University of the Witwatersrand

School of Geography, Archaeology and Environmental Science

EXPLORING THE VALUE OF TOURISM CLIMATE INDICES FOR 18 LOCATIONS IN SOUTH AFRICA

Dissertation submitted to the Faculty of Science in fulfilment of the requirements for the degree Master of Science

Dean Connor Robinson

Johannesburg, June 2016

Declaration

I hereby declare that this dissertation is my own, original work, except where otherwise acknowledged. It is being submitted for the degree MSc to the University of the Witwatersrand, Johannesburg. I have not submitted it previously, for the purpose of obtaining a degree, qualification or otherwise at this, or any other, university.

Dean Robinson

Date

Abstract

The tourism climate index (TCI) provides information on the levels of comfort for tourism activity based on the climate of a destination. This index has been widely used to quantify the impacts of climate change on tourism at a diversity of destinations. The index is calculated based on the monthly averages of seven variables. To apply this index in South Africa, meteorological datasets of each variable were obtained from the South African Weather Service for 18 locations across South Africa. Each location is climatically distinct and relies on the tourism sector to generate social and economic development within the region. The 18 study sites, are influenced by differences in elevation, the Benguela and Agulhas currents, found along the west and east coast of the country respectively, and by the temporal scale at which summer and winter rainfall occurs across the country. Various data limitations resulted in the need for an adapted tourism climate model in order to calculate the climate suitability of all the chosen locations. The annual mean TCI scores for the period 2005-2014, reveal excellent to ideal climate suitability for tourism at the majority of the locations, with TCI scores ranging between 80.20 and 93.00. However, for the same period, East London, Port Nolloth and Belfast have annual average TCI scores between 74.88 and 79.20, which indicates that their climate suitability is considered to be very good. During the period 2005-2014, the majority of the locations experienced an increase in their climate suitability for tourism. Mean Monthly TCI scores indicate seasonal variations in the climate suitability of destinations across the country. These results suggest that Durban and St Lucia have the most favourable climate conditions for tourism during winter; while Cape Town, Paarl, Port Elizabeth, East London, Port Nolloth and Knysna have the most favourable climate conditions for tourism during summer; and Bethlehem, Bloemfontein, Johannesburg, Kimberley, Ladysmith, Nelspruit, Pilanesberg, Pretoria, Polokwane, and Belfast have the best climatic conditions for tourism during spring and autumn. The difference in average TCI scores across the country and the rate at which these TCI scores change over temporal scales highlights the need for constant monitoring of the climate suitability in these regions, particularly because they are reliant on the tourism sector. Rainfall and average thermal comfort had the most negative influence on the annual mean TCI scores, whilst daytime thermal comfort had the most positive influence on the same TCI scores. Tourism academics and researchers in South Africa were interviewed and they perceive climate change to be a social issue that will only impact the South African tourism sector in the future. The perceptions of the tourism academics and researchers are important as they are often the first people to engage with information pertaining to issues about tourism in South Africa. Although none of the respondents could provide a clear indication of when they perceive climate change to have an impact on the South African tourism sector, the majority of them believe that that TCI can be used as a tool to quantify the impacts of climate change on the tourism sector. This would improve the capacity of tourism stakeholders to adapt to the resultant impacts. However, most of the tourism academics and researchers clearly stipulated that the TCI should be used in conjunction with current climate change and tourism research in the country.

Acknowledgements

I would first like to thank my supervisors Professor Gijsbert Hoogendoorn, Doctor Jennifer Fitchett and Doctor Raeesa Moolla. They have continually provided me with assistance, support and encouragement throughout the project. Their contributions to this study have been invaluable. A special thanks to Professor Hoogendoorn for his guidance and support on the qualitative section of this study. Many thanks must got to Doctor Jennifer Fitchett for her assistance with the statistical aspects of this study and for her continuous support and guidance throughout the process.

Second I would like to thank the South African Weather Service for providing me with meteorological data for my study sites. More specifically I would like to thank Joe Matsapola for accommodating my requests for various data records from the South African Weather Service. Thanks must go to the tourism academics and researchers who made time to participate in my study. Their contributions through the interview process were invaluable and added considerable value to my research.

Lastly, I would like to acknowledge the support of my family and friends, who provided constant motivation throughout the duration of this study.

Contents

List of Figures

List of Tables

List of Acronyms

BCI: Beach Climate Index

CA: Average Thermal Comfort

CD: Daytime Thermal Comfort

CIT: Climate Index for Tourism

ET: Effective Temperature

GCM: Global Climate Model

GEAR: Growth Employment and Redistribution

IPCC: Intergovernmental Panel on Climate Change

ITCZ: Inter Tropical Convergence Zone

LED: Local Economic Development

PET: Physiological Equivalent Temperature

RCM: Regional Climate Model

SAWS: South African Weather Service

SET: Standard Effect Temperature

SMME: Small Medium and Micro-enterprises

TCI: Tourist Climate Index

UNEP: United Nations Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

UNICEF: United Nations Children's Emergency Fund

UNWTO: United Nation World Tourism Organisation

USA: United States of America

WMO: World Meteorological Organisation

WTTC: World Travel and Tourism Council

Chapter 1: Introduction

1.1. Background to the Research

Tourism is one of the world's largest economic sectors and is rapidly expanding annually (Scott and Lemieux, 2010; Amelung and Nicholls, 2014). The United Nations World Tourism Organisation (UNWTO) stipulated that global international tourist's arrivals steadily increased in 2014 by 4.3% from 2013 to reach 1133 million visitors (UNWTO, 2015a). The record in 2012, of one billion international tourists travelling the world was followed by continued growth in 2013 and 2014, and forecasts suggest that international tourist's arrivals are set to increase by 3% to 4% in 2015 (UNWTO, 2014; UNWTO, 2015b). It has been estimated that global international tourist arrivals will increase at 3% per year between 2010 and 2030 to reach 1.8 billion visitors by 2030 (UNWTO, 2015a).

Despite continuous global economic challenges and geopolitical changes, international tourism has remained steady, with results in 2013 exceeding expectations and forecasts (UNWTO, 2014). This is highlighted by the direct contribution of tourism and travel to the global GDP (USD 71.6 billion and 3.6% of the total global GDP) in 2013 (World Tourism and Travel Council (WTTC), 2014). The sector's direct contribution to global GDP is projected to increase by 4.9% per annum to USD120.6 billion (3.5% of global GDP) by 2024 (WTTC, 2014), and surpass growth within the broader economy and other industries (WTTC, 2013; Amelung and Nicholls, 2014). Furthermore, in 2013 tourism and travel directly employed 8 181 000 people and it is expected to rise by 2.4% per annum to 10 609 000 jobs by 2024 (WTTC, 2014).

The attractiveness of a tourist destination and the choice of a tourism destination for visitors is inherently influenced by multiple factors, including climate, with some saying that climate is one of the most dominant factors influencing tourist flows around the globe (de Freitas *et al*., 2008; Becken, 2013; Roshan *et al*., 2016; Kovács and Unger, 2014; Falk, 2014; Dubois *et al*., 2016). Climate plays an important role when choosing a destination by regulating the time of year when climatic conditions are at their optimal, while simultaneously influencing destinations that offer the most ideal climatic conditions (Mieczkowski, 1985; Kovács and Unger, 2014). All tourism destinations are climate sensitive and the climate fundamentally affects the tourists thermal comfort and well-being, and the visitor's satisfaction with the tourist destination (Scott and Lemieux, 2010; Kovács and Unger, 2014). The quality and length of tourism seasons and the tourism demand is influenced by inter-annual climate variability (Scott *et al*., 2008; Kovács and Unger, 2014).

Due to the fact that many tourism activities occur outdoors, large parts of the tourism sector are climate dependent. This suggests that globally and regionally, the implications and effects (positive and negative) of climate change could be felt throughout the sector (Hamilton *et al*., 2005a; Amelung *et al*., 2007; Falk *et al*., 2014; Roshan *et al*., 2016). Climate change is a serious concern and one that is of global significance (Amelung and Nicholls, 2014), with unprecedented changes expected to occur in the earth's climate during the 21st century (Rosselló-Nadal, 2014). Additionally, it has been stipulated that tourism is one of the most sensitive sectors to climate change (Rogerson, 2016a). However, the costs and distributional impacts of climate change are not evenly shared across the globe (Mendelsohn *et al*., 2006). The collective historic emissions of CO_2 by developed countries, is far greater than the emissions released by developing nations (Sagar *et al*., 2006). As a result, there has been a widespread call for developed nations to facilitate adaptation in developing regions to lessen the impacts of climate change (Buob and Stephan, 2013).

International tourism predominantly occurs in developed countries (Scott and Lemieux, 2010). However, tourism is an important contributor to the national and local economies of many developing nations, including many African countries such as, Kenya, Botswana, Egypt and South Africa (Kirsten and Rogerson, 2002; Scott and Lemieux, 2010; Akinboade and Braimoh, 2010; Saarinen and Rogerson, 2013; Maharaj and Balkaran, 2014). The potential of tourism to contribute to economic development and social up-liftment in Africa was accentuated in the New Partnership for Africa's Development (NEPAD) tourism action plan (Rogerson and Visser, 2011a), which recognised tourism as one of the sectors with considerable potential to aid in the economic regeneration of the continent, through the diversification of African economies and through the generation of foreign exchange (NEPAD, 2004). According to the UNWTO, Africa experienced a 2% increase in international tourist arrivals in 2014 from the previous year and sub-Saharan Africa maintained an increase of 3% in 2014 from the previous year (UNWTO, 2015a). The tourism sector plays a vital role in the economic development processes in African countries such as South Africa (Binns and Nel, 2002; Rogerson, 2008; Akinboade and Braimoh, 2010; Rogerson and Visser 2011b).

South Africa regards tourism as its 'passport to development' (Binns and Nel, 2002; Rogerson and Visser, 2011a; Visser and Hoogendoorn, 2011). Furthermore, it is perceived as a strategy to attract foreign investment, create jobs and reduce adverse social effects (Kirsten and Rogerson, 2002; Maharaj and Balkaran, 2014; Saarinen, 2014; Hoogendoorn *et al*., 2016). This is highlighted by the South African National Tourism sector strategy, which predicts the country's tourism economic contribution to increase from R318.16 billion in 2015 to R499 billion in 2020 (Maharaj and Balkaran, 2014). South Africa is regarded as Africa's leading tourist destination (Rogerson and Visser, 2011b). Despite Africa showing lower levels of international tourist arrivals compared to other destinations around the globe (*Figure 1.1*), it has been suggested that between 2010 and 2030 arrivals in emerging destinations (like South Africa and other developing countries around the world) are expected to increase at double the rate of those destinations in developed economies (UNWTO, 2015).

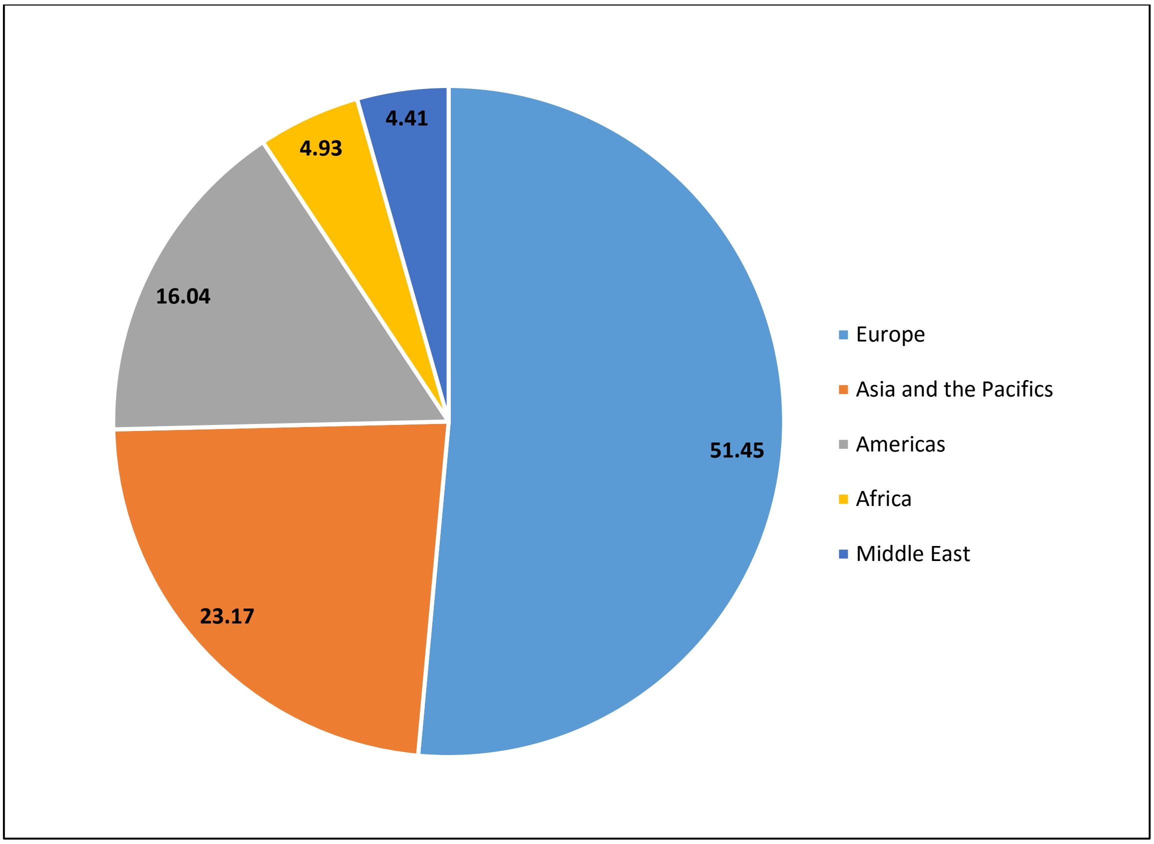


Figure 1.1: International tourist arrivals (%) (Adapted from UNWTO, 2015b).

It has been claimed by Kalabokidis *et al.* (2015) that global climate change will inevitably alter temperature and precipitation patterns around the world. According to the Intergovernmental Panel on Climate Change (IPCC), the majority of global climate models indicate that global temperatures are set to increase over the coming century (IPCC, 2007; Moreno, 2010; Zinyengere *et al*., 2013). The average temperature projections under different emission scenarios indicate increases between 1.8˚C to 4˚C during the current century (Zinyengere *et al.,* 2013).

It is predicted that for all the seasons across Africa, there will be a warming that is greater than that of the global mean (Zinyengere *et al*., 2013). More specifically, various climate trends and scenarios for South Africa show that annual average temperatures have increased by nearly 1.5 times that of the global mean for the period 1960 to 2010 (Stevens *et al*., 2014; Rogerson, 2016). Both minimum and maximum temperatures have showed annual increases during the same time period between 1960 and 2010 (Stevens *et al*., 2014). Despite projections varying for South Africa, an overall trend exists, which indicates that all provinces will experience warmer conditions in the future (Stevens *et al*., 2014). The rainfall predictions are far more uncertain, however, there is a consensus that there will be drier conditions to the west and south of the country and wetter conditions over the eastern part of the country (Stevens *et al*., 2014). These projected climatic changes for South Africa can have a significant impact on the natural and environmental resources, many of which form the foundation of many of the different types of tourist activities that the country has to offer (Spenceley and Goodwin, 2007).

There has been wide recognition that the impacts of climate change cannot be escaped, and as a result there has been a significant movement towards identifying and implementing appropriate adaptation or mitigation strategies in response to the impacts of future projected climate change (Tompkins *et al*., 2010). Many adaptation and mitigation strategies have been used at destinations around the world, but it is important to recognise the need for destination specific responses to future climate change (UNWTO and UNEP, 2008). Furthermore, a country’s geographical and economic characteristics and the perceptions of people living in the country play a major role in addressing climate change and the impacts it may have on a particular region (O’ Connor *et al*., 1999; Ungar, 2000; Leiserowitz, 2005).

Due to the increase in competition within the tourism sector and the projected threats of climate, climate indices and other metrics, such as, the Physiological Equivalent Temperature (PET), Effective Temperature (ET) and Standard Effect Temperature (SET) have been developed in an attempt to determine the significance of climate on tourism (de Freitas *et al*., 2008). These metrics and indices have been formulated to explore the suitability of various tourist actives such as beach and water activities and game viewing, with regards to climate conditions of a particular location (Kovács and Unger, 2014). Some of the early indices that were applied to tourism include the PET, ET and SET, these were initially developed to account for human comfort in general (Moreno and Amelung, 2009). However, these metrics ignore important non-thermal aspects of weather (Moreno and Amelung, 2009), and therefore present a fundamental limitation when being applied to the tourism sector.

More recently, in an attempt to effectively measure the effects of climate on tourism, various composite indices have been developed (Cegnar and Matzarakis, 2004). These came in the form of the beach climate index (BCI) developed by Morgan *et al*. (2000), and the climate index for tourism (CIT) which was developed by de Freitas *et al*. (2008). However, both these models were fundamentally limited in the fact that they were both only validated at a very small spatial scale and were not tested and validated at a broader geographical scale. As a result, the BCI and the CIT did not take into account the potential for cultural differences in perceptions of suitable climate (Moreno and Amelung, 2009).

The index that is used in this study, is the tourism climate index (TCI), and is one of the most widely used indices in the world for tourism (Kovács and Unger, 2014). The TCI used in this study was developed by Mieczkowski (1985) and adapted by Perch-Nielsen (2010). The index is calculated based on the monthly averages of seven variables: maximum daily temperature; mean daily temperature; minimum daily relative humidity; daily relative humidity; precipitation; daily sunshine hours and wind speed (Perch-Nielsen *et al.,* 2010). The TCI simply provides information on the levels of comfort for tourism activity based on the climate of a destination (Amelung *et al*., 2007). Despite the TCI having fundamental limitations, it is the most widely used index within tourism and climate change research. Its generalisability has been extensively proven through studies across the globe and in different climatic conditions (c.f. Scott *et al*., 2004; Amelung and Viner, 2006; Amelung *et al*., 2007; Amelung and Nicholls, 2014; Kovács and Unger, 2014; Grant, 2015). More importantly, the TCI is not limited to assessing the impacts of climate suitability for the purpose of one type of tourism activity, it is scaled for activities that involve moderate to low levels of physical activities (such as game viewing) and is not just restricted to beach activities like the CIT and the BCI (de Freitas *et al*., 2008).

1.2. Rationale

As a result of the tourism sector being heavily reliant on climate and weather systems and being severely affected by changes in these systems (Rosselló-Nadal, 2014), large amounts of literature exist which focuses on the impact of climate change on tourism (c.f. Agnew and Viner, 2001; Madison, 2001; Elsasser an Burki, 2002; Hamilton *et al*., 2005a; Hamilton *et al*., 2005b; Amelung *et al*., 2007; Peeters and Dubois, 2010; Colakoglu and Mil, 2011; March *et al*., 2014; Kubokawa *et al*., 2014). However, this research has predominantly been conducted in developed countries, with limited literature exploring the effects of climate change on tourism in Africa. Research on the likely impacts of climate change on tourism in South Africa remains limited. Therefore, due to the tourism sectors important role in aiding social and economic development in South Africa (Rogerson, 2007; Visser and Hoogendoorn, 2011; Rogerson, 2014a), it is imperative that the effects of climate change on tourism in South Africa be explored and documented.

