during the winter months of June, July and August in Etosha Safari. Increased temperatures and rainfall variability associated with climate change may impact the suitability rating of winter tourism (Scott *et al.,* 2004).

South Africa, parts of Namibia and Botswana are projected to experience the largest increase in temperature in southern Africa, greater even than the global mean warming, particularly during the September to November season (Maúre *et al.,* 2018). Maúre et al. (2018) examine the potential impacts climate change may have on temperature and precipitation under two future climate scenarios: 1.5°C and 2°C temperature increase scenarios over southern Africa. According to the study, a large part of Namibia and southern Angola are projected to have significant decreases in precipitation, of up to $0.4mm^{-1}$ per day (Maúre *et al.,* 2018). Lu et al. (2016) argue that the variability of rainfall requires higher resolution data than the coarse spatial resolution of the GCMs used in the IPCC AR5 for predicting future change in precipitation patterns. Achieving the Paris Agreement is crucial for southern Africa as the future climate scenarios pose risks to economic productivity through impacts on human and ecological health systems (IPPC, 2018). Projections depict western, southern Africa becoming drier under the calculations of the Coordinated Regional Downscaling Experiment (CORDEX) and Reginal Climate Models (RCMs) (Engelbrecht and Engelbrecht, 2016). Heat waves and frequency of droughts are expected to increase under A2 scenario by the end of 2100 under both Representative Climate Pathway (RCP) 4.5 and 8.5, which are likely to act as a deterrent for tourism—particularly those with low adaptive capacity (Fitchett *et al.,* 2016a; Fitchett *et al.,* 2017; Dosio, 2017). Strong signals of warming and drying are consistent with the Coupled Model Intercomparison Project Phase 3 (CMIP3) and 5 (CMIP5; Taylor *et al.,* 2012).

This has the potential to impact environmental conditions which could deter tourists through infectious disease, wildfires, insect or water-borne pests (for example jelly fish or algae) or extreme events, including tropical cyclones. Greece was affected by severe wildfires in the summer of 2000 and again in 2018, more than 50 per cent of tourists cancelled their travel arrangements to Greece after the deadly fires (Blandford, 2019). Decreases in precipitation and increases in temperature may shift and cause delays in the onset of rainfall; which has severe consequences for tourism, ecosystems, agriculture, coastal livelihoods and water resources (IPCC, 2018). Thus, the necessity of the Paris Agreement, especially for the southern African region of developing countries, cannot be overemphasised (Maúre *et al.,* 2018).

6.7. FACTORS THAT AFFECT TOURISM IN NAMIBIA OTHER THAN CLIMATE

Rapid population growth, pollution, excessive consumption of resources, and gradual deterioration of fertile land are some of the pressures that has led to an unprecedented degradation of the natural environment (Morais *et al.,* 2019). According to reports of the United Nations World Tourism Organization, nature tourism and ecotourism are amongst the fastest growing sectors in tourism (Global Ecotourism, 2019). According to the *Namibe Tourism Master Plan (*EDETA, 2013*)* nature-based tourism is based on three principles: 1) it is interested in natural and cultural areas and resources; 2) it must contribute to nature conservation; and 3) will benefits the local residents (Morais *et al.,* 2018). Government authorities of Namibia and Angola created one of the largest trans-boundary conservation and tourism areas in Africa to preserve the Namib Desert coastline and the adjacent dunes (Morais *et al.,* 2019). Namibia is very dependent on natural resources for maintaining its economic status (Wilhelm, 2012). There are four perspectives under which tourism in Namibia is viewed:

1) financially, as it is a means generating income through foreign exchange,

2) the private sector, tourism is viewed through product development and generating competition for commercial gain,

3) conservatives, as a method for sustaining natural resources through conservation

4) NGOs, tourism is a component of rural community development

[Ashley, 2000; Massyn, 2007; Naidoo *et al.,* 2016].

Service innovation has become a key driver in profit making, customer retention and destination branding for the basis of customer satisfaction in tourism (Chivandi *et al.,* 2017).

This links closely to the business model of the tourism providers and how the business best meets the needs of its customers (Figure 6.4; Baden-Fuller and Morgan*,* 2010).

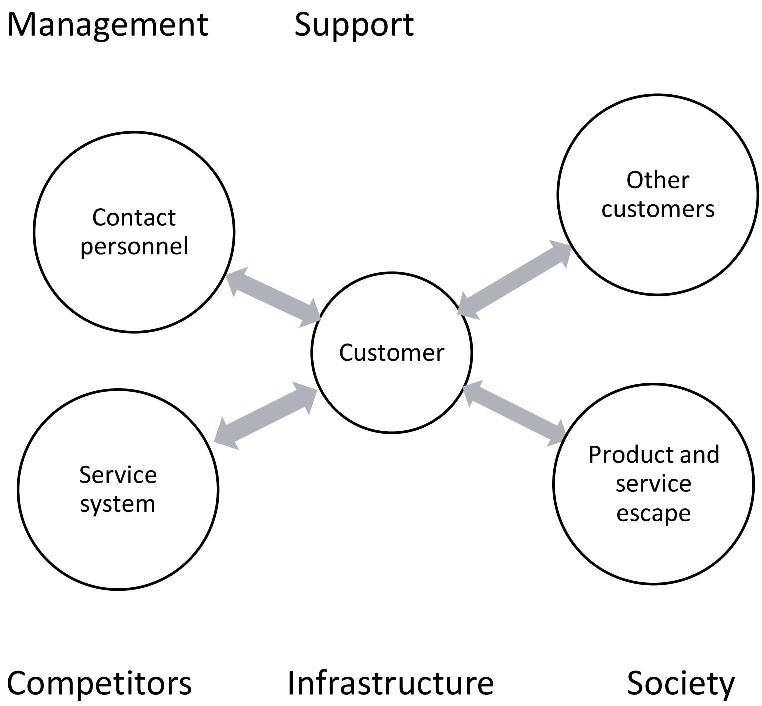

Figure 6.4: Interactivity of the service interactions (after Chivandi *et al.,* 2019).

Greater consideration of the pros and cons associated with tourism should be taken into account for the economic aspects (Lorde and Jackman, 2013). Inflation, security needs, land use changes, all require informed consideration (Lorde and Jackman, 2013; Kavita and Saarinen, 2016). On the other hand, the changes tourism creates in cultural, social and environmental aspects of Namibia are rarely discussed in relation to the planning strategies (Kavita and Saarinen, 2016). Coastal communities are under stress from rapid urbanisation, growing unemployment, housing shortages, growing waste and water management issues, and increased pollution along the shoreline (Kavita and Saarinen, 2016). In recent years, community-based management of natural resources emphasises local participation as a strategy for sustainability (Aref, 2011). Although there is tourist 'hotspots', rural community involvement in tourism has been actively promoted since the beginning of the new thinking of the 1990s (Ashley, 2000). Local communities are expected to benefit socially and financially from tourist activities that take place on a local level (Saarinen, 2010). The government developed a reform agenda, namely Vision 2030, in which tourism in Namibia is expected to become a more lucrative sector to aid in solving inequality in the country (Scholz, 2009).

Informal enterprises, specifically those with more restricted access to formal land ownership, which mainly include women and mobile producers who use land that is either communally owned or allocated through informal tenure particularly struggle to obtain credit for their businesses through formal channels (Atela *et al.*, 2018; Gannon *et al.,* 2020). It is often the female entrepreneurs that notably experience the greater barriers to resources and economic participation, which is seen across countries in Africa (Morais *et al.,* 2019; Gannon *et al.,* 2020). Sociocultural and gender roles predominantly shape their access to their desired resources and are overlooked through the use of 'blanket' approaches that do not reflect the motives and power structures context (Atela *et al.*, 2018).

6.8. LIMITATIONS

As do all research projects, this study encountered limitations. Limitations of this research predominantly regard to the nature of access to meteorological data for developing regions. One of the primary limitations for research using the TCI in developing countries, such as Namibia, and Lesotho and South Africa for which the TCI has already been calculated, is uninterrupted, continuous measurements of each component required for the calculation of the climatic suitability of the tourism destination (Nicholson *et al.,* 2012; Hoogendoorn and Fitchett, 2016; Fitchett *et al.*, 2016a). Free access to online meteorological data is an additional limitation. Limitations of research are important to note as it may influence the accuracy of information used in future research. This section highlights the measures taken to mitigate the limitations in this research, the limitations will be explored as well as the measures that could be considered for future research.

The capacity of developing countries to survive climate change is lower than that of developed nations; as a result of high levels of poverty; limited government financial resources, skills and technologies (Tervo-Kankare *et al.,* 2018). Tourism sectors of developing countries, much like Namibia, would benefit considerably from more comprehensive meteorological recording (Fitchett *et al.,* 2016b). Additionally, the potential for accurately calculating indices for climatic suitability of tourist destinations will provide critical information for the tourism sector under future climate change scenarios (Fitchett *et al.,* 2016b). The possibility of a combination of the TCI with projected future climate scenarios for Namibia is not possible in this research due to the data availability limitations.