The Tourist Climate Index (TCI) is one of the most comprehensive and widely recognised tools which indicates whether the local climate of a particular destination is likely to improve or decline over time, with a particular focus on tourism-based activities (Perch-Nielsen *et al*., 2010; Roshan *et al*., 2016; Kovács and Unger, 2014). The TCI is a tool which provides a quantitative representation of climate for the purpose of tourism-based activities. Studies conducted in developed countries, predominantly in the European regions have used TCIs to explore changes in suitable climatic conditions for tourism (c.f. Perch-Nielsen *et al*., 2010; Mieczkowski, 1985; Kovács and Unger, 2014; Kubokawa *et al*., 2014; Amelung and Nicholls, 2014; Scott *et al*., 2004). However, the use of TCIs in South Africa remains limited. In addition, due to the limited use of TCIs in South Africa, it is not yet certain whether or not this is a tool that can be effectively used in developing world context. Therefore, this study will attempt to assess the value and effectiveness of the TCI in the South African context. In an attempt to do so, tourism researchers and academics will be interviewed, and their perceptions of the current trends in tourism in South Africa, along with other expert knowledge, will be used to explore and determine the value that TCIs can offer to future research in the country.

Using the TCI model, this study will provide an indication of the suitability of climatic resources for tourism across the country. This information will allow governments, organisations and other tourism stakeholders to gain an insight into how climate change is having an impact on the suitability of different destinations in the country from a climatic perspective over the study period. The findings of this study may also provide information to stakeholders in the tourism sector, which may prove to be beneficial during the planning and decision-making stages of adaptation processes in the future. More importantly, this research acts as a starting point for further research into the use of climate-tourism indices in the South African context, and what value they hold in acting as an effective tool in assessing the changing climate and the potential impact it may have on destinations around the country.

1.3. Study Aim

The fundamental aim of this study is to contribute to the existing international and South African literature on climate change and tourism. More specifically, the aim is to contribute knowledge on the nature and extent of climate variability and change in South Africa in recent times, and to explore how this change has influenced the suitability of destinations in South Africa as a tourist destination, according to the TCI model. In addition, the study aims to establish the value and effectiveness of the TCI in determining the suitability of climate for tourism at destinations throughout South Africa.

The research objectives are:

1. To explore the long-term Tourism Climate Indices (TCIs) for 18 locations across South Africa to:
   A) Determine the climate suitability of each location and
   B) Study the spatial patterns in variation
2. To determine the direction and magnitude of change in the TCI scores over the study period to:

    A) Determine whether certain locations are becoming more or less climatically suitable for tourism
    B) Explore the spatial patterns in the observed changes
3. To explore the perceptions of tourism academics and researchers in South Africa regarding the relationship between climate change and tourism, and the suitability of TCIs.

1.4. Structure of the Thesis

The thesis has been structured into seven chapters, the first being the introduction to the study and the main study aims. Chapter 2 provides synthesis and critical analysis of the literature on climate change and tourism. Additionally, it explores climate change in South Africa, the relationship between the developed and developing world, and adaptive capacity. It also investigates the tourism sector, and literature on the key stakeholders. Chapter 3 provides a description of South Africa, and provides justification for the 18 study sites selected. Chapter 4 outlines the methods used in this study, and is divided into quantitative and qualitative sections. Chapter 5 presents the results for the study, while Chapter 6 provides critical analysis and engages with the literature. A conclusion is presented in Chapter 7.

Chapter 2: Literature Review

2.1. Introduction

On a global scale, tourism is one of the fastest expanding sectors and has a major role to play in national and local economies (Scott and Lemieux, 2010). Despite this important role, it faces many challenges with one major challenge being climate change (Moreno, 2010; Scot and Lemieux, 2010). Until recently, climate change has been recognised as having the potential to have wide and far reaching negative impacts on the global tourism market (Scott *et al*., 2004; Hamilton *et al*., 2005b; Moreno, 2010; March *et al*., 2014). In addition, UNWTO and UNEP (2008) have stipulated that the tourism markets will be affected both directly and indirectly by climate change, with direct impacts influencing major decision making processes of tourists, regarding when and where to travel, while indirect impacts of climate change result from changes in the natural environment of a destination (Agnew and Viner, 2001; Reddy, 2011). While these organisations acknowledged the impact of climate change on tourism, they also highlighted the bilateral relationship between tourism and climate change, by acknowledging the impact that tourism has on climate (Simpson *et al*., 2008; Colakoglu and Mil, 2011).

In light of the recognition that the impacts of climate change cannot be avoided, there has been a shift towards identifying and implementing appropriate adaptation or mitigation strategies in response to the impacts of future projected climate change (Tompkins *et al*., 2010; Dubois *et al*., 2016). Despite various general adaptation strategies being implemented at different destinations around the world, it is important to recognise the need for unique and localised adaptation or mitigation strategies based on destinations, characteristics and the type of tourism product being offered (UNWTO and UNEP, 2008). The geographical and economic characteristics of a region or country will determine the extent to which they are vulnerable to climate change impacts, and ultimately the level of their adaptive capacity (Simpson *et al*., 2008). In addition, to some destinations' geographical and economic characteristics, the literature has highlighted the importance and significant role that people's perceptions play in addressing the global issue of climate change (O' Connor *et al*., 1999; Ungar, 2000; Leiserowitz, 2005). It has been suggested that individuals' understanding of climate change and its associated impacts is imperative and plays a major role in determining their support for mitigation or adaptation strategies and policies (Wolf and Moser, 2011).

Both domestic and international tourism in South Africa have experienced continued growth since the transition into a full democracy, and the promotion of tourism since then has been regarded as an important tool to achieve social and economic development (Binns and Nel, 2002; Lee and Chang, 2008; Akinboade and Braimoh, 2010; Kavita and Saarinen, 2016). The predominant focus of the South African tourism literature has risen from the policy context of the country and revolves around four major themes:

1) Responsible tourism
2) Pro-poor tourism
3) Tourism-based local economic development (LED)
4) Tourism-based SMME

[Hoogendoorn and Rogerson, 2015]

Climate change will have far reaching and significant impacts on South Africa, ranging from the household level (affecting the way people live) to a national level, where industries have to adapt and change as a result (UNICEF, 2011). These impacts will be felt across all sectors of the economy, including tourism (Davis, 2010). Some research in South Africa regarding tourism and climate change has already identified some impacts of climate change on tourism in the country (Hoogendoorn *et al*., 2016; Fitchett *et al*., 2016). However, limited research exists and it is imperative that there is a continued effort to broaden the scope of tourism research in South Africa to focus on aspects such as the relationship between climate change and the tourism sector.

This chapter will discuss the literature on global climate change and its relationship with tourism and assesses the impact of climate change on developing and developed nations. Furthermore, this chapter will explore the uncertainty surrounding climate change, and the importance of perceptions regarding climate change and the role they play when it comes to implementing strategies to adapt to or mitigate against climate change. A comprehensive review will be carried out that explores the literature pertaining to mitigation and adaptation to climate change in general, and on the tourism sector specifically. This chapter will go on to review the literature surrounding climate change in South Africa and what the potential impacts of climate change may mean for the tourism industry in the country. An extensive review of the tourism literature in South Africa will be carried out, and will discuss how the tourism landscape has evolved over recent decades. Finally, the chapter will take a look at different methods of assessing climate suitability for tourism activities, but more importantly, will explore the literature surrounding the tourism climate index (TCI) and why it is the best suited model for this study.

2.2. Global Climate Change and its Relationship with Tourism

Weather and climate are an important aspect of tourism, with some identifying climate as the predominant factor that alters tourist flows on a global scale (Moreno, 2010; Scott and Lemieux, 2010). Weather is the state of the atmosphere at any given place and time, while climate can be described as the measurement of the average and variability of surface variables such as temperature, precipitation and wind over a period of minimum 30 years (IPCC, 2007; WMO, 2013). More simply put, climate is the average weather conditions over a period extending a minimum of 30 years (WMO, 2013). The distribution of tourists temporally throughout the year and the environmental context in which tourism occurs, is greatly influenced by climate (Moreno, 2010; Fitchett *et al*., 2016). This is due to, firstly, seasonal changes around the globe. Natural factors of seasonality relate directly to a destination's climate, which can either attract or deter tourists from visiting a location (Amelung *et al*., 2007). Secondly, climate allows two locations to be compared, and thus influences people's choices based on what climate suits their preferences (Moreno, 2010).

Despite the important role of climate on tourism activities around the world, until recently over the past two decades, very few studies explored the relationship between climate and tourism (Scott *et al*., 2004; March *et al*., 2014). More recent times have seen a wide recognition by governments and tourism stakeholders, that climate change has the ability to significantly impact tourism on a global scale (Hamilton *et al*., 2005b; Moreno, 2010).

Climate change is projected to impact tourism in the future, however, the impacts of climate change are already being felt at destinations, and influencing various decisions within the tourism sector (Simpson *et al*., 2008). The United World Tourism Organisation (UNTWO), has identified four general categories of climate change impacts that will not only impact tourist destinations, but also their competitiveness and sustainability (UNWTO and UNEP, 2008;

Reddy, 2011). Direct impacts of climate change ultimately have a major impact on the decision-making process of tourist (with regards to when and where to go) (Agnew and Viner, 2001; Saarinen *et al*., 2012; Rosselló and Santana-Gallego, 2014). This is due to the fact that weather and climate have an influence at both the destination location and the source location (Agnew and Viner, 2001). It therefore influences decision-making processes of tourists because it alters the climatic attractiveness of a location (Reddy, 2011). One of the fundamental direct impacts of climate change on tourism will be the redistribution of climatic resources between different tourism destinations (Ehmer and Heymann, 2008; Marshall *et al., 2011*). Therefore, due to the changes in the length and quality of climate dependent tourism periods, the competitive relationship between destinations could be altered and therefore affect the viability and profitability of tourism businesses and operators around the world (UNWTO, 2009; Reddy, 2011).

It has been acknowledged that the natural environment is a significant resource for global tourism markets (Uyarra *et al*., 2005). The indirect impacts of climate change are a result of climate change impacting a destination's environment (Agnew and Viner, 2001). Therefore, changes in the natural environment or conditions of a destination, as a result of climate change can potentially have significant impacts for the tourism destination (UNWTO, 2009). Such changes can lead to water shortages, threats to the local biodiversity and landscape aesthetics, increase coastal erosion and may potentially damage pertinent tourism infrastructure due to extreme weather events such as flooding (Reddy, 2011). Due to the natural environment, which is sensitive to changes in climate, being a significant resource for global tourism, the tourism sector is vulnerable to the impacts of climate change (Agnew and Viner, 2001).

Vulnerability has become an important concept to consider when dealing with the human-environment boundary (Perch-Nielsen, 2010). For the purpose of this study, the concept of vulnerability will follow from the definition provided by the IPCC Fourth Assessment Report, which defines vulnerability as:

> A function of a system's exposure to climate change, its sensitivity, and its adaptive capacity
>
> [Perch-Nielsen, 2010: 581; *Table 2.1*]

Table 2.1: Important components of the vulnerability definition (Adapted from Perch-Nielsen, 2010).

Component	Description
Exposure	"Nature and degree to which a system is exposed to significant climatic variations" (IPCC 2001: 987).
Sensitivity	"The degree to which a system is affected, either adversely or beneficially, by climate variability or change" (IPCC 2007: 881) (The effect may be direct or indirect)
Adaptive Capacity	"The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC 2007: 869).

Using this definition of vulnerability, Perch-Nielsen (2010) developed a matrix to assess the vulnerability of the tourism sector to climate change (*Table 2.2*). This was achieved by combining the three components of vulnerability; exposure, sensitivity and adaptive capacity, with different mechanisms that might have a direct or indirect effect on the tourism sector (Perch-Nielsen*,* 2010). This matrix has been developed for the general tourism sector and can be adapted to specific tourism activities and can be used at different scales (Perch-Nielsen, 2010).

Various local, national and international mitigation strategies and policies that look to reduce GHG emissions can potentially cause transport costs to increase (due to certain tax regulations that have been implemented or because of the high cost of alternative energy sources and technology) and change environmental perceptions and attitudes, which could ultimately lead to tourists changing their destination choices (UNWTO, 2009). Lastly, climate change may have indirect societal change impacts (UNWTO and UNEP, 2008). It is suggested that climate change impacts and the resultant mitigation and adaptation processes will have significant economic costs and therefore threaten future economic growth in many economies around the world (Simpson *et al*., 2008).

Table 2.2: Conceptual framework for the vulnerability of the tourism sector to climate change (from Perch-Nielsen, 2010b).

	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						

Reflecting this wide-spread recognition of the potential impacts that climate change could have on the tourism sector, the United Nations World Tourism Organisation (UNWTO) along with United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO), met in Davos, Switzerland in 2007, for the Second International Conference on Climate Change and Tourism (Moreno, 2010). One of the major outcomes of the conference, is reflected through the 'Davos declaration' which states that:

> 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. It is estimated to contribute some 5% of global CO_2 emissions.
>
> [UNEP and UNWTO, 2008: 13]

This declaration alludes to the fact that the impacts of climate change are already being felt by the tourism sector, but that the tourism sector is partly responsible for the CO_2 emissions responsible for climate change (Simpson *et al*., 2008; UNEP and UNWTO, 2008). This highlights the need for simultaneous action to be taken to reduce the contribution of the tourism sector in terms of CO_2 emissions, and assisting in reducing the impacts of these climatic changes on the tourism sector (Moreno, 2010). This highlights the bilateral relationship between climate change and tourism (*Figure 2.*1; Colakoglu and Mil, 2011).

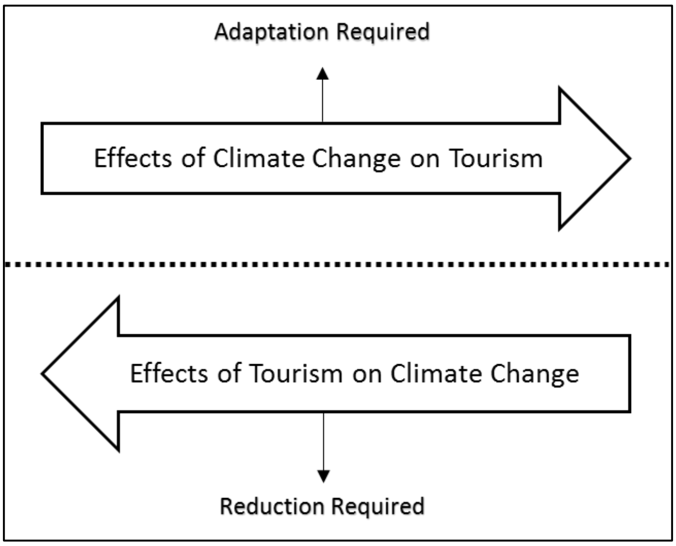


Figure 2.1: The bilateral relationship between climate change and tourism (Adapted from Colakoglu and Mil, 2011).

The tourism sector contributes to climate change through the emission of greenhouse gases (GHG), particularly CO_2, but also methane, nitrous oxide and hydrofluorocarbons (Scott *et al*., 2012a; Saarinen *et al*., 2012). Tourism–related emissions take into consideration all domestic and international holiday and business travels (Scott *et al*., 2012a). The calculated tourism-related emissions take into account transport, accommodation and related tourism activities (such as quad biking or boat cruises), however, energy used for the construction of relevant infrastructure is not considered (Simpson *et al*., 2008). In 2005, aviation was contributing the largest portion of these emissions at 40% of the total emissions released by the tourism sector (Scott *et al*., 2012a). In addition to this, the tourism sector contributes to climate change through associated sectors, such as tour operators and their offices (Scott *et al*., 2012a).

It is projected that by 2035 the tourism sectors' contribution to climate change will have grown substantially, with the number of global trips increasing by 179% (UNEP and UNWTO, 2008). Tourism-related emissions are set to increase by 152%, even with the consideration of efficiency improvements and technological advancements (Simpson *et al*., 2008). It is important to note that these future estimations do not consider the contribution of new niche tourism markets that may emerge, which may contribute significantly to climate change (Scott *et al*., 2012a).

Thus, it is evident that tourism is contributing to the acceleration of climate change, through increased emission output from the tourists, and is in direct contrast to the global objective of reducing and mitigating the release of GHGs and ultimately reducing the impact of climate change (UNEP and UNWTO, 2008; Scott *et al*., 2012a). Due to the high level of growth in the tourism sector, technological innovation alone will not be able to achieve the reductions in GHG emissions (UNEP, 2015). It is, therefore, imperative that behavioural changes (from the tourists' perspective) and structural changes (from the tourism sectors' perspective) take place over the coming decades, in order to reduce tourists' contribution to global climate change (UNEP, 2014).

While some emphasis is placed on the tourism sector's contribution to climate change, the majority of studies and literature are concerned with the impacts of climate change on tourism activities and the sector (c.f. Agnew and Viner, 2001; Amelung *et al*., 2007; Hamilton *et al*., 2005a; Jones and Scott, 2006; Amelung and Viner, 2006; Perry 2006). There is an increasing number of studies that are exploring how climate change can have a significant impact on a country and its tourism market, through its effects on the environment of that country (Uyarra *et al*., 2005). The effects of climate change and its resultant impacts on the tourism sector will vary significantly, based on the type of tourism market and the geographic region of a tourist destination (Simpson *et al*., 2008).

Climate change has the potential to result in regional and seasonal changes in tourist flows (Ehmer and Heymann, 2008), therefore the consequences of climate change for tourism destinations will partly depend on the impacts experienced by its competitors (Simpson *et al*., 2008). Consequently, some destinations will essentially experience negative impacts, while other destinations will benefit from climate change (Ehmer and Heymann, 2008). In addition, it has been stipulated that the economies of some regions are being negatively impacted on by the environmental changes that are occurring as a result of climate change (Uyarra *et al*., 2005).

The Maldives, for example, places a strong emphasis on tourism as a means of creating jobs, increasing foreign exchange and ultimately using the tourism sector as a tool for social and economic development (Becken *et al*., 2011). The tourism sector is primarily focused around the natural aesthetics of the islands, with a major emphasis on beach and coral associated activities (Becken, *et al*., 2011). The future climate change projections for the Maldives suggest that the conditions will become increasingly more harmful to the tourism sector (Becken *et al*., 2011; *Table2.*1). Due to the low land elevation of the Maldives, sea-level rise poses a significant threat to the islands and the tourism activities that occur along the beaches of the islands (Agnew and Viner, 2001). Coastal erosion and possibly loss of landmass could be a result of the sea-level rise (Agnew and Viner, 2001). Coral bleaching is another major threat to the Maldives tourism sector, as a result of warming sea and lagoon temperatures (Agnew and Viner, 2001).

Table 2.3: The potential climate change risks in the Maldives and their significance to tourism. (Adapted from Becken *et al*., 2011).

Potential Climate Risk Events	**Consequences of and significance to tourism**
Raised sea level and high High wave events/periods	Coastal erosion (Damages beaches used by tourists), landmass loss, flooding
Higher Lagoon/ Ocean Temperatures Altered ocean currents and wind patterns	Coastal erosion (Damages beaches used by tourists), landmass loss, different surfing conditions,
Higher air temperatures	Thermal discomfort for tourists, thermal stress for plants and animals (reduces attractiveness of an area)
Rainfall variability and greater extreme events	Drought and flooding

Studies have been conducted over the last two decades that specifically explore the impact of climate change on winter tourism, specifically on skiing destinations (c.f. Whetton *et al*., 1996; Harrison *et al*., 2001; Scott *et al*., 2003; Unbehaun *et al*., 2008). The literature suggests that many skiing destinations in Europe, Australia and North America will experience an altitudinal shift in terms of where ski stations should be situated (March *et al.,* 2014). Therefore, ski resorts and stations that are found at a lower altitude would experience the negative effects of reduced quantity and quality of snow cover and will have to reduce the length of the ski season, and potentially close down the ski station (Ubenhaun *et al*., 2008; Reddy, 2011). It is stipulated that skiing locations in North America and Australia that are at high altitudes and facing northwards, will experience positive impacts of climate change and will benefit from the misfortunes of other locations (Scott *et al*., 2007b). The use of artificial snow production is becoming widely used to reduce the impacts of changes in snow cover in these areas, however, the long term use of such an adaptation measure could have economic and environmental repercussions (March *et al*., 2014).