The growing research surrounding tourism-climate research has mainly focused on destinations in the Global North, particularly Europe, the Middle East and the US (Scott and McBoyle, 2001; Scott *et al.,* 2004; Sobhani and Zengir, 2020). Furthermore, data limitations pose a severe and fundamental problem as it affects the extent of the tourism stakeholders and government capacity to explore the potential impacts of climate change at major tourism destinations across a given country (Scott and Becken, 2010). For effective adaptation of destinations to the impacts of climate change, it is argued that a proactive attitude and well-structured planning is needed by major tourism stakeholders and the comprehensive management of resources by government agencies (Amelung and Nicholls, 2014).

6.9. SYNOPSIS

In the context of current literature as well as the aim and objectives, the interpretations and discussion of the results (in *Chapter 5*) are presented in this chapter. It is to be noted that the limitations discussed in *section 6.8.* do not discredit the results of this research. To address all the objectives, it is demonstrated that calculation of the Tourism Climate Index is consistent with literature, despite the data sample of the weather stations over a 10-year period rather than 30 years.

In using the TCI to calculate the classification of the climate suitability for tourism in Namibia, it is noteworthy that the use of the TCI will be disputed amongst scholars (Morgan *et al.,* 2000; de Freitas *et al.,* 2008; Scott *et al.,* 2016; Scott *et al.,* 2019a). This is due to the deficiencies cited within the literature of a lack of empirical testing of the results of the TCI. This further emphasises the need for a standard approach to the quantification of climate conditions for the purpose of determining the climatic suitability of climate for tourism. The index has a societal value for planning and management of climate resources for tourism. In the classification and spatial distribution of the climate conditions in Namibia, there is a latitudinal gradient. The higher TCI scores are found in central and southern Namibia, while the lower TCI scores are found in the northern regions, except in Winter where the coastal regions are included in the lower score classifications. The results reveal that winter is the best season for tourism, which is important for further adaptation methods for tourist operators. The correlation between peak tourist visitation and the best suited season for tourism is based on a short-term record and would require a very strong correlation for a significant result (Yömaa, 2014; Fitchett *et al.,* 2017). In calculating the TCI for Namibia, this research has contributed to the existing literature on tourism-climate research, particularly for Africa.

CHAPTER 7: SYNOPSIS

7.1. INTRODUCTION

Few studies have applied the TCI to regions in the global South, these include Lesotho and South Africa (Fitchett *et al.,* 2016a, b; Fitchett *et al.,* 2017; Noome and Fitchett, 2019). There is concern amongst researchers in the global South regarding the lack of integration between tourism and climate change research in this region as it hinders potential future adaptations (Kájan and Saarinen, 2013; Fitchett *et al.,* 2016b; Hoogendoorn *et al.,* 2016; 2018a; Hoogendoorn and Fittchett, 2018b). The Tourism Climate Index is a composite measure for the assessment of the climate factors most relevant to the quality of the average tourism activities and tourism comfort, and is to date still the index most widely used (Mieczkowski, 1985; Scott and McBoyle, 2001; Amelung and Viner, 2006; Amelung *et al.,* 2007; Nasabpour *et al.,* 2017; Amiranashvili *et al.,* 2018; Noome and Fitchett, 2019).

Since the first known tourism climate index publication in 1985 by Mieczkowski, many studies have sought to calculate an accurate account of the climate suitability of destinations for tourism (Scott and McBoyle, 2001; Scott *et al.,* 2004; Amelung and Viner, 2006; Amelung *et al.,* 2007; Roshan *et al.,* 2016; Fitchett *et al.,* 2016b Fitchett *et al.,* 2017; Nasabpour *et al.,* 2017; Amiranashvili *et al.,* 2018; Noome and Fitchett, 2019). Across these attempts to calculate the climate suitability of these destinations around the globe varying methods have emerged to improve on the TCI deficiencies, and as a result there is much dispute regarding the importance of each index for climate suitability ratings (Morgan *et al.,* 2000; de Freitas *et al.,* 2008; Scott *et al.,* 2016; Scott *et al.,* 2019a). Until a universal index is agreed upon, the use of the TCI in tourism-climate research, in spite of its deficiencies is nevertheless useful for the comparison of bioclimatic comfort levels for the average tourist and is based on climate variables commonly available from weather stations and climate models, thus making data accessible and the calculation simple (Mieczkowski, 1985; Matzarakis *et al.*, 2010; Perch-Nielsen *et al.,* 2010; Javan, 2017; Amiranashvili *et al.,* 2018). The index is effective in that it can be applied to various destinations across the globe, unlike the CIT which is aimed at coastal tourism (Li *et al.,* 2018a).