Beach tourism may be directly affected by climate change, through increased temperatures, which may lead to tourists experiencing decreased levels of comfort at particular destinations. (Ehmer and Heymann, 2008; Moreno and Amelung, 2009). In addition, it has been stipulated that other regions such as Turkey, Spain and France may start to experience warmer climate conditions, which would play out as an increased frequency of hotter days' weather, and may result in significant discomfort for tourist during peak summer tourist period (Amelung *et al*., 2007). However, many countries in northern Europe (which form a large portion of the Mediterranean tourist visitors) are projected to experience warmer conditions, resulting in future improvements in climate suitability for tourism in summer (Amelung *et al*., 2007). This indicates a likely increase in domestic tourism, and increased tourist numbers from countries in southern Europe (Amelung *et al*., 2007).

The annual average temperature in Australia is projected to increase by 0.4 to 4˚C by 2050 with more extreme warming inland and less warming over the coastal regions (Hughes *et al*., 2003). Tourist destinations in northern Australia, for example Queensland, are projected to experience a decline in their climatic suitability and attractiveness for tourism during certain periods of the year (Amelung and Nicholls, 2014). In addition, this decline in climatic suitability is set to be most noticeable during the summer months from December to February, which coincides with the busiest international tourist season in Australia (Amelung and Nicholls, 2014). Furthermore, Brisbane and the Gold Coast are set to experience significant declines in their climatic attractiveness, with increased temperatures, in particular during the tourism peak season (Amelung and Nicholls, 2014). Conversely, more southern regions of Australia, such as Melbourne, Adelaide and areas of the South Coast are set to experience an improvement in their climatic conditions, which will enhance and prolong the tourist season (Amelung and Nicholls, 2014).

Tourism is largely influenced by its local environment, local climate and the climate sensitive natural resources, on which tourism is primarily based (UNWTO and UNEP, 2008). Climate change risks to tourism globally include threats to winter sports, coastal/beach tourism, wine tourism, nature based tourism, sports tourism and water based tourism (*Table 2.4)*. These depend on the tourism offerings of the country in question, and the changes in climate likely for that location (*Table 2.4*). In addition, the impacts of climate change on tourism are influenced by the tourist's perceptions (Perch-Nielsen *et al.,* 2010). Tourists are not primarily concerned with the average temperature or precipitation of an area, rather, they are concerned with the thermal comfort and length of the rain periods as these greatly influence the ability to take part in various tourist activities (Rosselló-Nadal, 2014; Moreno and Amelung, 2009). Therefore, it is important that the impacts of climate change are considered based on regional and local climate scenarios (UNWTO and UNEP, 2008). In essence, tourism stakeholders and decision-makers need research that can sufficiently portray climate change at a regional and local scale in order to make relevant and accurate decisions regarding adaptation and mitigation strategies (UNWTO and UNEP, 2008).

Table 2.4: The potential climate change risks at destinations and their significance to tourism (Agnew and Viner, 2001; March *et al.,* 2014; Rosselló-Nadal, 2014).

Location	Tourism Sector/s	Potential Future Climate Change Risks	Consequences of and significance to tourism
European Alps	Winter Sports	Temperature Increases Reduced precipitation falling as snow Loss of valued alpine species (plants and animals)	Shortening of the snow season (Ultimately the tourists season) Reduced tourist attractiveness Increased temperatures can lead to avalanches and thus damage tourism infrastructure
Eastern Mediterranean	Coastal/Beach Tourism	Large temperature increases (in excess of 4°C) Increase in heat wave frequency Increased water stress and restrictions High levels of pollution	Thermal discomfort for tourists Lack of water can inhibit tourist activities Decreased levels of attractiveness
Southern Spain	Coastal/Beach Tourism Wine Tourism	Increased summer temperatures Drier conditions Increased malaria risk Flash Floods Increased frequency in forest fires	Health risks for tourists Damage to tourism infrastructure More pressure on tourism infrastructure during off peak season (winter)
Australia	Nature-based tourism Skiing Coastal/Beach Tourism	Increase in summer temperatures (1°C by 2020 and 4°C by 2050) Decrease in seasonal cloud cover and rainfall Sea level rise Increased risk of malaria Increase in storm surges Coral bleaching	Decreased snow cover (thus shorter snow season) Potential health risks for tourist (Malaria and skin cancer- due to decreased cloud cover) Risk to tourism infrastructure Reduced attractiveness to the destination

South-eastern and Mid-Atlantic US coastline	Coastal/Beach Tourism Sight-seeing	Sea level rise Coral bleaching Damage ecologically important wetlands and ecosystems Increase in the intensity and frequency of storms	Coastal erosion and threat to beach activities Reduced attractiveness to the destination Inhibit tourist activities (on wetlands) Extreme weather and climate may deter tourists Storms may damage vital tourism infrastructure
Brazil	Nature-based Tourism Coastal/Beach Tourism	Detrimental impact on ecosystems Rising Temperatures Decreased Rainfall Sea level rise	Biodiversity loss (Forests and animals) Reduced aesthetic appeal Coastal erosion (Damages beaches used by tourists) and landmass loss Rising temperatures could impact the thermal comfort of tourists
Scotland	Skiing Sports Tourism (Golf) Sight-seeing	Warmer average temperatures Increased precipitation Variable snowfall Increased storm frequency Coastal erosion	Threaten the viability and profitability of the skiing industry Warmer weather may attract more tourist for short and long holidays Increased precipitation can increase discomfort levels of tourists Threaten coastal golf courses
European Lakes	Water-based Tourism	Increased average temperatures Decreased precipitation Reduced lake levels Enhance concentrations of pollution along shorelines	Potential threat to the fresh water ecosystems and lakes themselves Impact recreational fishing industry in streams due to drier temperatures Impact tourism potential of the lake shorelines Potential threat to lake infrastructure (such as marinas) Reduced lake attractiveness

2.3. Perceptions of Climate Change

Climate change poses a major global risk to human and to the environment (Spence *et al*., 2012). As a result, there has been an urgent call for action to be taken in response to the changing climate. Since the turn of the 21st century, this action has come in the form of two fundamental responses namely; mitigation and adaptation (Wardekker, 2011). Climate change mitigation deals with the technological, economic and social changes and substitutions that result in reduced GHG emissions or by increasing greenhouse gas sinks (UNWTO and UNEP, 2008). Climate change adaptation involves implementing changes to behaviour that will allow for societies to adjust to, and respond to, the changes and thus allowing them to better deal with the impacts (Wardekker, 2011).

The perception of tourism stakeholders regarding climate change can play an influential role in making decisions or formulating plans (Scott *et al*., 2008). Understanding the perceptions of tourism stakeholders is important, due to the major role that tourism sector plays regarding economic and social development (Valls and Sarda, 2009). It has been argued that public perceptions of climate change and its associated risks are critical to reduce GHG emissions (Spence *et al*., 2012). Attitudes are closely associated to perceptions (Pickens, 2005). The process by which humans interpret and organise sensations (vision, hearing, touch, taste or smell), to produce a significant experience of the world, is referred to as perception (*Figure 2.2*; Pickens, 2005). An individual's existing personal beliefs, attitudes and personality all play a role in selecting the stimuli that is received to form a perception (Pickens, 2005).

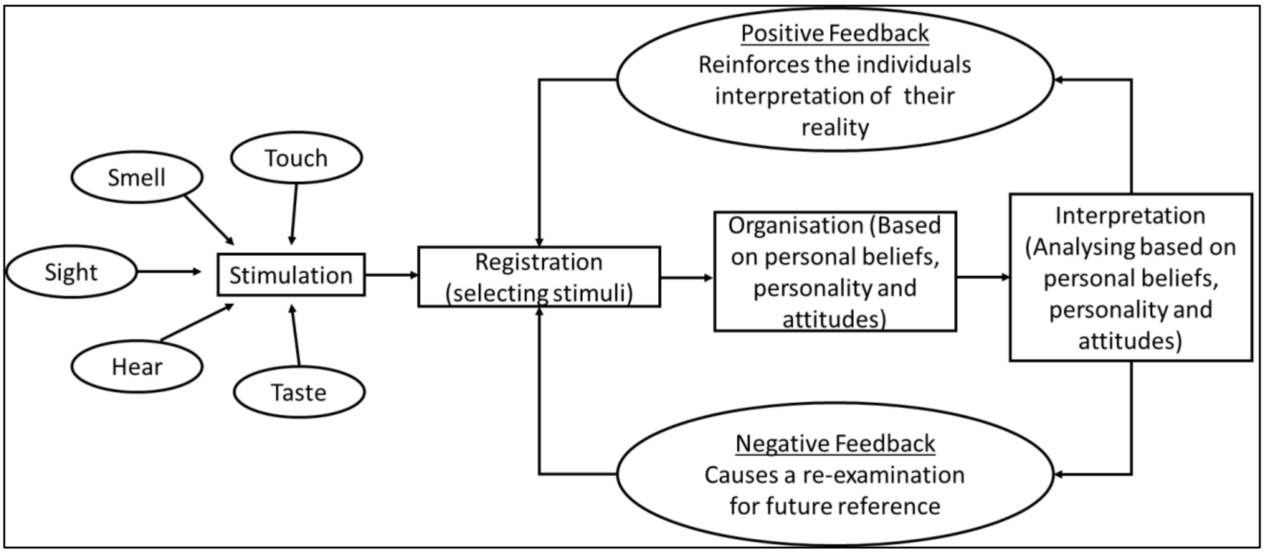


Figure 2.2: The basic process through which a perception is formed (Adapted from Pickens, 2005).

People's perceptions and understandings of climate change are significantly important in addressing this global issue and the issues associated with it (c.f. Bord *et al*., 1998; O' Connor *et al*., 1999; Ungar, 2000; Leiserowitz, 2005). The literature suggests that how individuals understand climate change and its impacts is vital in determining their understanding of, and support for, mitigation and adaption policies, and their willingness to adjust their behaviour accordingly (Wolf and Moser, 2011).

Various mass media sources and internet communications relating to climate change highlight the wide ranging and competing scientific and public perceptions regarding the presence of climate change and its associated impacts, such as denial, scepticism, apathy and conviction (Boykoff, 2004). Large portions of the perceptual uncertainty and scepticism relating to climate change arises from conflicting, unreliable and insufficient scientific evidence and from untrustworthy and misdirecting sources of information (Whitmarsh, 2011). It is suggested that the media's portrayal and dramatization often leads to an over exaggerated public perception regarding climate change and the level of uncertainty and controversy that exists (Shakeela and Becken, 2013). In light of these perceptions and views of climate change, that stand in contrast to some mainstream scientific evidence and policy views, many scientific and political bodies have indicated that the sceptical and contrasting perceptions of climate change by the public can hinder the ability of countries to gain support to tackle the issue of climate change (Weber, 2010; Whitmarsh, 2011).

Individuals who hold sceptical perceptions regarding climate change and its impacts are likely to act in an unsustainable manner because, without the belief that climate change exists they will have no reason to change their behaviour (Lorenzoni *et al*., 2007). It is imperative that people believe that climate change is a natural phenomenon, and that the accelerated rate at which this change is occurring is because of anthropogenic impacts on the environment (Stoll-Kleeman *et al*., 2001). Once people understand that their actions can negatively impact the environment, organisations and governments can show and educate people that changes in personal behaviours are important for tackling climate change (Stoll-Kleeman *et al*., 2001) In addition, individuals who are uncertain about causes and impacts of climate change often use that uncertainty as a means for inaction (Spence *et al*., 2012).

Providing the public with scientific evidence that is tailored to their perceptions of climate change, with the aim of correcting their views of the matter, while simultaneously highlighting actions that individuals can adopt to reduce the impacts of climate change, will not be sufficient (Lorenzoni and Pidgeon, 2006). This is due to the complex nature of climate change perceptions that are defined by conceptualisations of agency, trust and responsibility (Slovic, 1993; Lorenzoni and Pidgeon, 2006). Therefore, individuals will only take the necessary action to reduce the impacts of climate change if they feel that they can, and should, make a difference (Stoll-Kleeman *et al*., 2001).

Public perceptions of climate change, indicate that individuals in developed countries perceive climate change to be a distant threat that will not have any impact on their lives (Wolf and Moser, 2011). Additionally, they perceive climate change as an issue that is a concern for the future, that it concerns other people in other places and is more likely to affect other species to a greater extent (Ohe and Ikeda, 2005). As a result of these perceptions, efforts to implement mitigation and adaptation strategies are in turn perceived to be trivial or unnecessary (Weber, 2010). However, it has also been suggested that an individual's perceptions of climate change can be influenced by the individual's physical environment or setting (Spence *et al*., 2011). There is a global perception that developing countries, which are considered physically vulnerable to climate change, are at greater risk to the impacts of climate change (Spence *et al*., 2011; Spence *et al*., 2012). It is these developing regions that do not have the capability or capacity to adapt to climate change impacts (Spence *et al*., 2012).

Despite the notion that individuals from developing countries are more alarmed about climate change than individuals from developed countries (Spence *et al.,* 2012), there is still a wide and far reaching perception, where individuals from developed and developing countries perceive climate change and its impacts as a distant global problem that will not impact on their lives at the local level (Uzzell, 2000; Rathzel and Uzzell, 2009). It is therefore imperative that future communications of climate change, its causes and its impacts are done so, in such a manner, so as to instil a sense of responsibility into society (Lorenzoni and Pidgeon, 2006). Gaining a better understanding of perceptions from key stakeholders will potentially enhance the effectiveness and efficiency of future mitigation and adaptation efforts, and not just in the tourism sector but across many different industries and sectors (Wolf and Moser, 2011).

2.4. Foresight, Adaptation and Mitigation in the Tourism Sector

Countries around the world and economic sectors, including tourism, cannot escape the impacts of climate change, and therefore there is a definite need for the appropriate adaptation or mitigation strategy to be implemented in response to projected changes in climatic resources (UNWTO and UNEP, 2008; Tompkins *et al*., 2010). Geographical and economic characteristics of a region will determine the extent to which they are vulnerable to climate change impacts, and ultimately the level of their adaptive capacity (Simpson *et al*., 2008). Adaptation to climate change is defined as:

"An adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities" (Adger *et al*., 2005: 78).

Adaptation can take two forms, first, it can involve building adaptive capacity which increases the ability of individuals or groups to adapt to climatic changes, and second, it involves implementing the adaptation decisions (Tompkins *et al*., 2010; Tompkins and Eakin, 2012).

These two forms of adaptation can be implemented in advance, prior to the impacts of climate change or they can be implemented in response to climate change (Adger *et al*., 2005). It is important to note that adaptive capacity is essential for the successful design and implementation of adaptation strategies or approaches, therefore, adaptation strategies cannot be implemented at destinations unless those destinations have the capacity to do so (Simpson *et al*., 2008).

Tourism stakeholders have already begun to use a variety of different adaptation measures in order to deal with the expected and current climate change impacts that are being experienced (*Table 2.3;* Simpson *et al*., 2008). Despite the fact that very few adaptation measures have been initiated at the local scale of individual destinations, there have been a few instances where this is the case (*Table 2.6*; Simpson *et al*., 2008). Adaptation within the tourism industry is often very specific to the destination's climate and the tourism product that is being offered (UNWTO and UNEP, 2008). This location and product specific adaptation will eventually lead to a range of adaptation strategies and methods being used within the global tourism sector (Simpson *et al*., 2008). It is however, important to note that adaptation cannot circumvent all current and expected impacts of climate change, due to various practical constraints namely; the costs involved, access to current and relevant information, and access to technology (Füssel, 2007).

Limitations and barriers to adaptation exist, which often result in failed attempts to cope with the impacts of climate change (de Bruin and Dellink, 2011). A fundamental limitation to adaptation, particularly in developing countries, is the cost of the adaptation process/es (de Bruin and Dellink, 2011). Many adaptation approaches require an initial investment, which often cannot be raised by the institution or government that are attempting to implement them (de Bruin and Dellink, 2011). Another major limitation to adaptation lies within the fact that there may be a problem of delayed response to climate change impacts (Berkhout *et al*., 2006). It often takes much time to implement adaptation measures; cultural and societal factors may result in a delayed response to climate; political systems and international cooperation of climate change polices may add to the delay, and lastly many institutions and organisations tend to wait for better information, which is often gathered over long periods and thus may delay the adaptation process (de Bruin and Dellink, 2011).

Table 2.5: Climate change adaptation methods/policy and strategies that have been used in the tourism sector (Adapted from Simpson *et al*., 2008).

	Tourism Stakeholders	
Type of Adaptation	**Tourism Businesses**	**Tourism Industry Association**
Behavioural	GHG emissions offset initiatives	GHG emissions offset initiatives Water conservation programmes
Research	Identifying suitable site locations (tourism product specific)	Identifying tourist and knowledge gaps Assessing awareness of businesses to climate change adaptation options
Managerial	Diversification of products and markets Promoting regions that haven't been negatively impacted Closing during off-peak periods	Training seminars on climate change adaptation Using seasonal forecasts to guide marketing efforts Encourage sustainable environmental management
Education	Holding educative seminars for employees about climate change and adaptations	Public education through awareness campaigns
Technical	Production of artificial snow Water recycling initiatives Infrastructure designed to withstand extreme events (Cyclone proof structures)	Monitoring and early warning technology (to inform tourism businesses) Provide up-to-date information on adaptation methods and techniques
Policy	Hurricane interruption guarantees Complying with environmental policy and regulations	Setting up adaptation funds to implement adaptation strategies International cooperation to lobby for GHG emission reductions through adaptation and mitigation

It has been stipulated that the tourism sector as a whole has a high adaptive capacity, however the ability and capacity of different stakeholders within the sector to adapt varies considerably (Scott *et al*., 2009). The ability to successfully adapt to climate change from all stakeholders in the tourism industry, depends on whether they adopt a proactive or reactive attitude; their flexibility and if their capital resources are adequate enough to fit the cost of change (Amelung and Nicholls, 2014).

Tourism service providers (transport providers, travel agents and tour operators) who do not have fixed infrastructure or assets at a particular destination, are able to adapt to climate change easier than those operators who have fixed assets such as hotel and resort owners (*Figure 2.3*; Simpson *et al*., 2008). These tourism service providers (with no fixed assets) are able to respond to and adapt to tourists' demands and essentially influence the tourists' choice of destination (UNWTO and UNEP, 2008). Tourism service providers such as resorts and hotels have the least chance of adapting to climate change due to the fact that they have fixed assets in a particular destination (Amelung and Nicholls, 2014). Lastly, tourist have the highest adaptive capacity, based on access to three key resources; time, money and information (Simpson *et al*., 2008). This adaptive capacity for tourist comes with the ability to change their travels plans with regard to what destination they visit and at what time they visit different destinations (UNWTO and UNEP, 2008).

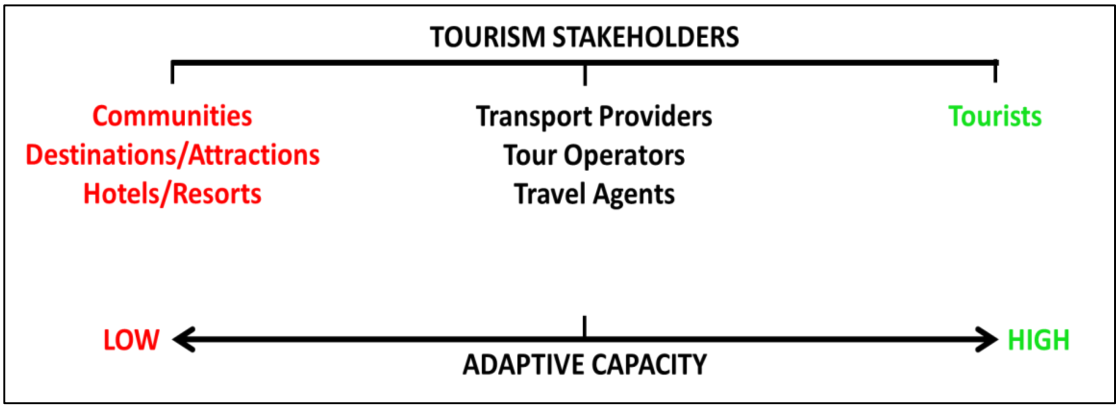


Figure 2.3: The adaptive capacity of different stakeholders within the tourism sector (Adapted from Scott *et al*., 2009).

Climate change mitigation deals with the technological, economic and social changes that result in reduced GHG emissions (UNWTO and UNEP, 2008). Climate change mitigation poses a significant challenge for the global tourism sector, first, as tourism related GHG emissions are significantly increasing (Reddy, 2011). Second, many mitigation programmes in the tourism sector have to find a balance between reducing GHG emissions while simultaneously promoting tourism as a tool for social and economic development (Reddy, 2011). Four major mitigation strategies to reduce GHG emissions from the tourism sector have been identified, 1) Reducing energy use- which can be achieved through changing travel habits; 2) Improving energy efficiency- using new technology that enables a decrease on energy demand; 3)

Increasing the use of renewable energy and lastly 4) through the sequestration of CO_2 in carbon sinks (UNWTO and UNEP, 2008; Simpson *et al*., 2008).

It is important to note that mitigation and adaptation can be differentiated based on the spatial scale at which they become effective (Buob and Stephan, 2013). Regardless of where greenhouse gases are removed, the benefits of mitigation are felt around the world. However, adaptation only enables the communities in which the strategies were implemented, to feel the benefits (Tol, 2005).

Although technological innovation is considered to have the most potential to reduce GHG emissions in the tourism sector, it alone will not be able to achieve the desired reductions in emissions (Simpson *et al*., 2008). It is, therefore, the responsibility of the tourist and the tourist industry to implement behavioural and structural changes within the sector to achieve a level of reduction in GHG emissions that will reduce the impacts of climate change (*Table 2.6*; Simpson *et al*., 2008; Hoogendoorn *et al*., 2015).

To successfully reduce GHG emissions to a point where it will no longer have negative consequences on the tourism sector requires a dynamic and multidimensional strategic approach. It has been stipulated that adaptation and mitigation can be used simultaneously across destinations to significantly reduce the projected impacts of climate change (Reddy, 2011). However, it is important to acknowledge that the successful implementation of both mitigation and adaptation strategies and actions is reliant on socio-economic and environmental circumstances of a particular destination, and the availability and accessibility of necessary information and technology (Kaján and Saarinen, 2013).

Table 2.6: The different adaptation (in orange) and mitigation (in green) efforts that have been implemented in the tourism sector (Simpson *et al*., 2008).

Tourism Destination	Climate Change Impact	Implemented Adaptation Strategies/Policies/Measures/Techniques	Stakeholders Involved in Implementation
Mozambique	Increased frequency of extreme events (cyclones)	Building a new sea wall to protect the towns infrastructure from storm surges/cyclones Exploring the option of ecological protection, through vegetated sand dunes	World Bank Ministry of Tourism in Mozambique
Thailand	Water shortages (Due to variability in precipitation)	Construction of new dams Developing old mines to act as water sources Implementing water recycling systems Designing a fee structure for water consumption	Tourism Authority of Thailand Local and national government agencies
USA	Decreased natural snowfall Greater variability during ski season	Artificial snow production Slope contouring (reduces the amount of artificial snow needed) Product and market diversification (Resorts introduce new activities for tourists not focused on skiing) Operate during off peak seasons	Ski Resort Companies Local Government
Caribbean and Gulf of Mexico	Increased summer temperatures (extreme) Increase in strength and frequency of hurricanes	Marketing campaigns to down-play the increasing temperatures (and target different tourists markets) Improved air-conditioning Hurricane interruption policies (Allows tourist to come back and enjoy their stay when the hurricane has subsided	Caribbean Tourism Organisation National Governments Businesses in the accommodation sector
Australia	Extreme and higher sea surface temperatures Increase in severity and frequency of coral bleaching	Developed the 'Coral Bleaching Response Plan' (Aims to provide a framework for the protection and conservation of coral reefs through various adaptation processes) Cooling the surface temperature of the ocean surrounding coral reefs with cool water Putting up shading mechanisms to protect the coral reefs	Great Barrier Reef Marine Park Authority Tour Operators Australian Ministry of Tourism

Tourism Destination	Need for Mitigation due to Climate Change	Implemented Mitigation Strategies/Policies/Measures/Techniques	Stakeholders Involved in Implementation
Singapore	Reducing GHG emissions (Hotels)	Designed and implemented 'Energy Smart Buildings Scheme' to achieve greater energy efficiency Implemented new heat recovery systems in hotels	Ministry of the Environmental and Water Resources Singapore Hotel Association Hotels
South Africa	Reducing CO_2 Emissions Conserving Biodiversity	Monitors their energy consumption across the business and sets targets to reduce consumption Energy meters have been installed across all business areas Installed energy saving lights in all hotel rooms Education towards 'green habits'	Selected Guest house owners in Gauteng and KZN
Caribbean (Cruise Ships)	Reducing Emissions and Waste	Signed a memorandum to use new technology to manage waste and to design environmentally friendly ships (gas and steam powered) Cruise liners had adopted mandatory environmental standards	Florida-Caribbean Cruise Association International Council of cruise liners
Nepal	Reducing GHG Emissions	Implemented plans to increase public transport Promoted the use of electric vehicles in high density areas	Nepal Ministry of Science

2.5. Climate Change in Developing Countries

Societies that rely heavily on resources which are sensitive to climate change, often developing countries, may be left more vulnerable to climate change and its associated risks (Adger *et al*., 2003). This is due to the fact that these nations cannot to afford technology that allows them the option of alternative resources, such as genetically modified foods (Kurukulasuriya *et al*., 2006). This vulnerability can further aggravate the social and economic challenges that are currently being experienced in these developing countries, due to these countries having to use financial resources to combat the impacts of climate change rather than focusing these resources on other social and economic issues (Adger *et al*., 2003). The literature suggests that a country's vulnerability to climate change is determined by it sensitivity, its exposure, its physical setting and by its capacity to adapt (Adger *et al*., 2003). Therefore, due to lower capital intensity and technological flexibility, developing countries cannot adapt effectively and are left far more vulnerable than developed regions (Deressa *et al*., 2005; Kurukulasuriya *et al*., 2006; Fitchett *et al*., 2014).

Despite this vulnerability, the distributional impacts and costs of climate change are not evenly spread across the globe (Mendelsohn *et al*., 2006). It is widely agreed that the GHG emissions associated with human induced climate change are from the developed nations (Mertz *et al*., 2009). Carbon dioxide has a long lifespan in the atmosphere and this means that the current increase in CO_2 emissions has been caused by developed nations' industrialisation processes (Sagar *et al*., 2006). The cumulative emissions of CO_2 by developed nations greatly outweighs the contribution made by developing regions (Sagar *et al*., 2006). Despite developing nations accounting for approximately three-quarters of the global population, they still only account for a small amount of the global CO_2 emissions, despite increases in developing nations' contribution in recent years (Sagar *et al*., 2006).

Human, institutional and financial resources would enable developing countries to adapt to, and deal with, the impacts of climate change by having people that understand how to plan and implement adaptation strategies, and by having the necessary financial resources to implement any adaptation strategies (Buob and Stephan, 2013). The uneven distribution of climate change and its associated costs will leave developing countries worse off than developed countries for a variety of reasons, first, the physical impacts of climate change are projected to be much greater in developing regions; second, many developing countries are heavily reliant on agriculture as a source of income and employment and therefore this will be jeopardised by climate change; third, the higher proportion of poor people in these developing countries are more vulnerable and will more likely feel the negative impacts of climate change and lastly, the capacity to adapt is very limited by various factors, such as, access to information, costs, and technology. (Mertz *et al*., 2009).

Developing countries therefore have specific adaptation requirements (Mertz *et al*., 2009; Buob and Stephan, 2013). However, despite the impacts of climate change and the need for adaption, many developing countries do not acknowledge climate change as their most significant challenge (Mertz *et al*., 2009; Reddy, 2011). Many developing countries perceive poverty reduction, economic growth along with other social issues to be more important to deal with (Reddy, 2011).

It has been widely argued that developed countries, due to their cumulative historic emissions, should facilitate adaptation in developing countries, to lessen the impacts and effects of climate change in developing countries (Buob and Stephan, 2013). In so doing, developed countries will not only assist developing countries to reduce the local deleterious effects of climate change, but will simultaneously ensure that developed countries remain partners for economic growth, international security and global governance (Buob and Stephan, 2013). Despite this argument for adaptation to be facilitated by developed countries, the majority of such initiatives are based on voluntary contributions and are not based on any underlying requirement or obligation (Buob and Stephan, 2013). Furthermore, Buob and Stephan (2013) have demonstrated that the contribution of developed countries to facilitate adaptation in developing countries is relatively small compared to the scale of the costs associated with the impacts of climate change.

The significant cost of climate change and adaptation in developing countries may detrimentally impact their ability to promote economic growth and deal with a range of other crippling social issues (Christiansen *et al*., 2012). Despite the small portion of funding by developed countries, and public and private sector financing constraints in developing countries, efforts can be made by developing countries to enhance their ability to attract investment for adaptation and to deal with the incremental costs of climate change (*Table 2.5;* Christiansen *et al*., 2012).

Table 2.7: The principles that need to be created by developing countries to attract both private and public financing for adaptation mitigation in response to climate change (Christiansen *et al*., 2012).

Principles	Description
Return of Investment	Ensure that the project has the ability to be effective and successful in reducing the risk of climate change.
Collaborative Action	Ensure that the project enlists the services of multiple parties and funders with different resources and capacities. This will spread the cost of the funding and make it more attainable.
Adaptation Rationale	Describe what and how the adaptation and mitigation strategy will aid in reducing the climate change impact. Any additional cost for the project should be justifiable.
Policy and Institutional Framework	Ensure that there is a reduction in uncertainty, regulatory barriers and ensuring procedural transparency. This will make the country more attractive to public and private funding.

Due to the fact that climate change and its impacts are a global issue, developed countries that support climate protection initiatives can benefit from these projects that are initiated in developing countries (Rübbelke, 2011). It is therefore imperative that further research into the impacts of climate change at the national and local scale of developing countries, such as this one, be avidly pursued to enhance the certainty of what to expect, which will allow for better planning and strategic proactive responses to be put in place. In addition, this will allow for improved estimations of the cost of climate change on these developing regions, which could enhance the chance for funding from developed countries.

2.6. Tourism and Climate Change in Africa

Tourism is an important sector for most African economies, with inimitable natural and historical capital, which is been used widely as a means for achieving social and economic development (Nyaupane and Chhetri, 2009; Hambira and Saarinen, 2015). During 2014, it is estimated that international tourist arrivals in Africa increased 2% from the year before and the continent saw 56 million people enter its borders (UNWTO, 2015a; *Table 2.8*). In addition, tourist receipts increased by US$ 1 billion to US$ 36 billion in 2014 (UNWTO, 2015a). It is important to note that during the 2013/2014-year international tourist arrivals in Côte d'lvoire increased substantially by 24%, while Madagascar experienced an increase of 13% during the same period (UNWTO, 2015a).

Many African countries have natural parks filled with abundant wildlife, which provides them with a comparative advantage in nature-based tourism and ecotourism (Hambira and Saarinen, 2015). This advantage provides many African nations the ability to take part in international tourism. However, it is important to note that the tourism sector in most African countries is so heavily reliant on the natural resources, and is therefore highly vulnerable to the effects of climate change (Preston-Whyte and Watson, 2005; Scott *et al*., 2012b; Hambira *et al*., 2013). Africa has been recognised as one of the continents that is most vulnerable to climate change and variability due to various environmental and social stressors and low adaptive capacity (Reid *et al*., 2007).

The tourism sector in Egypt is one of the primary sources of foreign currency for the country and is an important tool for social and economic development (Ahmed and Hefny, 2007). A major tourist attraction in Egypt revolves around the rich archaeological history that the country holds. However, in recent decades there has been increased interest in ecotourism (Ahmed and Hefny, 2007). Presently, the majority of the revenue generated from tourism is derived from the Red Sea region, where tourists visit to dive along the coral reefs (Marshall *et al*., 2011). As is custom with other natural attractions around the world, coral reefs are sensitive to the impacts of climate change (Hughes *et al*., 2003). Although the effects of climate change have not reached the coral reefs along the Egyptian Red Sea yet, it is only a matter of time before these impacts are a reality (Marshall *et al*., 2011). This will greatly impact the social and economic benefits that the region derives from tourism and could ultimately impact the country (Scott *et al*., 2007a). The wetlands in the northern parts of Egypt, which hold significant tourism value for the country, are likely to be impacted by climate change, resulting in a further decline in economic performance of the country (Ahmed and Hefny, 2007; Shaaban and Ramzy, 2010).

Botswana and Namibia rely heavily on nature-based tourism and ecotourism to generate foreign exchange and drive social and economic development (Reid *et al*., 2007; Hambria *et al*., 2013). There is very little literature and research regarding the impact of climate change on tourism in Namibia, but it has been suggested that the likely impacts could be: 1) Change in supply of tourists due to the loss of habitat, 2) Change in supply and demand due to loss of biodiversity, and lastly 3) Change in demand due to increases in humidity, water borne diseases and temperature (Reid *et al*., 2007). A study by Hambria *et al.* (2013) revealed that many tourism stakeholders in Maun, Botswana, were concerned that increased temperatures would alter the vegetation and ultimately result in the migration of wildlife to areas that are more suitable. In addition, multiple tourism stakeholders expressed their concerns regarding water bodies drying up in the face of increased temperatures (Moswete and Dube, 2014). Another major concern for the stakeholders of the area were largely concerned with the impact of climate change on the aesthetic value of the region due to a potential loss of vegetation and biodiversity (Hambria *et al*., 2013; Moswete and Dube, 2014). It is, therefore, vital that African countries continue to research and explore the impacts of climate change at a local and national scale, so as to better understand effects of climate change within the context of their country and based on their specific tourism offerings.

Reducing the impacts of climate change in African countries requires action immediately. However, this requires domestic political determination, but often there is little action taken to act accordingly (Reid *et al*., 2007). There is a continued increasing growth in interest towards the importance of climate change policy needs for tourism sectors in African countries (Becken and Clapcott, 2011). Despite the increased interest in climate change and tourism policy needs, many countries do not even have national climate change policies in place (Hambira and Saarinen, 2015). Botswana serves as a good example, due to the fact that it has continually shown interest in developing a strategy to combat and cope with the impacts of climate change, but still has not developed a national climate change policy that could deal with these issues.

Botswana, has been committed to achieving sustainable growth and environmental conservation, and they have shown this by signing and ratifying various multilateral environmental agreements, such as the UNFCCC (United Nations Framework Convention on Climate Change) and have established a National Climate Change Committee (Hambira and Saarinen, 2015). However, Botswana has not implemented a policy to deal with, and respond to, climate change. Instead, the issue of climate change is being addressed indirectly through certain policies that are intended to promote sustainable growth and development (Hambira and Saarinen, 2015).

A study by Hambira and Saarinen (2015), identified that policy makers in Botswana perceive climate change to be a real threat, which has the potential to negatively impact the tourism sector in the country. However, the policy makers highlighted the fact that there is a definite need for more research regarding climate change and its impacts on the country, and specifically the tourism sector (Hambira and Saarinen, 2015). Despite the existence of uncertainties and knowledge gaps around climate change and its potential future impacts, it is imperative that all stakeholders involved in the tourism sector are aware of the future impacts (Hoogendoorn and Fitchett, 2016). This will allow all stakeholders to plan and implement effective and appropriate adaptation strategies for future and present tourism activities based on current projected climate change (Hambira *et al*., 2013). Ultimately, there is an urgent need for African countries to develop and implement climate change policies at local and national levels, to safe guard the tourism sector, which provides them with large potential for economic and social development (Becken and Clapcott, 2011; Hoogendoorn and Fitchett, 2016).

2.7. Climate Change in South Africa

Climate change has led to a significant amount of research on future climates and on the impacts of climate change on society (Kurukulasuriya *et al*., 2006). Over the last couple of decades, technological change and increased understanding of world global atmospheric systems have allowed for improvements in quantitative measures and estimates of climate change (c.f. McCarthy *et al*., 2001; Tol, 2002; Mendelsohn and Williams, 2004). Climate change models have identified that destinations around the world are expected to experience changes in their climate in the future, including South Africa (Table 2.7; Nhemachena *et al*., 2014).

The annual average temperature for South Africa is projected to increase between 1.1˚C to 2.4˚C by 2060 and further increasing between 1.6˚C to 4.3˚C by 2090 (Ziervogel *et al*., 2014). Models that offer less extreme outlooks regarding future climate change predict an overall increase in temperature throughout South Africa (Jawtusch, 2014). Furthermore, it is estimated that the number of extremely hot days is set to increase across all regions of the country, with a 20-39% increase in the number of hot days by 2090 (Karmalkar *et al*., 2012; Ziervogel *et al*., 2014).

Projections indicate that South Africa is set to experience a decrease in rainfall under all emission scenarios (UNICEF, 2011; Stevens *et al*., 2014). It is estimated that the reduction in rainfall in the future will decrease by 10% to 15% (Jawtusch, 2014). In a country that is already considered arid, this is a substantial problem that could have serious impacts on the future of South Africa (UNICEF, 2011; Jawtusch, 2014). This is as a result of increased future temperatures potentially causing increased levels of drying and evapotranspiration (UNICEF, 2011; Karmalkar *et al*., 2012).

In light of these predicted changes, there will be an increase in the number and intensity of extreme events in the country (UNICEF, 2011; Ziervogel *et al*., 2014; Rogerson, 2016). These extreme events include extreme heat, periods of drought, water stress and greater intensity storms that are more frequent and result in high levels of flooding (Jawtusch, 2014). It is anticipated that there will be changes in the El Niño-Southern Oscillation which will further exacerbate the drier conditions in the country (Karmalkar *et al*., 2012).

Climate change will have far reaching and significant impacts on South Africa, ranging from the household level (affecting the way people live) all the way to national level, where whole industries have to adapt and change as a result (UNICEF, 2011). These impacts will be felt across all sectors of the economy (Davis, 2010). The projected changes in South Africa will have significant impacts on the water systems and resources (UNICEF, 2011; Nhemachena *et al*., 2014). A major resulting impact of this it that water scarcity problems in South Africa will be exacerbated (UNICEF, 2011). One sector that will be greatly affected by these resultant water problems is agriculture (Nhemachena *et al*., 2014; Araujo *et al*., 2014). Many poor communities base their livelihoods and food security on climate sensitive rain fed crops (Nhemachena *et al*., 2014). Due to the expected changes in rainfall and temperature, agriculture is expected to be detrimentally affected, which will place further strain on food security in the country (c.f. Kurukulasuriya *et al*., 2006; Nhemachena *et al*., 2010). However, it is suggested that the impacts of climate change on agriculture can be reduced through various adaptation strategies (Lobell *et al*., 2006; UNICEF, 2011).

Tourism, one of South Africa's fastest growing and biggest industries is vulnerable to the impacts of climate change (Stevens *et al*., 2014; Rosselló-Nadal, 2014). One of the major threats of climate change to the tourism sector is that changes in temperature and rainfall can lead to a significant decrease in the levels of comfort experienced by the tourists in a particular location because the climate will no longer be suitable for various tourist activities (Stevens *et al*., 2014; Perch-Nielsen *et al.,* 2010). This leads to decreased levels of satisfaction by the tourist and could ultimately result in reduced economic gains as a result of the destination not being climatically suitable for tourism activities (Mieczkowski, 1985; Stevens *et al*., 2014; Kovács and Unger, 2014). Tourists will ultimately stop visiting a particular location because it has become unpleasant and other destinations may have become more suitable and appealing (Mieczkowski, 1985; Perch-Nielsen *et al.,* 2010).