Countries with dire temperature and rainfall projections, with a population particularly dependant on specific climate for tourism, which are vulnerable to climate variability will suffer the most due to their high dependence on seasonal characteristics for tourism, among other activities (Engelbrecht *et al.,* 2015; Fitchett *et al.,* 2017; Roffe *et al.,* 2019). To address the knowledge gap in tourism-climate research in Africa, this study intended to be the first to quantify the climate suitability for Namibia. The results and inferences of this study are presented in *Chapter 5 (Results)* and *Chapter 6 (Discussion).* This chapter presents a synthesis of the work from previous chapters, firstly by highlighting the extent to which the aim and objectives were achieved from *Chapter 1 (Introduction)*. Secondly, the future trajectories in this field are explored. Lastly, within the broader context of Africa, this chapter emphasises the significance of the main findings of this study, most notably the important of continued research in understanding the relationship between climate change and tourism.

7.2. ACHIEVEMENT OF STUDY AIMS AND OBJECTIVES

The aim and objectives of this study are viewed under *1.2. Rationale, study aims and objectives* under *Chapter 1 (Introduction).* The primary aim of this research was to assess the climate suitability of Namibia for tourism based on the Tourism Climate Index. The main objectives of were developed for the purpose of addressing this primary aim through contributing to the existing knowledge gaps in southern African tourism-climate research highlighted throughout *Chapter 1 (Introduction)* and *Chapter 2 (Literature Review)*. Objectives for this study were achieved through the use of maximum daily temperature, mean temperature, minimum relative humidity, mean relative humidity, daily sunshine hours, total monthly precipitation, and monthly average wind speed (Mieczkowski, 1985; Per-Nielsen *et al.,* 2010), over a 10-year period (2008-2018) from seven weather stations across Namibia. In accomplishing the objectives of this study, it must be noted that the data limitations, discussed in *6.8. Limitations* under *Chapter 6 (Discussion)*, have not compromised the achievement these objectives. The objectives are presented in order as they are listed under *1.2. Rationale, study aims and objectives* under *Chapter 1 (Introduction)*, with the purpose to present the extent to which these objectives have been achieved.

4. *To calculate the TCI scores for seven locations spread across Namibia over the period 2008-2018.*

This objective required the calculation of seven combined climate variables from each of the seven weather stations over the study period (Perch-Nielsen *et al.,* 2010), the results of these calculations are presented under *5.3. Tourism Climate Index*, *5.3.1. Study period mean TCI score*, and *5.3.2. Annual mean TCI scores* of *Chapter 5 (Results)*. The process of achieving this objective is detailed in *4.3. Calculation of the TCI* under *Chapter 4 (Methods).* This objective was achieved through quantifying the seven climate variables using the TCI formula on both a mean and annual scale.

The purpose of these calculations was to determine the climate suitability of the weather stations across Namibia for tourism. The discussion regarding the results of these calculations is presented in *6.3. Spatial distribution of climate suitability of Mean Annual TCI scores in*

Namibia and *6.4. Seasonal distribution of climate suitability for mean monthly TCI scores in Namibia* under *Chapter 6 (Discussion)*. In summary, the annual and monthly TCI scores are consistent with the published literature of which destinations were the most climatically suitable as well as the expected best time of year for tourism in Namibia according to climate (Sylvia *et al.,* 2012; Leeney, 2014; Kimaro *et al.,* 2015). Hence, the weather stations selected for this study were determined appropriate for objectives two and three.