Climate change may potentially lead to increased events of flooding, drought and land degradation and loss (Agnew and Viner, 2001). This will ultimately impact negatively on tourist activities and threaten the viability of various tourism markets in South Africa (Agnew and Viner, 2001).

Table 2.8: The potential climate change risks South Africa and their significance to tourism. (Agnew and Viner, 2001; Scott *et al*., 2007b; Nyaupane and Chhetri, 2009).

Potential Climate Risk Events	Consequences of and significance to tourism
Sea level rise	Coastal erosion and threat to beach activities
Decrease in average rainfall	Reduced attractiveness to the destination Water Restrictions Inability to participate in some water based activities
Redistribution of biodiversity	Inhibit tourist activities (on wetlands)
Greater intensity and frequency of extreme events	Storms may damage vital tourism infrastructure
Increase in average temperatures	Extreme weather and climate may deter tourists Reduce the attractiveness of the pristine landscapes Make outdoor activities uncomfortable
Damage ecologically important wetlands and ecosystems	Reduced aesthetic appeal

2.8. Tourism in South Africa

During the apartheid era (1948-1994), many industries were negatively impacted, with the tourism sector being the most severely affected (Visser and Rogerson, 2004). Apartheid directly restricted the flow of international tourists to the global South (Visser and Rogerson, 2004). Furthermore, the limited ability of previously disadvantaged groups to move freely and access certain facilities under apartheid, meant that domestic tourism was adversely affected (Rogerson and Lisa, 2005; Rogerson and Visser, 2011c). It has, therefore, been stipulated that only after apartheid was tourism considered as a tool for social and economic development (Visser and Rogerson, 2004). Research surrounding tourism in South Africa during apartheid was not focused on development, instead it was concerned largely with white elite tourism (Rogerson, 2007).

Since the transition of South Africa into democracy, the country has witnessed continued growth in both domestic and international tourism (Binns and Nel, 2002; Akinboade and Braimoh, 2010). Since the fall of apartheid, the promotion of tourism has been regarded as a vital strategy to achieve economic and social development (Binns and Nel, 2002; Lee and Chang, 2008; Kavita and Saarinen, 2016) for this reason it has been given significant attention in post-apartheid South Africa (Kirsten and Rogerson, 2002; Lee and Chang, 2008; Maharaj and Balkaran, 2014). Due to South Africa not having a dominant position within the international tourism market during apartheid, there was an initial delay between tourism expansion and relevant guidelines to control and direct the growth to achieve social transformation and economic growth once apartheid had ended (Rogerson, 2002a; Rogerson, 2002b; Rogerson and Visser, 2011a).

With the increased role of tourism as a development strategy in Africa, various studies have been conducted to explore the policy developments surrounding tourism and its impact that this strategy has on the various African countries (c.f. Dieke, 1994; Kiambo, 2005; Dieke, 2010). Since the increase in significance of tourism in South Africa, there has been a major shift of focus from policy makers and academics with regards to the role of tourism in the country (Visser and Rogerson, 2004; Rogerson and Visser, 2011a). During the first decade of democracy, a number of early studies were conducted which focused on the initial post-apartheid tourism policy development and evolution (c.f. Rogerson and Visser, 2004; Visser and Rogerson, 2004; Rogerson and Visser, 2007). However, this is no longer perceived by main contributing academics to be the current themes in research tourism in South Africa (Visser and Hoogendoorn, 2011). The current and dominant themes within the literature have risen from the South African policy context and they primarily revolve around four different but interrelated perspectives (*Table 2.*6; Visser and Hoogendoorn, 2011).

The initial policy frameworks, which were developed to ensure that a more equitable and non-discriminatory society was brought about (Spenceley and Goodwin, 2007), made it evident that the post-apartheid government's approach to tourism expansion was through responsible tourism (Visser and Hoogendoorn, 2011). The fundamental objectives of responsible tourism, are that (1) tourism would be driven by the private sector; (2) the government would provide the relevant frameworks and infrastructure for the sector to grow; and (3) that community involvement is imperative and will form the foundation for tourism development; tourism should be conducted under strict environmental and sustainable practices, and tourism will be used as a tool to empower and develop communities that were negatively affect by the apartheid government (Rogerson, 2002b; Visser and Rogerson, 2004).

In light of this *Tourism in GEAR* (Growth Employment and Redistribution) was formulated to aid in the achievement of these objectives (Visser and Rogerson, 2004). This initiative played an important role in influencing policy and was of particular interest at the time of its release, shortly after the transition into a full democracy (Visser and Rogerson, 2004). This was due to the fact that, at the time, tourism was not considered a tool for development and it was completely left out of South Africa's key macro-economic framework documents (Rogerson, 2002b). In essence, *Tourism in GEAR* was ahead of its time with regards to policy development and ultimately fell directly in line with the objectives of responsible tourism (Visser and Rogerson, 2004; Visser and Hoogendoorn, 2011).

Despite there being a strong dominance of responsible tourism principles within the policy framework documents, in practice there continues to be minimal involvement of poor communities as the main tourism stakeholders (Van der Merwe and Wocke, 2007; George and Frey, 2010; Visser and Hoogendoorn, 2011). It has been suggested that the very notion of what responsible tourism is and what its resultant benefits may be, are major obstructions to its successful implementation (Van der Merwe and Wocke, 2007). Despite optimistic attitudes towards responsible tourism, the highly competitive nature of the tourism market, and the high cost of transforming businesses towards responsible tourism management practices, are part of the reason as to why its implementation is often not completely successful (George and Frey, 2010). It is therefore postulated that government support needs to extend further than just policy development in order to ensure that there is effective transformation that ultimately benefits the poor (Visser and Hoogendoorn, 2011).

The second approach to tourism development in South Africa that is directly linked to the national policy frameworks on responsible tourism is referred to as pro-poor tourism (Visser and Hoogendoorn, 2011). Pro-poor tourism is an approach that is primarily concerned with providing the poor with maximum economic benefits (Rogerson, 2014c). Rogerson (2014c) stipulates that pro-poor tourism has become one of the major focuses of tourism literature in the global south over the last fifteen years. More specifically, pro-poor tourism literature in South Africa is heavily focused on intervention programmes in rural areas and township tourism development (c.f. Ndlovu and Rogerson, 2003; Briedenhann, 2008; Booysen, 2010). Further research within the pro-poor tourism approach focuses on the advantages and disadvantages of community-based models for tourism development (Visser and Rogerson, 2004). The literature on tourism in South Africa is often very limited and considered less important compared to other developed regions, however, this is not the case surrounding pro-poor tourism (Rogerson, 2014c; Rogerson 2012).

Tourism is often used as a form of intervention within communities to achieve local economic objectives and is commonly referred to as tourism-based local economic development (LED) (Visser and Hoogendoorn, 2011). This third approach is often closely related with pro-poor tourism initiatives (Visser and Hoogendoorn, 2011). Since the fall of apartheid, LED has been escalated from isolated local development to a point where all local authorities are obliged to promote LED (Rogerson, 2014b). Tourism is now widely acknowledged by the South African government as a tool, through which development can be attained while simultaneously benefitting the host community (Binns and Nel, 2002). Although tourism-based LED acts to promote growth in some regions, it has been stipulated that using tourism as a development strategy may not be successful in all regions, especially if a particular location does not attract large amounts of tourism (Rogerson and Rogerson, 2011). However, such locations can pursue route tourism as an avenue of potential growth and development (Visser and Hoogendoorn, 2011).

One limitation that has been identified with tourism-based LED is that the benefits and economic gains are not equally distributed within the host community (Lourens, 2007). This occurs for two fundamental reasons: first, the communities do not participate fully in the aforementioned initiatives and second, due to the lack of necessary skills and resources within the given communities, which leads to the employment of non-local labour and outsourcing resources from other communities (Visser and Hoogendoorn, 2011). This notion strongly emphasises the need for skills development programmes in local communities to enable them to effectively and efficiently pursue the opportunities that are created through tourism-based LED initiatives (Rogerson, 2007). Through increased community participation and capacity building, the benefits of tourism projects in communities tend to spread wider and therefore enhancing equality (Rogerson, 2007). Although tourism-based LED is a prominent approach to achieving the country's economic objectives, it is often argued that projects dealing with tourism-based development in communities are formulated individually rather than within the broader tourism planning context (Rogerson, 2007; Visser and Hoogendoorn, 2011). It is indicated that the success of an LED project, and the benefits to local communities are far greater when there is a commitment to pro-poor development and where Small Medium and Micro-enterprises (SMMEs) can play a role within the community (Rogerson, 2008).

The final approach that has a strong position within tourism research in South Africa deals with the development of tourism-based SMMEs (Hoogendoorn and Rogerson, 2015). It has been a continuous theme in national government policy development since 1994 to support the growth and development of SMMEs (Rogerson, 2005). Tourism SMME development in South Africa plays an important role in the wider national commitments to transform the ownership structure of the tourism sector in such a way as to support previously disadvantaged groups (Rogerson, 2005). The tourism SMMEs play a vital role in making the South African tourism industry more competitive on a global scale (Rogerson, 2005). Achieving goals of increased earnings, reducing adverse social and cultural effects, and creating job opportunities are far more effectively achieved through the promotion of small tourism businesses rather than large ones within developing countries (Rogerson, 2005).

Despite the potential benefits of tourism SMME development in South Africa, it has been stipulated that using tourism SMMEs to achieve national development goals has been faced with significant challenges (Rogerson, 2007). These challenges include the inability to become fully operational and the inability to generate income that is sustainable (Rogerson, 2007). It has been identified that SMMEs contribution to employment growth in the country has remained low. This is as a result of SMMEs not being fully integrated into broader production structures and many of the enterprises cannot grow past being a one-person business (Rogerson, 2005).

A large part of the literature surrounding SMMEs deals with identifying and understanding the challenges that face SMMEs in South Africa and why they are unsuccessful in achieving their transformational objectives (Rogerson, 2005). This vein of literature highlights that little support with regards to accessing the market is offered; there is minimal information and financial support and lastly there are very few efforts to develop entrepreneurial skills within communities (Nieman *et al*., 2008*).* Furthermore, social issues such as crime, security and service delivery (or lack of) play a role in negatively impacting on the success of SMMEs (Rogerson and Visser 2011b). It was previously mentioned that skills development and capacity building within poorer communities will positively influence the ability of the communities to thrive and operate successful tourism-based initiatives, this holds true for tourism SMMEs (Visser and Hoogendoorn, 2011). The literature suggests that it is extremely difficult for tourism SMMEs to establish themselves within the South African market (Rogerson, 2004; Visser and Rogerson, 2004; Visser and Hoogendoorn, 2011).

<u>Table 2.9:</u> The four dominant South African tourism research perspectives.

Perspective	Description
Responsible Tourism	Aims to achieve cooperation between government, the private sector and the public. Community involvement is important and will form the basis of tourism development. Tourism will be used as a tool to empower those that were previously disadvantaged.
Pro-Poor Tourism	Closely related to responsible tourism, but is focused on providing the poor with maximum economic benefits. Sets out to achieve this through intervention programmes in rural areas and through township development.
Tourism-based LED	Closely related to pro-poor tourism approach. This approach is seen as a tool that allows for development to take place in a particular area, while directly and simultaneously benefitting the community in that area.
Tourism-based SMME	Supports the growth and development of SMME focused on offering tourism products. Ultimately seeks to transform the ownership structure of the tourism sector, in order to support and empower the previously disadvantaged groups.

Research exists in South Africa that deal specifically with tourism, these include nature-based tourism (c.f. Mahoney and Van Zyl, 2002; Lindsay *et al*., 2005; Brooks, 2005;; Spierenburg and Wels, 2010; Ferreira, 2011; Lapeyre, 2011), second home and/or holiday home tourism (c.f. Pienaar and Visser, 2009; Hoogendoorn *et al*., 2009; Long and Hoogendoorn, 2014; Visser and Hoogendoorn, 2015; Hoogendoorn and Visser, 2015), other themes of research look into factors that are preventing tourism development in the country (c.f. Ferreira and Harmse, 2000; George, 2003; Donaldson and Ferreira, 2009), sports tourism (c.f. Kotze, 2006; Visser and Kotze, 2008; Ingle, 2008; Steinbrink *et al*., 2011; Campbell and Phago, 2008; Hammett, 2011), fishing tourism (Hoogendoorn, 2014), bed and breakfasts and hotel tourism (Rogerson, 2014d; 2014e; 2014f; Hoogendoorn *et al*., 2015), township tourism (Booysen, 2010; George and Booysen, 2014), volunteer tourism (c.f. Stoddart and Rogerson, 2004; Rogerson and Slater, 2014) and medical tourism (Dangor *et al*., 2015).

These different avenues of research in South Africa within tourism tend to primarily focus on the impacts of tourism from a human perspective (Visser and Rogerson, 2004). Although climate change has been identified as a significant threat to tourism in the twenty-first century, only 2% of academic tourism research explores aspects of climate change relating to the tourism industry (Morrison and Pickering, 2013). This argument is further reinforced by the fact that there is a little concern in the literature regarding to how climate change may potentially impact the South African tourism industry. A study by Steyn (2012) explores the impacts of climate change on tourism and attempts to identify actions that can be taken to adapt to or mitigate the impacts of climate change within the tourism sector. However, the scope of the study conducted by Steyn (2012) is limited to the Western Cape Province of South Africa. Furthermore, it is stipulated that the tourism sector is 5-7 years behind other major industries with regards to climate change research (Morrison and Pickering, 2013). Therefore, due to the limited amount of literature in South Africa on tourism and climate change, this study will hopefully act as a catalyst for further research on climate change and tourism. This study will also contribute to the existing internationally-based research on tourism and climate change.

2.8.1. Potential Impacts of Climate Change on South African Tourist Activities

The South African Tourism industry is naturally diverse and allows for a wide inclusion of different stakeholders and businesses (Spenceley and Goodwin, 2007). This has ultimately led to a wide range of tourist activities being offered throughout the country (Visser and Rogerson, 2004). It was previously mentioned that weather and climate and any resultant change in these systems has a significant impact on the tourism sector (Scott, 2003). It is important to note that the change in the weather and climate can have significant impacts on the environmental resources (which form the foundation of different tourist activities) of a region (Scott, 2003; Spenceley and Goodwin, 2007).

Nature-based tourism is not only one of the fastest growing tourist markets globally, but it is one of the most prominent tourist markets in South Africa, as a result of its high levels of biodiversity and pristine landscapes (Scott, 2003; Nyaupane and Chhetri, 2009; Stevens *et al*., 2014). Nature-based tourism plays a significant role within the tourism sector (c.f. Mahoney and Van Zyl, 2002; Lindsay *et al*., 2005; Brooks, 2005; Spierenburg and Wels, 2010; Ferreira, 2011; Lapeyre, 2011; Rogerson *et al.,* 2013). Nature-based tourism includes a multitude of different activities ranging from camping and hunting to hiking and safaris (Nyaupane and Chhetri, 2009). Climate plays an important role when it comes to nature-based tourism and it can lead to an increase or decrease in tourist numbers in the long term, due to changes in the frequency of precipitation and changes in temperature making the outdoors uncomfortable (Gomez Martin, 2005; Saarinen and Tervo, 2006). Tourism activities and markets based on built attractions such as malls, theme parks and museums are to a certain extent relatively protected from the impacts of climate change, whereas nature-based tourism is extremely sensitive to climate change (Nyaupane and Chhetri, 2009).

Future climate change can potentially lead to a decreased tourism experience by altering the climate characteristics (temperature, wind, fog and humidity) that affect nature-based tourism (Saarinen, 2006; Nyaupane and Chhetri, 2009; Kaján and Saarinen, 2013). Furthermore, climate change will ultimately affect nature-based tourism by impacting on the natural resources on which this tourism market is based (Scott *et al*., 2007a; Saarinen, 2006). Climate change may potentially alter the biodiversity and reduce the landscape aesthetics of various attractions (Root *et al*., 2003). With changing patterns of rainfall and temperature come changes in the distribution of vegetation and ultimately a change in animal distribution (Agnew and Viner, 2001). This will greatly reduce the ability of various nature-based tourism destinations to attract tourists. This will consequently lead to widespread negative economic impacts for surrounding areas in the affected region (Scott, 2003). With a general decrease in rainfall and an increase in extreme events, the tourist experience could be significantly hindered as a result of major flooding, which will disrupt travel routes to different regions or destinations (Stevens *et al*., 2014).

The wine industry goes hand-in-hand with tourism-based on the characteristics that are associated with drinking wine, such as relaxation, hospitality and meeting up with people for social events (Bruwer, 2003). The majority of the wine industry in South Africa is situated outside of major metropolitan areas and, as a result, the industry plays a significant role in contributing to regional development, job creation and tourism (Bruwer, 2003). Although wine is the central product, various activities and sub-industries have been associated with it, such as wine tourism (Charters and Ali-Knight, 2002). Wine tourism is primarily reliant on the natural resources of the surrounding environment and therefore is susceptible to changes in climate and weather systems (Spenceley and Goodwin, 2007).

During the twentieth century there was an increasingly large acknowledgment of the growing relationship between sport and tourism (Gibson, 2003). Sports tourism has been defined by various studies, although the definitions are different they all bear very similar characteristics. Tassiopoulos and Haydam (2008) broadly define sports tourism as:

> Including travel away from one's primary residence to participate in sports activity, for recreation or competition purposes, travel to observe sport at grassroots or elite level, and travel to visit a sports attraction such as a sports museum
>
> [Tassiopoulos and Haydam, 2008: 871]

International research exists that primarily focus on the role of sport and how tourism and sport interact with each other to form the sports tourism niche (c.f. Kurtzman and Zauhar, 1995; Gammon and Robinson, 1997; Gibson, 2003; Tassiopoulos and Haydam, 2008). Sports tourism has played an influential role in shaping government policy in countries, such as Canada, Australia and South Africa (Gibson, 2003).

Sports tourism in South Africa has been recognised as a sub-sector of the broader tourism offerings of the country (Tassiopoulos and Haydam, 2008). In addition, the South African government has encouraged the development of sports tourism products, as they offer a potential for a specialised niche tourism market within the country (Tassiopoulos and Haydam, 2008). Due to the fact that the majority of sports tourism activities are held outside, they rely heavily on climate variables. Therefore, climate change in South Africa may impact on the ability of the country to attract sports enthusiasts, and reduce the attractiveness of this tourism niche market to locations around the world.

It has been widely accepted that among all sectors, agricultural production and the associated activities are the most easily affected and vulnerable to climate change and variability including viticulture (Adams *et al*., 1990; Rosenzweig and Parry, 1994; Parry *et al*., 2004;

Deressa *et al*., 2005; Jones *et al*., 2005; Lobell *et al*., 2006). Consequently, this poses a massive threat to the viability of the wine industry, but also to the wine tourism industry. Climate change poses the potential to increase the impact of pests and diseases on vineyards as a result of milder winters; increases in carbon dioxide may potentially alter the quality and profitability of wine production (Jones *et al*., 2005). The impacts on viticulture as a result of climate change are highly variable, both geographically and on the different varieties (Jones *et al*., 2005). It is therefore, not only the dependent relationship of the wine tourism market on the wine industry and its associated climate change challenges that poses a risk to the success of this tourist activity, but the highly variable nature of the climate change impacts on viticulture that pose a significant threat (Jones *et al*., 2005).

It is, therefore, imperative that local and national levels of governments, scientists and tourism officials and other associated tourism industry stakeholders come together to develop a strategic approach to manage, adapt and mitigate the future potential impacts of climate change on the tourism industry in South Africa (Scott, 2003).

2.9. Tourist Climate Index

Due to the increase in competition within the tourism sector, coupled with the potential of climate change to impact the tourism sector, indices have been developed to represent the significance of climate on tourism (Fergusson, 1964; Davis, 1968; Murray, 1972; Harlfinger, 1991, Becker, 1998; de Freitas *et al*., 2008). These metrics have been developed to explore the suitability of various tourist activities, such as, beach and water activities and game viewing with regards to climate conditions (Kovács and Unger, 2014). Despite the inherent complexity in establishing the influence of climate on tourism, it has been stipulated that there are three aspects of climate that are relevant to tourism (Moreno and Amelung, 2009). In addition, it has been argued that tourists respond to the combined effects of different elements within their surrounding environment, such as, temperature, wind, rain, amount of sunshine and humidity (de Freitas, 1990; Gomez-Martin, 2005). As a result, an all-encompassing index would need to include all three aspects of climate that are relevant to tourism, namely, physical, thermal and aesthetic aspects (de Freitas *et al*., 2008; Moreno and Amelung, 2009). The physical aspect refers to climatic features such as air quality, rain, and ultraviolet radiation that may lead to physical displeasure (Moreno and Amelung, 2009). The thermal aspect deals with the combined effects of different atmospheric variables (air temperature, wind, humidity, personal factors and short/long wave radiation) and determines the comfort of the tourists (Kovács and Unger, 2014). Lastly, the aesthetic aspect deals with elements that enhance and prolong the ability of tourists to enjoy the visual appeal of an area (de Freitas *et al*., 2008). Factors such as sunshine, cloud, visibility and length of day are included under the aesthetic aspect of climate that is relevant for tourism (Moreno and Amelung, 2009).

However, not all indices account for these three aspects of climate. Thermal indices, such as the Physiological Equivalent Temperature (PET), Effective Temperature (ET) and Standard Effect Temperature (SET) were first developed to account for human comfort in general and were later applied to tourism (Moreno and Amelung, 2009). When determining the effects of climate on humans, it is imperative that aspects of the effects of all thermal components on the heat balance of the human body be assessed and accounted for (Lin and Matzarakis, 2011). Based on this, various thermal indices, such as the ones mentioned above, have been applied to assess the outdoor thermal comfort of tourists (Lin and Matzarakis, 2011). A major advantage of thermal indices, are that they are based on, and evolved from physiological research (Moreno and Amelung, 2009). However, a fundamental limitation of thermal indices, especially when they are applied to assessing the thermal comfort of tourists, lies within the fact that these indices ignore important non-thermal aspects of weather (Moreno and Amelung, 2009).

In more recent times, it is often argued that using a composite index is preferred compared to thermal indices (Cegnar and Matzarakis, 2004) when assessing the suitability of climate conditions from a tourist perspective (Moreno and Amelung, 2009). Various composite index models have been developed to measure the suitability of climate conditions for tourism (c.f. Mieczkowski, 1985; Morgan *et al*., 2000; de Freitas *et al*., 2008; Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014; Amelung and Nicholls, 2014). In 2000, Morgan *et al*. (2000) developed a climate index specifically for beach tourism. This index contained similarities to the tourism climate index, developed by Mieczkowski (1985), except for the daily thermal component (Moreno and Amelung, 2009). Mieczkowski's tourism climate index (TCI) model is at the basis of this study and will be discussed in further detail below. The fundamental difference between these two indices is in the rating and weighting schemes. Morgan *et al*. (2000) based their rating and weighting schemes on the preferences of beach users situated on northern European beaches. This proved to be a major advantage of the beach tourism index (BCI), as it enabled the index to be specifically tailored to assess the suitability of climate conditions for tourists who are only interested in beach activities at northern European beaches (Wales, Turkey and Malta). However, this presents itself as an inherent disadvantage of the index due to the fact that the results obtained by Morgan *et al*. (2000) may be hard to generalise to other regions of the world because of intercultural differences in climate preference (Moreno and Amelung, 2009).

de Freitas *et al*. (2008) developed a composite index, which is referred to as the climate index for tourism (CIT). This index is an integrated model for tourism and recreation, and assesses the climatic resources for activities that are very climate sensitive, specifically beach tourism (de Freitas *et al*., 2008). The CIT incorporates thermal, aesthetic and physical aspects of climate. However, if any of the physical component thresholds (wind and rain) of the index are exceeded, the physical aspect of the index overrides the thermal and aesthetic components to affect the satisfaction rating (de Freitas *et al*., 2008). One of the fundamental advantages of this index is that it recognises the overriding affect that physical factors may have on thermal and aesthetic factors when assessing the climate suitability of a region (de Freitas *et al*., 2008). This index has been validated against the preferences of beach tourists and provides a more detailed and accurate assessment of the climate suitability of beach going tourists in a particular region (de Freitas *et al*., 2008). A significant limitation of this index lies in the fact that the model has only been tested at a small spatial scale and there is little evidence that the results of this study and model conducted by de Freitas *et al*. (2008) can be generalised to other regions of the world.

As a result of this, these two particular tourism climate indices only focus on beach-going tourists- the beach climate index (BCI) and climate index for tourism (CIT) will not provide a useful assessment of the climate conditions in South Africa for tourism in general, that require low to moderate levels of physical activity (Amelung and Nicholls, 2014).

One of the most widely used indices to date is the Tourism Climate Index (TCI) (Moreno and Amelung, 2008; de Freitas *et al*., 2008; Kovács and Unger, 2014; Fitchett *et al*., 2016). The TCI was initially formulated by Mieczkowski (1985), to incorporate all three aspects of climate that are relevant for tourism (Perch-Nielsen *et al.,* 2010), and to evaluate and quantify the effects of atmospheric conditions on tourism (Mieczkowski, 1985; Amelung *et al*., 2007). The TCI is scaled according to the comfort required for the most common tourist activities such as beach and water activities, game viewing and other activities that involve low to moderate levels of physical effort (Amelung and Nicholls, 2014). Although new, and more comprehensive indices, such as the CIT, have been developed in recent times, the TCI developed by Mieczkowski (1985) and adapted by Perch-Nielsen (2010) is the most suitable tourism climate index for this study. First, because it is scaled for activities that involve moderate to low levels of physical activities (such as game viewing) and is not just restricted to beach activities such as the CIT and the BCI (de Freitas *et al*., 2008). Second, the generalisability of the TCI model has been proven through multiple studies that have used the TCI under different climatic conditions (*Table 2.8*; c.f. Scott *et al*., 2004; Amelung and Viner, 2006; Amelung *et al*., 2007; Amelung and Nicholls, 2014; Kovács and Unger, 2014; Grant, 2015).

Mieczkowski's (1985) original TCI formula was designed to include twelve monthly climate components that the literature identified as important to a tourism index (Scott *et al*., 2004). However, due to climate data constraints the number of climate components in the TCI formula was reduced to seven (Mieczkowski, 1985). These seven variables included in the TCI formula are based on monthly averages and include: maximum daily temperature; mean daily temperature; minimum daily relative humidity; daily relative humidity; precipitation; daily sunshine hours and wind speed (Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014; Amelung and Nicholls, 2014; Fitchett *et al*., 2016). These seven variables are then combined to form five sub-indices (*Table 2*). These five sub-indices were then weighted by Mieczkowski (1985) according to their influence on tourist's well-being (Rosselló-Nadal, 2014). The majority of studies that have used TCIs have made use of the same amount of factors that were originally stipulated in Mieczkowski (1985) formula and the weightings of the sub-indices have remained constant (c.f. Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014; Amelung and Nicholls, 2014). However, studies have moved away from the original formula in order to base the TCI on preferences of tourist for specific tourist activities (Moreno and Amelung, 2009; Morgan *et al*., 2010; Rosselló-Nadal, 2014).

Table 2.10: The categories in the conceptual framework presented by Scott and McBoyle (2001) (Adapted from Kovacs and Unger, 2014).

Category	Description
Year-round Optimal	TCI≥ 80 for each month of the year
Year-round Poor	TCI< 40 for each month of the year
Summer Season Peak	Highest TCI scores in summer
Winter Season Peak	Highest TCI scores in winter
Bimodal- shoulder peaks	Highest and second highest TCI scores in spring and/or autumn
Dry Season Peak	Highest TCI scores in spring or autumn

Scott and McBoyle (2001) developed a conceptual framework of six potential types of annual TCI score distributions for a given location. This conceptual framework allows for the climatic resources of all destinations to be classified into one of the following categories (Figure 2.4 and Table 2.11; Kovacs and Unger, 2014). This study will use this framework to categorise the long term annual TCI scores for each of the chosen study sites throughout South Africa.

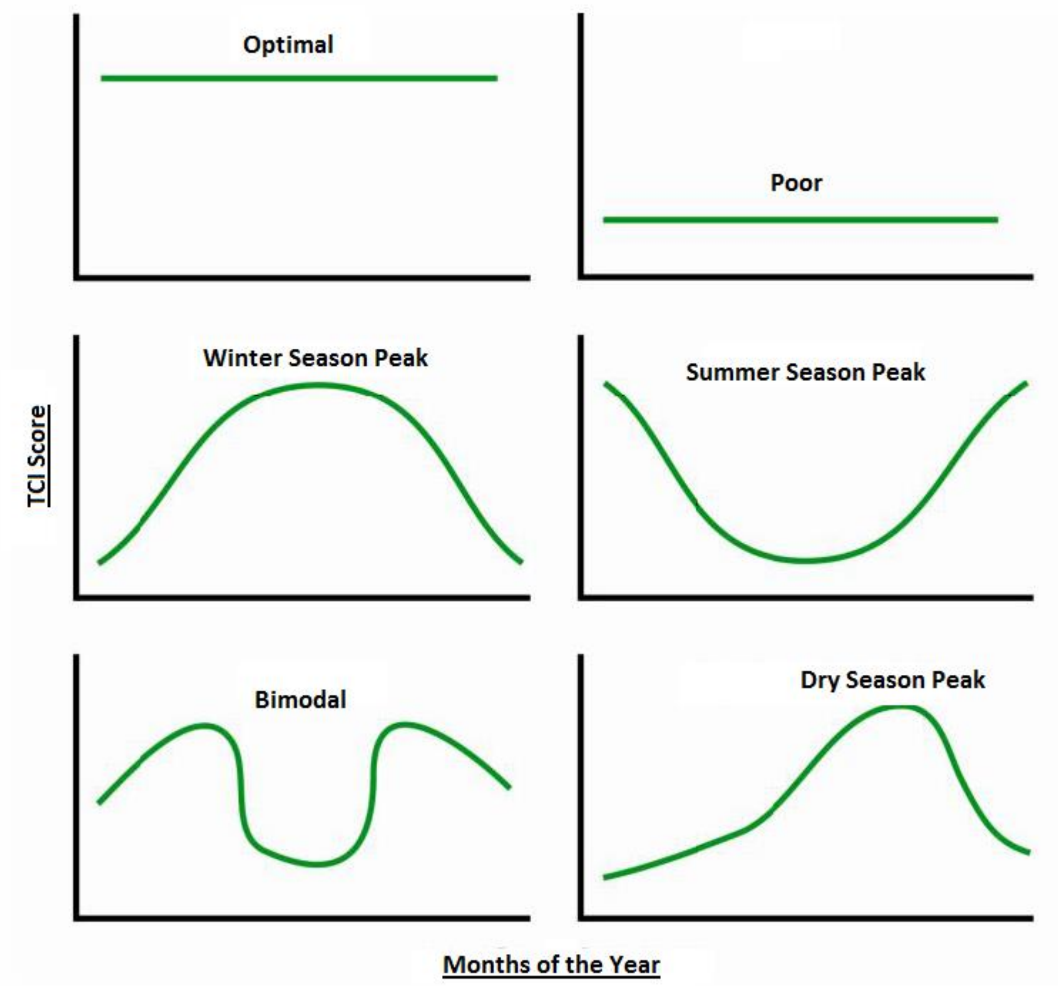


Figure 2.4: Conceptual framework of annual tourism climate distributions for the southern hemisphere (Adapted from Scott and McBoyle, 2001).

It is important to note that the TCI cannot predict tourist arrivals (Amelung *et al*., 2007). The index merely serves to provide information on levels of comfort for tourism activity based on the climate. The TCI does not recognise the existence and quality of infrastructure that supports tourism, such as, accommodation and transport (Amelung and Nicholls, 2014). Therefore, a region may have a particularly high TCI score but can still experience low tourist arrivals as a result of a multitude of factors other than climate, such as, political factors and a lack of necessary infrastructure to support tourism (Amelung *et al*., 2007).

One of the major advantages of the TCI is its ability to be used to analyse the change in climatic resources through the changing climate (Perch-Nielsen *et al.,* 2010). A fundamental goal of a climate index is to provide an analysis of seasonal patterns (Rosselló-Nadal, 2014). Due to the TCIs sub-indices being based on monthly climate data, the impacts of projected climate change can be identified (Rosselló-Nadal, 2014). The amount of research concerning tourism and its relationship with climate change is comparatively limited compared to other economic sectors around the world, despite its large and consistent growth in recent decades (Scott *et al*., 2004). The TCI is able to measure the climatic attractiveness of regions under different climate change scenarios and to compare it to current conditions (Rosselló-Nadal, 2014), such studies have taken place at a global scale, while other such studies have been focused on developed regions (c.f. Scott *et al*., 2004; Amelung and Viner, 2006; Amelung *et al*., 2007; Amelung and Nicholls, 2014; Kovács and Unger, 2014). In addition, it has been proven through multiple studies that the TCI can be applied to different regions around the world, and that the TCI model and the results that it generates has the potential to be generalised across the globe. However, only one TCI study has been conducted in developing regions. Fitchett *et al*. (2016) calculated the TCI for two coastal towns in South Africa, St Francis Bay and Cape St Francis (Visser and Hoogendoorn, 2011). It is therefore imperative that further studies are conducted in South Africa to fully understand the impacts of climate change on the tourism sector. Furthermore, it is important that the TCI is tested in the South African context at a larger spatial and temporal scale in order to explore if the index can be applied to a developing countries context. Having a better understanding of such effects will allow for more effective planning within the tourism sector and thus enhancing the ability of tourism to drive economic and social development and transformation (Rogerson and Visser, 2011a).

Table 2.11: The studies that have used the Tourism Climate Index (TCI) to evaluate the climatic conditions of tourist destinations.

Author	Year	Journal	Region of Study	Main Findings
Scott *et al*	2004	Climate Research	North America	Under future climate change scenarios, the number of cities in the USA with 'excellent' TCI values in winter will increase. Lower TCI values in Mexico in winter in the future indicate that it could become less competitive as a tourist destination in winter. Longer and improved future summer conditions in Canada indicate that the country could become more competitive in the international tourism market.
Amelung *et al*	2007	Journal of Travel Research	Global	Future climate projections and TCI values indicate that there will be temporal and spatial redistributions of suitable climate conditions for tourism around the globe. Many areas considered suitable will lose climatic attractiveness while other destinations will become increasingly more attractive.
Hein *et al*	2009		Spain	Future projections (2060) indicate the Mediterranean winter has acceptable TCI values and the rest of Europe have TCI values that are considered unfavourable for tourists. Spring and autumn indicate good and excellent TCI values. Summer conditions have changed significantly from good and excellent conditions to only acceptable.
Perch-Nielsen *et al*	2010	Climatic Change	Europe	Current climatic conditions are most favourable for tourism in Southern Europe and decrease with an increase in latitude and altitude. Future projections indicate a northward shift in the band of favourable weather, improving climatic conditions for tourism in northern and central Europe. Southern Europe, under future summer conditions, loses its attractive climatic conditions for tourism.

Author	Year	Journal	Region of Study	Main Findings
Amiranashvili *et al*	2014	Transactions of the Georgian Institute of Hydrometeorology	Georgia	January, February and December had a TCI value that corresponds to the 'Marginal' category. March and November had a TCI value that corresponds to the 'Acceptable' category. April had a 'Good' TCI value and May, July, August and October had a 'Very Good' TCI value. June and September had an 'Excellent' TCI value. Overall the climate in Tbilisi for tourism is favourable for the most part of the year.
Kovács and Unger	2014	Quarterly Journal of Hungarian Meteorological Service	Central Europe	Most optimal climatic conditions for tourism are in the shoulder seasons of all places that were explored. Summer is increasingly unpleasant for sight-seeing as a result of increased heat Large differences between the cities regarding the timing of different climatic conditions (seasonality).
Kubokawa *et al*	2014	Journal of the Meteorological Society of Japan	Japan	TCI for Japan under present conditions indicates summer as the most comfortable season for tourism. Under future conditions, the TCI indicates that spring and autumn will become more optimal for tourism while the summer season becomes less comfortable for tourists.
Rosselló-Nadal	2014	Climatic Change	Global	Future climate change would result in traditional warm destinations around the world to lose climatic attractiveness to tourists. High latitude countries would become more climatically attractive for tourists.
Amelung and Nicholls	2014	Tourism Management	Australia	Future projections demonstrate: There will be a shift southward of the most suitable conditions for tourism. Northern locations in Australia will experience a decline in suitable climate conditions for tourism.

Author	Year	Journal	Region of Study	Main Findings
Fang and Yin	2015	Atmosphere	China	Climate for the majority of regions in China are comfortable for visitors during autumn and spring. Climate conditions vary in summer and winter with conditions existing ranging from an ‘unfavourable’ TCI value to an ‘excellent’ TCI value along a latitudinal progression. Most places in China rank as having five to eight ‘good’ TCI category months.
Olya and Alipour	2015	Tourism Management	Northern Greece	The TCI values for all the tested stations ranged from 73 to 79, indicating that most of the regions have a ‘very good’ climate for tourism.
Roshan *et al*	2016	International Journal of Biometeorology	Iran	Increases in TCI values occur for at least one station each month. The Kashan, Tabriz, Orumiyeh, Shahreord, Zahedan and Torbat-e-Heidarieh stations all experienced increases in TCI values for more than 6 months starting from 1970 to 1980.
Fitchett *et al*	2016	South African Journal of Science	South Africa	Digital Elevation Model developed for the towns indicates that the projected sea level rise for 2050 and 2100 will lead to parts of the beaches washed away. TCI values indicate that the climate is becoming worse for tourists’ comfort and that the towns will become less attractive in the future as a tourism destination.

Despite the TCI being widely used, it has a number of fundamental limitations (Moreno and Amelung, 2009; Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014). One of the major limitations of the TCI lies within its subjective nature and due to its lack of verification (Perch-Nielsen *et al.,* 2010). The weightings of the five sub-indices are to some extent based on biometeorological literature and research, but to a large extent are also based on expert opinion (de Freitas *et al*., 2008; Rosselló-Nadal, 2014). Recent derivatives of the TCI are seeking to eliminate the lack of verification against tourist perceptions with regards to ideal conditions for different tourist activities (Moreno and Amelung, 2009). Although Mieczkowski (1985) indicated that the TCI formula could be changed in terms of ratings and weightings for specific activities, this has only recently been explored (Moreno and Amelung, 2009; Rosselló-Nadal, 2014). Morgan *et al*. (2010) altered the TCI by basing it on tourist preferences for climate conditions and swimming water temperature (which were obtained through questionnaires) and therefore altering the TCI to specific tourist market groups by using different weightings. Another area of criticism of the TCI that is widely recognised is that the index does not identify the potential of overriding effects of certain climate variables during specific tourist activities (Moreno and Amelung, 2009). Furthermore, the TCI does not recognise the potential of geographical and intercultural preferences in climate (de Freitas *et al*., 2008). Again, efforts have been made to adjust the TCI to account for the potential of overriding effects and differences in climate preferences (Gomez-Martin, 2006; de Freitas *et al*., 2008).