5. *To assess the variability in the TCI for the seven weather stations selected in Namibia*.
    a. *To determine the annual spatial distribution of the TCI scores*
    b. *To map the seasonal distribution of the TCI scores*

This study is the first to attempt to assess the variability of mean annual and monthly TCI scores for seven weather stations selected across Namibia. These objectives assess both the spatial and seasonal distribution of the TCI in Namibia, the results of which are presented in *5.3.3. Tourism Climate typologies* and *5.3.4. IDW seasonal distribution of the TCI* under *Chapter 5 (Results).* The first part of this objective, the mean annual distribution of the TCI scores, was assessed through six tourism-climate typologies detailed under *4.4. Spatial distribution of the TCI* of *Chapter 4 (Methods).* The results of the determined typologies are presented in *5.3.3. Tourism Climate typologies* under *Chapter 5 (Results),* where they were compared to countries around the world that have calculated the TCI in *6.3. Spatial distribution of climate suitability of Mean Annual TCI scores in Namibia* under Chapter 6 (Discussion; Kovacs and Unger, 2014; Roshan *et al.,* 2016; Nasabpour *et al.,* 2017; Huang *et al.,* 2018). Resulting spatial distribution of TCI scores did not agree with some of the distributions of destinations in the global North (Huang *et al.,* 2018). As theorised in *1.2. Rationale* under *Chapter 1 (Introduction)*, the TCI scores differ from those proposed by Mieczkowski (1985) and Amelung et al. (2007) under a higher resolution for studying the climatic conditions for successful tourism.

The second part of this objective, mapping the seasonal distribution of the TCI scores, was addressed through IDW mapping detailed in *4.5. Seasonal distribution mapping of the TCI using ArcGIS* under *Chapter 4 (Methods)*. The distribution of each season for each of the weather stations, presented in *5.3.4. IDW seasonal distribution of the TCI* under *Chapter 5 (Results),* were compared along with mean seasonal distribution of the TCI scores to the seasonal distribution of the destinations with TCI scores in *6.4. Seasonal distribution of climate suitability for mean monthly TCI scores in Namibia*, *6.4.1. Spring*, *6.4.2. Summer*, *6.4.3. Autumn* and *6.4.4. Winter* under *Chapter 6 (Discussion)***.** The high annual TCI scores were reflected in the mean monthly TCI scores of the weather stations, climatic suitability appeared to exist by a latitudinal gradation whereby the higher the latitudinal gradient the lower the TCI output and the lower the gradient the higher the TCI output as presented in *6.4. Seasonal distribution of climate suitability for mean monthly TCI scores in Namibia* under *Chapter 6 (Discussion)*. Tourism seasonality is possibly the most important aspect in tourism economy (Amelung *et al.,* 2007; Hoogendoorn and Fitchett, 2016; Li *et al.,* 2018a; Sobhani and Zengir, 2020).

6. *To explore how climate variability will influence the TCI scores and the suitability of destinations in Namibia for tourism*.

This objective required the assessment of climates factors that could influence the TCI scores for each of the selected weather stations, as detailed in *2.8. Anticipated changes to Namibian* *climatic conditions* under *Chapter 2 (Literature Review)*. The results, described *in 5.4. Factors influencing the TCI score*, *5.4.1. Factors increasing the TCI score* and *5.4.2. Factors decreasing the TCI score*, demonstrated the extent to which each of the seven variables influenced the final TCI output. The potential shifts in seasonal TCI characteristics due to projected climate variability is discussed in *6.5. Climate Factors Influencing the Mean Monthly TCI Scores* under *Chapter 6 (Discussion)*. Furthermore, the implications of climate change in the broader context of tourism was discussed.

7.3. SIGNIFICANCE OF THE STUDY FINDINGS

The results calculated and determined under *Chapter 5* and further discussed under *Chapter 6*, incorporated with existing knowledge reviewed in *Chapter 2*, highlight the need for continued research in the field of tourism-climate literature following this study. The results of this study have contributed to academic research as well as added socio-economic value for tourists and tourism stakeholders. In terms of socio-economic value, the results and inferred implications regarding tourism seasonality may be translated into information which could be accessible to the public (specifically tourists and tourist operators) of Namibia (Fitchett *et al.,* 2017; Mueller *et al.,* 2020).

The mean annual TCI scores fall within the "good" to "excellent" climate ratings, which confirms that Namibia has high climatic suitability ratings for tourism. The variability within the TCI scores in enough to differentiate between the climatic suitability of the locations chosen for this study, and it is validated internationally as it is beneficial for the comparison with studies the have calculated TCI ratings for other locations. Moreover, greater seasonal variation which allowed for clearer selection processes between destinations is noted *in 6.4. Seasonal distribution of climate suitability for mean monthly TCI scores in Namibia* under *Chapter 6 (Discussion)*. Since this study already demonstrates a relatively high agreement between the literature and the results, translating the results into accessible information for the use of the general public (tourists) and government in Namibia for tourism adaptative strategies is of importance. The use of the spatial and seasonal distribution of climate resources in Namibia derived from the TCI is significant as it may greatly assist in positive efforts towards tourism and other economic sectors sensitive to climate.