2.10. Conclusion

The global climate change and tourism section of this literature review has highlighted the importance of the natural environment to tourism, and extent to which climate change can impact on the tourism of a destination. It is important to note that tourism product offerings are often destination specific and, as a result, many adaptation strategies need to be tailored to deal with the specific climate change impacts being experienced at each destination. Consequently, to better realize the extent to which climate change is impacting on the tourism sector of a destination, it is necessary to study as many different destinations as possible across the globe. Whilst, many attempts have been made to quantify the impacts of climate change on tourism at destinations around the world, many earlier attempts were not successful and did not account for all aspects that are considered important to the thermal comfort of tourists. The tourism climate index section of the literature review has highlighted that some studies (de Freitas *et al*., 2008; Morgan *et al*., 2000) have developed tourism activity specific indices, particularly for beach tourism. However, the most widely used index to assess the impact of climate change on tourism, predominantly in developed countries, is the tourism climate index developed by Mieczkowski (1985) and adapted by Perch-Nielsen *et al*. (2010). The literature has highlighted the importance of the tourism sector in South Africa, whilst climate change literature has indicated that South Africa is set to experience changes in its climate in the future. However, very few studies have been undertaken on the response of the climate suitability of destinations in South Africa to ongoing climate change. Furthermore, with climate change and tourism studies in South Africa only having been done over a small spatial and temporal scale, this study would contribute to this local gap, while simultaneously adding to the global understanding of the relationship between climate change and tourism.

Chapter 3: Study Site

3.1. Introduction

This study evaluates the TCI scores for 18 locations in South Africa from 2005-2014. South Africa was chosen as the study region for this project, due to the diverse range of climatic characteristics that exist across the country, the availability of high quality climate data, and the scarcity of literature on the effects of climate change on tourism in South Africa. Therefore, South Africa and the selected locations within the country can be used to assess the impact of climate change on the tourism sector. Climate data for the different components of the TCI at each location, were provided by the South African Weather Service (SAWS). This enables the TCI to be calculated at an annual and monthly scale at each location. Furthermore, it allows for a comparison to be made regarding the influence of climate change on the climate suitability for tourism at each location. This chapter provides a description of the general climatic characteristics and climate controls of South Africa, and the contemporary climate conditions of the specific locations used in this study. The chapter also briefly outlines the major tourist attractions in South Africa, but provides a short description of the main tourism markets situated at each of the chosen sites.

3.2. Study Site Justification

The initial scope of the study set out to target 50 locations throughout South Africa (*Table 3.1*). However, due to lack of availability and inconsistent long-term climate data for locations across the country, the study was reduced to include 18 locations that had the necessary climate data needed for the purposes of this study. Therefore, this study will focus on 18 locations throughout the nine provinces of South Africa. The locations were chosen based on the following set of criteria:

- Allow for a relatively even geographic balance between inland and coastal locations.
- Ensure that there is a relatively even distribution of locations through the different provinces.
- Represent a significant economic role in the tourism sector.

- Each Location has a distinct climate with reliable weather stations, that capture the data required to calculate TCIs, namely, maximum daily temperature; mean daily temperature; minimum daily relative humidity; daily relative humidity; precipitation; daily sunshine hours and wind speed.

It is evident from *Table 3.1*, that there is a significant lack of data available for a large portion of South Africa. This is primarily due to the fact that a particular location does not have a SAWS weather station, the SAWS weather station only records rainfall data or a particular SAWS weather station was decommissioned and there are no available records. As a result, this research was limited to using locations that had the necessary data needed to calculate the TCI.

With the aim of identifying the impacts of climate change on the climate suitability of locations for tourism in South Africa, it is unfortunate that regions in which major tourism attractions, such as the Drakensberg, Kruger National Park, Kubusi Indigenous Forest and Hogsback forest in the Eastern Cape, Namaqua National Park and Richtersveld World Heritage in the Northern Cape, and the Karoo could not be included in this study because of the lack of data. These and many other attractions play a vital role in attracting tourists to South Africa and, therefore, it is important that the impacts of climate change on these areas and tourist attractions are explored and evaluated in detail, in order to protect them from significant negative impacts of climate change in the future. It is important to note, from a climate record perspective, that the best quality weather records come from multiple weather stations in major cities, such as Johannesburg and Cape Town. However, it is not always necessary to have multiple records for the same locations, especially when there is a lack of weather stations in smaller cities and towns throughout the country.

Table 3.1: The initial choice of study sites for this research and the climatic data provided by SAWS for each of the locations.

Location	T_{max}	T_{min}	Wind Speed	Rainfall	Humidity	Cloud Cover	Sunshine Hours
Belfast	2005-2014	2005-2014	2005-2014	2005-2014	2005-2014	-	
Bethlehem	1981-2014	1981-2014	1981-2014	1981-2014	1981-2014	1981-2014	1981-2014
Bloem	1950-2014	1950-2014	1991-2014	1950-2014	1991-2014	1992-2014	1992-2014
Cape Town	1956-2014	1956-2014	1956-2014	1950-2014	1966-2014	1956-2014	1966-2014
Carletonville	1962-2014	1962-2014	-	1962-2014	-	-	-
Cederberg	-	-	-	-	-	-	-
Clarens	1987-1991	1987-1991	-	1950-2014	-	-	-
Dullstroom							
Durban	1957-2014	1956-2014	1956-2014	1956-2014	1956-2014	1956-2010	-
East London	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1959-2014
George	-	-	-	-	-	-	-
Graaff-Reinet	-	-	-	-	-	-	-
Grahamstown	-	-	-	-	-	-	-
Hazy View	-	-	-	-	-	-	-
Hermanus	-	-	-	-	-	-	-
Hluhluwe	-	-	-	-	-	-	-
Hoedspruit	1956-2014	1996-2014	-	1996-2014	1996-2014	-	-
Johannesburg	1985-2014	1985-2014	1992-2014	1985-2014	1992-2014	1985-1994	1992-2014
Kimberley	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1959-2014
Knysna	1997-2014	1997-2014	1997-2014	1997-2014	1997-2014	-	-
Kruger National Park	-	-	-	-	-	-	-

Location	T_{max}	T_{min}	Wind Speed	Rainfall	Humidity	Cloud Cover	Sunshine Hours
Ladysmith	1994-2014	1994-2014	1994-2014	1994-2014	1994-2014	-	
Langebaan	-	-	-	-	-	-	-
Margate	-	-	-	-	-	-	-
Mooi River	2000-2014	2000-2014	2000-2014	2000-2014	-	-	
Nelspruit	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014	-	-
Newcastle	-	-	-	-	-	-	-
Nottingham Road	-	-	-	-	-	-	-
Paarl	1997-2014	1997-2014	1997-2014	1997-2014	1997-2014	-	-
Parys	-	-	-	-	-	-	-
Port Elizabeth	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1959-2014
Phalaborwa	-	-	-	-	-	-	-
Piet Retief	-	-	-	-	-	-	-
Pilanesberg	1996-2014	1996-2014	1996-2014	1996-2014	1996-2014	-	-
Polokwane	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014
Port Nolloth	1985-2014	1985-2014	1985-2014	1985-2014	1985-2014	1985-2014	1999-2014
Potchefstroom	1997-2014	1997-2014	1997-2014	1997-2014	1997-2014	-	
Pretoria	1994-2014	1994-2014	1994-2014	1950-2014	1999-2014	-	-
Queenstown	-	-	-	-	-	-	-
Robertson	-	-	-	-	-	-	-
Rustenburg	-	-	-	-	-	-	-
St Lucia	1983-2007	1983-2007	1983-2007	1983-2007	1983-2007	1983-2007	
Stellenbosch	-	-	-	1978-2014	-	-	
Still Bay	-	-	-	-	-	-	-

Location	T_{max}	T_{min}	Wind Speed	Rainfall	Humidity	Cloud Cover	Sunshine Hours
Tzaneen	-	-	-	-	-	-	-
Vanderbijlpark	-	-	-	-	-	-	-
Vereeniging	-	-	-	-	-	-	-
Vryburg	-	-	-	-	-	-	-
Welkom	-	-	-	-	-	-	-
Worcester	-	-	-	-	-	-	-

3.3. Climate Controls of South Africa

South Africa is the southernmost country in Africa and stretches latitudinally from 22°S to 35°S and longitudinally from 17°E to 33°E (South African Government, 2015a; Karmalkar *et al*., 2012). South Africa is considered to be a subtropical location, with its climate being influenced by differences in elevation, by the Indian Ocean to the southeast and the Atlantic Ocean to the southwest, and the temporal scales at which summer and winter rainfall occur across the country (Karmalkar *et al*., 2012; Jawtusch, 2014).

The temperature varies considerably in South Africa, with high temperatures reaching in excess of 32°C in summer and several degrees below 0°C at higher elevations on the interior plateau (Jawtusch, 2014). There are also considerable differences between the temperatures on the west and east coasts of the country, as a result of the different ocean currents at each coastline (South African Government, 2015a). The warm Agulhas current flows southward along the eastern shores of the country and results in an increase in the temperatures along the eastern coastline (Chase and Meadows, 2007), while the Benguela current flows northward in the Atlantic Ocean along the western coastline of the country, resulting in cooler temperatures (Jawtusch, 2014; South African Government, 2015a). The influence of these two ocean currents result in the temperatures along the eastern shoreline being approximately 5°C warmer than temperatures at the same latitude along the western shoreline (Karmalkar *et al*., 2012). Due to the inland plateau that rises in the northeast, the temperatures vary from south to north of the country (Karmalkar *et al*., 2012). However, the plateau results in higher temperature ranges between night and day over the interior of South Africa, while the coasts do experience such extreme temperature ranges (Jawtusch, 2014).

South Africa is considered a semi-arid country, with an annual rainfall of approximately 464mm which is relatively low compared to the world average of 860mm per year (South African Government, 2015a). The central and northern interior of the country along with the eastern regions, all receive the majority of their rainfall during summer months as a result of convective rainfall (Karmalkar *et al*., 2012). The southwestern region of South Africa receives most of its rainfall during the winter months, from May to August, and is as a result of mid-latitude frontal rainfall (Jawtusch, 2014). It should be noted that there is a considerable variation in the amount of rainfall from east to west of the country, which is predominantly influenced by the ocean currents, and due to the movement of the anticyclone over the country (Karmalkar *et al*., 2012).

3.4. Tourism Attractions in South Africa

South Africa has many different cultures, distinctly different climates across the country, and infrastructure that caters for a wide variety of different tourism niches such as business, cultural, nature-based, adventure, sports, wine and medical tourism. Each type of tourism will be briefly explained below:

Business Tourism: Business tourism involves individuals traveling away from their homes to work, but still finding time to take part in leisure activities before or after their work is complete, at a particular destination (Kulendran and Witt, 2003).

Cultural Tourism: It has been stated that cultural tourism is based on the search for and participation in, new cultural experiences that are aesthetic, emotional or intellectual in nature (Stebbins, 1997; Saarinen *et al*., 2014). South Africa has many different people with significantly different cultural backgrounds and is therefore an ideal place to visit for new cultural experiences

Nature-based Tourism: This type of tourism involves travelling to natural areas that are relatively undisturbed by humans (Valentine, 1992). Nature-based tourism is based around the specific act of studying, appreciating and enjoying the scenery and wildlife (Valentine, 1992). South Africa has many protected areas that are ideal for nature-based tourism, while also having 19 national parks and many private game reserves for tourists to visit.

Adventure Tourism: Involves travelling to remote areas, to experience a holiday that is not typical of the normal beach or nature-based tourism experience (Weber, 2001).

Sports Tourism: Involves an individual/s traveling away from their home to take part in a sports activity, whether it be for competition or recreation. Furthermore, it involves traveling to watch sports at any level, or to visit a sports attraction, such as a sports museum (Tassiopoulos and Haydam, 2008). South Africa has world class venues and infrastructure supporting these venues, and with various international sporting attractions held in South

Africa annually, such as the Cape Town Cycle Tour and the Cape Epic, it is a niche that is well developed within the country.

Wine Tourism: Involves travelling for the primary purpose of visiting wineries and the surrounding areas, while enjoying the lifestyle associated with wine estates (Charters and Ali-Knight, 2002).

Medical Tourism: It involves people traveling overseas to other countries to obtain either medical, surgical or dental care while at the same time taking the opportunity to be holidaymakers (Connell, 2006). This new niche of tourism has been driven by the high costs and long waiting lists in the individual's home country, while improved skills and new technology in the destination country, along with reduced costs of long haul transport have contributed to the increase in medical tourism (Connell, 2006).

Coastal Tourism: Involves a wide variety of tourist activities that range from leisure and recreationally orientated activities that occur in the coastal zones and off-shore coastal waters (Hall, 2001). These activities include, swimming, boating, recreational fishing, snorkeling and cruises (Hall, 2001).

South Africa has a wide variety of tourism activities and attractions within each of these tourism niche markets (*Table 3.2*). Due to the high level of importance on tourism to act as a tool to achieve social and economic development in South Africa, it is essential that these tourist attractions be maintained and looked after so that they can continue attracting tourists. Furthermore, South Africa should constantly be looking to diversify their tourism market in order to attract new and different tourists.

Table 3.2: Tourist attractions that can be found in different regions throughout South Africa (Adapted from the South African Government, 2015b).

Region	Tourist Attraction
Eastern Cape	St George's Park Valley of Desolation Addo Elephant Park, Mountain Zebra Park, Tsitsikamma National Park
Freestate	King's Park Rose Garden Mangaung African Cultural Festival The National Women's Memorial The Gariep Dam and the Gariep Dam Nature Reserve Clocolan (Cherry blossoms and San rock paintings) he Golden Gate Highlands National Park The Vredefort Dome
Garden Route	Attequas Kloof Pass Great Brak River (Small village that offers the opportunity for whale and dolphin watching) Gouritz River Gorge (Hiking, mountain biking, angling, and bungee-jumping) Mossell Bay (Point- for surfing and rock pools) Dagbreek Museum The Genadendal Mission and Museum complex
Gauteng	South African National Horsemanship The Sterkfontein caves The Constitution Hill Precinct The Apartheid Museum The Nelson Mandela Centre of Memory The National Zoological Gardens Natural areas (Suikerbosrand Nature Reserve, Kloofendal Nature Reserve and Walter Sisulu Botanical Gardens and Tswaing Crater Trail)
KwaZulu-Natal	Comrades Marathon Duzi canoe marathon Weza State Forest iSimangaliso Wetland Park The Kosi Bay Nature Reserve Hluhluwe-Umfolozi Park The Battlefield Route The Midlands Meander

Region	Tourist Attraction
Limpopo	Marakele National Park Game-hunting The Mapungubwe Archaeological Site The Kruger National Park
Mpumalanga	Blyde River Canyon God's Window Sabie Sabie The Cultural Historical Forestry Museum The Bridal Veil, Horseshoe and Lone Creek waterfalls, Prospector's Trail Lowveld Crocodile Canoe Marathon
North West	Pilanesberg National Park Kortkloof Cultural Village San rock engravings, Stone Age implements and structures (Witpoort, Gestoptefontein, Driekuil and Korannafontein)
Northern Cape	"Oasis of the Kalahari" The Wonderwerk Cave The Kalahari Raptor Centre Namaqualand Richtersveld National Park
Karoo	The Swartberg Nature Reserve and Pass The Klein Karoo Nasionale Kunstefees (National Arts Festival) The Cango Caves
Western Cape	Table Mountain National Park Cape Epic The South African Rugby Museum The Victoria and Alfred Waterfront Robben Island The Gold of Africa Museum Cape Town Cycle Tour Cape Town International Jazz Festival Cape Wine Routes

3.5. Selected Study Sites

The study sites for this research are located throughout the nine provinces of South Africa (*Map 3.1; Table 3.3*). The selected study sites are relatively evenly distributed across the country. Each of the chosen locations have relatively distinct climates and a SAWS weather station. The study sites for this research are scattered throughout the country, and will therefore provide an overview of the TCI in different regions of the country under different climatic conditions.

Each of these locations rely on tourism to some extent to contribute to their local economies. With each site having a relatively distinct climate and a variety of different tourist attractions on offer, it makes them ideal locations to explore the impacts of climate change on tourism. The extent and nature of the tourism product offerings that each location has to offer, is very diverse, with multiple locations such as Johannesburg, Cape Town and Durban all serving as nodes for business tourism, but at the same time offer tourist activities that range from tours to museums to visits to natural areas and botanical gardens. Therefore, tourists' attractions sensitive to outdoor climatic conditions are present at all locations. Although all the selected locations may offer similar sorts of broad tourism market offerings, the experience of each activity will be significantly different at each location due to the varying climatic conditions. Thus, these selected sites will allow for a comparison to be made across the country as to how climate is influencing climate for tourism and will give a good indication as to when and where there are suitable climate conditions for tourism.

Table 3.3: Overview of the selected study sites and their location, annual mean temperature and rainfall, and a tourist activity (SA Explorer, 2014; Climate data, 2014).