7.4. FUTURE RESEARCH TRAJECTORIES

This section discusses the future trajectories for tourism-climate research, specifically building on the aim and objectives of this research. Avenues for future research mainly surround the implications climate variability will have on TCI scores and tourism. Thus, it should be noted that even though this study concentrates on Namibia, future research using tourism-climate indices should be applied in Africa, specifically for the remaining countries across southern Africa (Fitchett *et al.,* 2017; Fitchett and Hoogendoorn, 2018; Mahmoud *et al.,* 2019; Noome and Fitchett, 2019). Future research to reach a better understanding of regional TCI score variability and to facilitate improved climate change forecasting for tourism in these developing regions (Fitchett *et al.,* 2017). Tourism sustainability is largely contingent on the ability of a destination to attract both local and international tourists in conjunction with the climatic suitability as a tourist attraction (Agnew and Viner, 2006; Steiger *et al.,* 2016; Scott *et al.,* 2020). Countries that will be the most vulnerable to a changing climate on their tourism sector are regions which do not have the infrastructural resources for continual sustainable adaptation (Fitchett *et al.,* 2016a).

Global, regional and local climate change projections are becoming essential for effective long-term adaptative strategies (Mahmoud *et al.,* 2019). Within the last two decades, there has been a significant amount of work surrounding the use of Atmosphere – Ocean Global Climate Models (AOGCMs) and their involvement with the Coupled Model Intercomparison Project phase 5 (CMIP5), which produced multimodel climate change simulations (Taylor *et al.,* 2012). However, countries with poor meteorological data availability may pose similar, or greater, limitations for the calculation of the TCI and future climate modelling (Fitchett *et al.,* 2016a).

On-going development of tourism-climate indices have been directed towards accurately capturing the climate conditions of a destination (de Freitas *et al.,* 2008; Yu *et al.,* 2009; Perch-Nielsen *et al.,* 2010; Scott *et al.,* 2016). Research into the objective experience of tourists in terms of climate has seldomly been applied in conjunction with TCI scores to gauge the sensitivity of tourists to climate (Fitchett and Hoogendoorn, 2019). Largely, the perceptions held by tourists of climate and weather at a travel destination was measured by weightings obtained from an 'expert opinion' (de Freitas *et al.,* 2008; Rossello-Nadal, 2014). Fitchett and Hoogendoorn (2019) compared the TCI output for 19 locations in South Africa with TripAdvisor reviews, which aligned with the distribution of climatic conditions mentioned in the reviews with only slight modifications to wind speed. The findings of the study are important for future research using the Tourism Climate Index (TCI), as the self-reported satisfaction of tourists at a destination will encourage accommodation establishments to address points of concern in a more specified and efficient manner (Fitchett and

Hoogendoorn, 2019). Furthermore, the work of the current study is valuable as the calculated TCI scores can be used as a tool for evaluating the climate suitability of seven destinations across Namibia for tourism in *5.3. Tourism Climate Index* under *Chapter 5 (Results)*, with the additional value that it can be compared around the globe to destinations that have calculated the TCI scores. However, to add more value for future research regarding climatic differences on a seasonal scale, TCI scores could be correlated with tourism flows including both arrivals and departures (Fitchett *et al.,* 2017).

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7.5. SYNOPSIS

This study was undertaken to assess the climate suitability of Namibia for tourism using the TCI. The climate suitability of Namibia for tourism assessed using the Tourism Climate Index (TCI) was conducted for the period of 2008-2018 from 7 weather stations which are spread relatively evenly across Namibia. Conducted in two parts, part one of this study focused on quantifying the climate suitability across the country for tourism. Part two of this study relates to the contribution of knowledge to the existing southern African literature on climate and tourism. Firstly, the TCI calculation was conducted using seven climate variables in the adapted version of Perch-Nielsen et al. (2010), originally developed by Mieczkowski (1985). The TCI was determined to be a suitable index approach acceded to in the literature, which stated that until an agreed bioclimatic index is revealed the use of the TCI in tourism-climate research (Mieczkowski, 1985; Matzarakis *et al.*, 2010; Perch-Nielsen *et al.,* 2010; Javan, 2017; Amiranashvili *et al.,* 2018). These TCI scores are the first conducted for Namibia and contribute to a description of the spatial distribution of climate suitability across the country.

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