Province	Location	GPS Coordinates	Annual Mean Temperature (˚C)	Annual Mean Rainfall (mm)	Tourist Attractions
Gauteng	Johannesburg	26.2044° S, 28.0456° E	16	543	-Business Tourism - Arts and Cultural Tourism -Adventure tourism -Paleo-Tourism -Historical Tourism
	Pretoria	25.7461° S, 28.1881° E	17.3	517	
North West	Pilanesberg National Park	25.2611° S, 27.1008° E	19.5	500	-Nature Tourism - Adventure Tourism - Business Tourism - Cultural Tourism
Western Cape	Cape Town	33.9253° S, 18.4239° E	16.9	853	-Business Tourism - Coastal Tourism - Adventure Tourism - Historical Tourism - Arts and Cultural Tourism - Lifestyle and Leisure Tourism
	Paarl	33.7274° S, 18.9558° E	17.6	770	
	Knysna	34.0356° S, 23.0489° E	17	779	
Limpopo	Polokwane	23.9000° S, 29.4500° E	17.3	598	-Nature Tourism - Adventure Tourism - Cultural Tourism

Province	Location	GPS Coordinates	Annual Mean Temperature (˚C)	Annual Mean Rainfall (mm)	Tourist Attractions
Kwa-Zulu Natal	St Lucia	28.3833° S, 32.4167° E	21.6	1129	-Historical Tourism -Cultural Tourism -Coastal Tourism -Business Tourism
	Durban	29.8833° S, 31.0500° E	20.9	975	
	Ladysmith	29.5597° S, 29.7806 ° E	18.3	740	
Northern Cape	Kimberley	28.7419° S, 24.7719° E	18	283	-Nature Tourism -Cultural Tourism -Adventure Tourism -Historical Tourism
	Port Nolloth	29.2500° S, 16.8667° E	14.7	72	
Eastern Cape	Port Elizabeth	33.9581° S, 25.6000° E	17.4	453	-Coastal Tourism -Nature Tourism -Historical Tourism -Lifestyle and Leisure Tourism -Arts and Cultural Tourism
	East London	32.9833° S, 27.8667° E	18.2	593	
Free State	Bloemfontein	29.1167° S, 26.2167° E	16.1	407	-Adventure Tourism -Historical Tourism -Cultural Tourism -Lifestyle and Leisure Tourism
	Bethlehem	28.2333° S, 28.3000° E	14.4	693	
Mpumalanga	Nelspruit	25.4658° S, 30.9853° E	19.8	796	-Nature Tourism - Lifestyle and Leisure Tourism - Cultural Tourism - Adventure Tourism
	Belfast	256833° S, 30.0167° E	13.2	835	

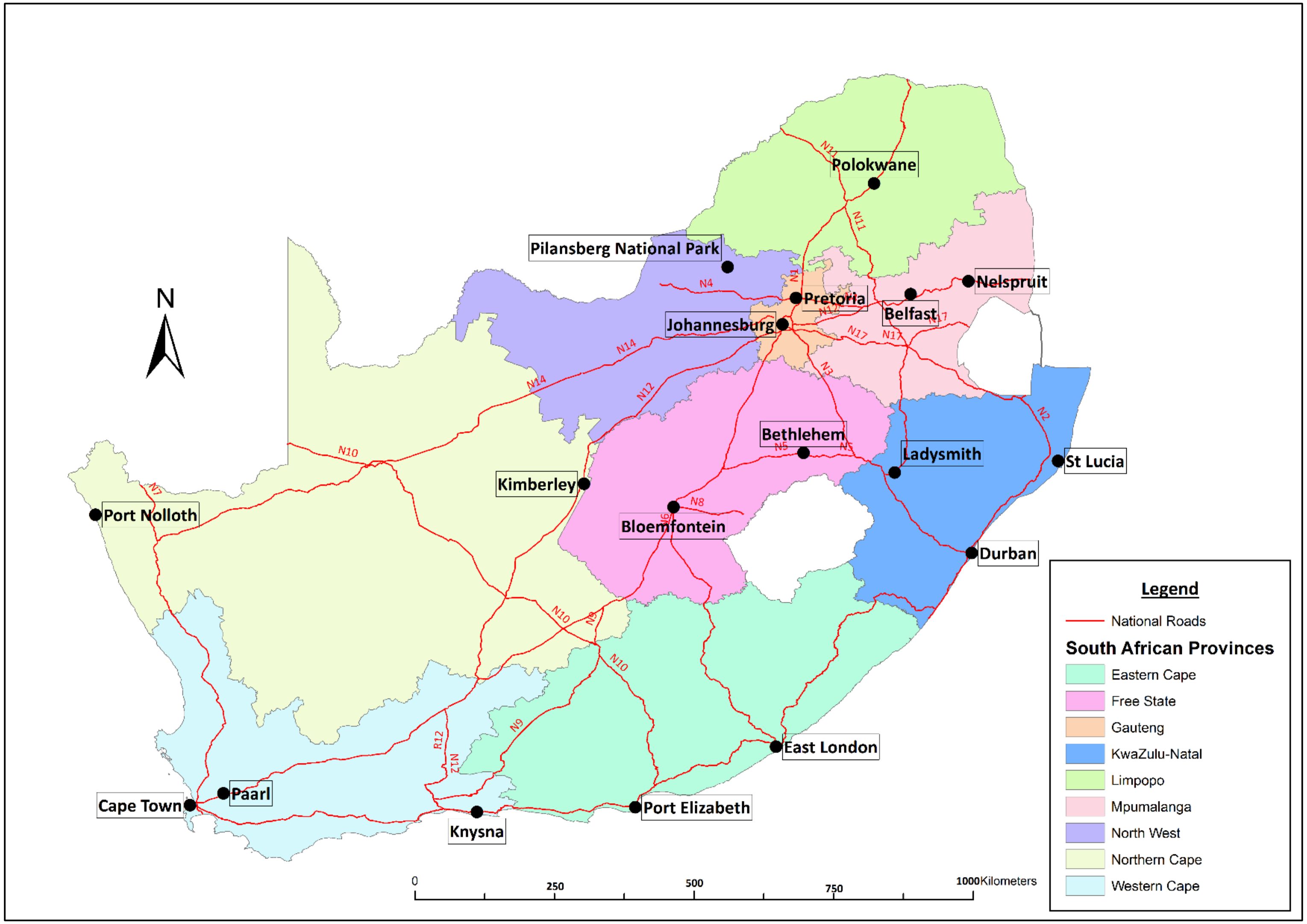


Figure 3.1: Map of the selected study sites.

3.6. Conclusion

The selected study sites all have distinctive climates and available weather data from the South African Weather Service. Furthermore, each location has a well-established tourism market, which plays an important role in driving the local economy towards social and economic development. These locations are thus ideal study sites to explore the impact of climate change on the climate suitability of destinations for tourism. Many of the tourism activities in the selected study sites are heavily dependent on climate and the environmental resources of the area, and therefore, climate change can have a major impact on the suitability of the area for tourism in the future. The methodology used in this study (*Chapter 4*) was aimed at exploring the impact of climate change on the climate suitability for tourism at each location for the period 2005-2014 and for the longest continuous time period for each location (based primarily on data availability).

Chapter 4: Methods

4.1. Introduction

The primary aim of this study is to explore the value of the Tourism Climate Index (TCI) in South Africa by exploring how climate change and variability is influencing tourism at 18 locations across the country. Furthermore, the study aims to contribute to international and local literature surrounding TCIs and further strengthen the existing literature on tourism and climate change in South Africa. To achieve this, meteorological data sets for the 18 locations (*Table 3.3*) were acquired; TCI models need to be run for each location to obtain the long-term TCI score for each of the chosen locations, and the TCI scores for each month of the year across the dataset and each year of the study period at each location; statistical analysis of the changes over time for each location over the study period will be conducted. Lastly, the study compares tourism academics and researcher's perceptions of climate change to TCI results to determine the value of TCIs within the South Africa context.

This chapter outlines the process through which the data for this study is obtained. Following this, will be a description detailing the methods used to calculate the TCI values for each location and a description of the statistical tools used to analyse the trends and changes in TCI values over the study period. It is important to note that this study uses both quantitative and qualitative methods, as such this chapter will be broken up into two sections: quantitative methods and materials and qualitative methods and materials. The quantitative section will comprise of a desktop statistical analysis and will calculate the TCI scores of 18 locations throughout South Africa, using climate data that will be obtained from the South African Weather Services. The qualitative section will be used to determine the validity of the findings of the TCI analysis through exploring the perceptions of major stakeholders in the tourism industry in South Africa with regards to the role of climate change in the tourism sector, and the extent to which TCI findings mirror changes in tourist numbers in various locations.

4.2. Quantitative Materials and Methods

4.2.1. Acquisition of Climate Data

To calculate and analyse the long-term annual and monthly Tourist Climate Index (TCI) scores for South Africa, climate data for each of the locations will be sourced from the South African

Weather Service *(Table 4.1)*. The climate data that are required to calculate the TCI input variables are selected based on previous TCI studies (Mieczkowski, 1985; Perch-Nielsen *et al*., 2010; Kovács and Unger, 2014; Kubokawa *et al*., 2014; Roshan *et al*., 2016), which include the 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. *Table 4.1* outlines the data that were obtained and the longest, most complete period across the variables for which data is available from the SAWS for each location. It is important to note that humidity data supplied by the South African Weather Service (SAWS) is given as a daily value and is not recorded hourly. As such, to obtain the minimum relative humidity for the TCI model, the minimum humidity value each month is used when calculating the TCI values. There were various limitations that were encountered during the data collection process, these are outlined in detail under *section 6.6.1* (Limitations in Data Collection).

Table 4.1: The data made available by SAWS for the locations used in this study.

Location	Max Temp	Min Temp	Wind Speed	Rainfall	Humidity	Cloud Cover	Sunshine Hours
Belfast	2005-2014	2005-2014	2005-2014	2005-2014	2005-2014	-	
Bethlehem	1981-2014	1981-2014	1981-2014	1981-2014	1981-2014	1981-2014	1981-2014
Bloemfontein	1950-2014	1950-2014	1991-2014	1950-2014	1991-2014	1992-2014	1992-2014
Cape Town	1956-2014	1956-2014	1956-2014	1950-2014	1966-2014	1956-2014	1966-2014
Durban	1957-2014	1956-2014	1956-2014	1956-2014	1956-2014	1956-2010	-
East London	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1959-2014
Johannesburg	1985-2014	1985-2014	1992-2014	1985-2014	1992-2014	1985-1994	1992-2014
Kimberley	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1959-2014
Knysna	1997-2014	1997-2014	1997-2014	1997-2014	1997-2014	-	-
Ladysmith	1994-2014	1994-2014	1994-2014	1994-2014	1994-2014	-	
Nelspruit	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014	-	-
Paarl	1997-2014	1997-2014	1997-2014	1997-2014	1997-2014	-	-
Pilanesberg	1996-2014	1996-2014	1996-2014	1996-2014	1996-2014	-	-
Polokwane	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014	1993-2014
Port Elizabeth	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1950-2014	1959-2014
Port Nolloth	1985-2014	1985-2014	1985-2014	1985-2014	1985-2014	1985-2014	1999-2014
Pretoria	1994-2014	1994-2014	1994-2014	1950-2014	1999-2014	-	-
St Lucia	1983-2014	1983-2014	1983-2014	1983-2014	1983-2014	1983-2014	-

4.2.2. Cloud Cover and Sunshine Hours Data

The data supplied by SAWS regarding sunshine hours, is split between the actual measurements of sunshine hours and total cloud cover (which is recorded in oktas). Oktas is used as a unit of measurement for cloudiness and is measured on a scale from 0 to 8 (Doorenbos and Pruitt, 1977). Due to the TCI model requiring sunshine hours, it is necessary to convert the total cloud cover data into sunshine hours. It is important to note that the process of converting cloud cover data into sunshine hours yields an estimation and not a precise value of the sunshine hours. This is predominantly due to the inherent difficulty of precisely measuring cloud cover (Hulme *et al*., 1995).

Table 4.2: Showing the respective values assigned to each okta that are used in the estimation of sunshine hours of a location (Adapted from Hulme *et al*., 1995).

Cloudiness (Oktas)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Expected Proportion of Sunshine (S)	0.95	0.85	0.75	0.65	0.55	0.45	0.35	0.15	0

To calculate the approximate daily sunshine hours using the cloud cover data, this study used a method that was put forth by Hulme *et al*. (1995). The following equation is used to estimate the sunshine hours:

$$\mathrm{n} = \mathrm{S(N)}$$

Equation 4.1: Converting cloud cover data to sunshine hours.

Where:

S= Expected Proportion of Sunshine relative to the okta reading

N= Maximum Possible number of sunshine hours for a location

n=Estimated Sunshine Hours

The maximum possible number of sunshine hours for a location is taken to be equivalent to the number of daylight hours based on its latitude. *Table 4.2* below represents the daylight hours of each month based on its latitude.

Table 4.3: Mean daily maximum daylight hours for different latitudes and months in the southern hemisphere (Adapted from Doorenbos and Pruitt, 1977).

	Months											
Latitude (°)	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
50	15.9	14.5	12.7	10.8	9.1	8.1	8.5	10.1	11.8	13.8	15.4	16.3
48	15.6	14.3	12.6	10.9	9.3	8.3	8.8	10.2	11.8	13.6	15.2	16.0
46	15.4	14.2	12.6	10.9	9.5	8.7	9.1	10.4	11.9	13.5	14.9	15.7
44	15.2	14.0	12.6	11.0	9.7	8.9	9.3	10.5	11.9	13.4	14.7	15.4
42	14.9	13.9	12.6	11.1	9.8	9.1	9.4	10.6	11.9	13.4	14.6	15.2
40	14.7	13.7	12.5	11.2	10.0	9.3	9.6	10.7	11.9	13.3	14.4	15.0
35	14.3	13.5	12.4	11.3	10.3	9.8	10.1	11.0	11.9	13.1	14.0	14.5
30	13.9	13.2	12.4	11.5	10.6	10.2	10.4	11.1	12.0	12.9	13.6	14.0
25	13.5	13.0	12.3	11.6	10.9	10.6	10.7	11.3	12.0	12.7	13.3	13.7
20	13.2	12.8	12.3	11.7	11.2	10.9	11.0	11.5	12.0	12.6	13.1	13.3
15	12.9	12.6	12.2	11.8	11.4	11.2	11.3	11.6	12.0	12.5	12.8	13.0
10	12.6	12.4	12.1	11.8	11.6	11.5	11.6	11.8	12.0	12.3	12.6	12.7
5	12.3	12.3	12.1	12.0	11.9	11.8	11.8	11.9	12.0	12.2	12.3	12.4
0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0

Ultimately this conversion process is not explicitly used in or during the operation of the TCI models. Initially it is included to convert the cloud data for Durban and St. Lucia into sunshine hours because these locations only have cloud cover data and not sunshine hours data. However, the cloud cover data for these locations did not extend over a long enough period and are therefore considered not reliable and are not included in the dataset. The result of which can be found in appendix D.

However, the estimation of sunshine hours is carried out for all locations that have cloud cover data and sunshine data (*Table 4.3*) that were supplied by the South African Weather Service. This is done so that the accuracy and reliability of this method of estimation could be tested and explored for future studies and for other developing countries that do not have access to freely available and complete datasets. Once the estimation process was completed, the estimated sunshine hours are correlated to the sunshine hours data supplied by SAWS.

Table 4.4: The locations used to test the accuracy and reliability of the proposed method for estimating sunshine hours from cloud cover data.

Location	Sunshine Hours (Supplied SAWS)	Cloud Cover	Calculated Sunshine Hours
Bloemfontein	1992-2014	1992-2014	1992-2014
Cape Town	1966-2014	1956-2014	1966-2014
East London	1959-2014	1950-2014	1959-2014
Kimberley	1959-2014	1950-2014	1959-2014
Polokwane	1993-2014	1993-2014	1993-2014
Port Elizabeth	1959-2014	1950-2014	1959-2014
Port Nolloth	1999-2014	1985-2014	1999-2014

4.2.3. Traditional Tourism Climate Index Methodology

Due to the data constraints, only nine of the chosen locations (*Table 4.5*) have a complete set of data across all the necessary variables needed to calculate the TCI. Consequently, for these locations, this study will use a TCI which is a derivative of the original formula developed by Mieczkowski (1985) and with adaptations introduced by Perch-Nielsen *et al*. (2010) and used in other studies around the world (Roshan *et al*., 2016; Kovács and Unger, 2014; Kubokawa *et al*., 2014).

The traditional TCI value for a particular location is calculated as follows:

$$\mathrm{TCI} = 2(4CD + CA + 2R + 2S + W)$$

Equation 4.2: The globally accepted Tourism Climate Index Formula.

Where:

CD= Daytime Thermal Comfort
CA= Average Thermal Comfort
R= Total monthly Rainfall
S= Monthly Average Sunshine Hours
W= Monthly average Wind Speed

Table 4.5: The locations in the study that have a complete set of data across all the variables needed to calculate the TCI using the globally accepted method.

	Max Temp	Min Humidity	Mean Temp	Mean Humidity	Wind Speed	Total Rainfall	Sunshine Hours
Bethlehem	✓	✓	✓	✓	✓	✓	✓
Bloemfontein	✓	✓	✓	✓	✓	✓	✓
Cape Town	✓	✓	✓	✓	✓	✓	✓
East London	✓	✓	✓	✓	✓	✓	✓
Johannesburg	✓	✓	✓	✓	✓	✓	✓
Kimberley	✓	✓	✓	✓	✓	✓	✓
Port Elizabeth	✓	✓	✓	✓	✓	✓	✓
Polokwane	✓	✓	✓	✓	✓	✓	✓
Port Nolloth	✓	✓	✓	✓	✓	✓	✓

Daytime Thermal comfort (CD) and Average Thermal Comfort (CA) need to be calculated and given as effective temperature to meet the requirements listed in *Table 4.7*. This is calculated using the following formula:

$$\mathrm{ET} = \mathrm{Temperature} - 0.4 * (\mathrm{Temperature} - 10) * (1 - \frac{\mathrm{Humidity}}{100})$$

Equation 4.3: The formula used to calculate the effective temperature for daytime thermal comfort and average thermal comfort.

Where:

ET= Effective Temperature *Temperature*= The respective temperature variable used to calculate either CD or CA

Humidity= The respective humidity variable used to calculate either CD or CA

Using the traditional TCI formula, this study will calculate the long-term TCI score using this globally accepted TCI model for each of the specified locations (*Table 4.4*), and TCI scores for each month of the year across the dataset and each year of the study period. To achieve this, the raw data supplied by SAWs is cleaned and processed into the correct format so as to meet the requirements of the TCI formula (*Table 4.8).*

Table 4.6: The sub-indices within the globally accepted TCI formula and their weighting (Adapted from Perch-Nielsen *et al*., 2010 and Kovács and Unger, 2014).

Sub-index	Abbreviation	Climatic Variables Required	Weight (%)
Daytime Thermal Comfort	CD	Mean monthly maximum temperature (˚C) Mean monthly minimum relative humidity (%)	40
Average Thermal Comfort	CA	Mean monthly temperature (˚C) Mean monthly relative humidity (%)	10
Wind	W	Monthly average wind speed (km/h)	10
Rainfall	R	Total monthly rainfall (mm)	20
Sunshine	S	Daily Sunshine (hour)	20

Each sub-index is rated on a scale, with W, R and S being rated on a scale from 0 (unfavourable) to 5 (optimal) while CA and CD are rated on a scale from -3 to 5 (Mieczkowski, 1985; Perch-Nielsen *et al*., 2010; Kovács and Unger, 2014; Roshan *et al*., 2016). Each sub-index is weighted according to their perceived importance as stipulated by Mieczkowski (1985) (*Table 4.6*). The climate readings assigned to each of these scores are outlined in *Table 4.7* below, and the raw data will be filtered to meet these categories. The maximum potential value of the final TCI is 100 (Mieczkowski, 1985). A TCI value greater than 40 is considered acceptable, a good score is greater than 60 and an excellent score is considered to be greater than 80 (Roshan *et al*., 2016; *Table 4.7)*.

Table 4.7: Rating categories of the final score of the TCI (adapted from Perch-Nielsen *et al*., 2010).

TCI Score	Category	Mapping Category
90-100	Ideal	Ideal
80-89	Excellent	Excellent
70-79	Very Good	Very Good and 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	

Table 4.8: Rating scales for each of the sub-indices in the TCI (from Perch-Nielsen, 2010).

Rating	Effective Temperature (°C)	Mean monthly precipitation (mm)	Mean monthly sunshine hours ($h.d^{-1}$)	Wind speed ($km.h^{-1}$)			Wind ($W.m^{-1}.h^{-1}$)
				Normal	Trade wind	Hot climate	
5.0	20-26	0.0 to 14.9	>10	<2.88-5.75	12.24-19.79		
4.5	19	15.0 to 29.9	9	5.76-9.03	9.04-12.23		
	27				19.80-24.29		
4.0	18	30.0-44.9	8	9.04-12.23			<500
	28						
3.5	17	45.0-59.0	7	12.24-19.79	5.76-9.03		
	29				24.30-28.79		
3.0	16	60.0-74.9	6	19.80-24.29	2.88-5.75		500-625
	30						
2.5	10-15	75.0-89.9	5	24.30-28.79	<2.88		
	31				28.8-38.52		
2.0	5-9	90.0-104.9	4	28.8-38.52		<2.88	635-750
	32						
1.5	0-4	105.0 to 119.9	3			2.88-5.75	750-875
	33						
1.0	(-)5-(-)1	120.0 to 134.9	2			5.76-9.03	875-1000
	34						
0.5	35	135.0-149.9	1			9.04-12.23	1000-1125
0.25							1125-1250
0	>36	>150.0	<1	>38.52	>38.52	>12.24	>1250
	(-)10-(-)6						
-1.0	(-)15-(-)11						
-2.0	(-)20-(-)16						
-3.0	<(-)20						

4.2.4. Mathematically Adapted Tourism Climate Index Methodology

Further data constraints resulted in nine other locations (Table 4.8) having no sunshine hour data or cloud cover data. Consequently, the globally accepted TCI model could not be used for these locations due to the lack of data.

Table 4.9: The locations in the study that have no sunshine hour data or cloud cover data.

	Max Temp	Min Humidity	Mean Temp	Mean Humidity	Wind Speed	Total Rainfall	Sunshine Hours	Cloud Cover
Durban	✓	✓	✓	✓	✓	✓	X	X
Belfast	✓	✓	✓	✓	✓	✓	X	X
Knysna	✓	✓	✓	✓	✓	✓	X	X
Ladysmith	✓	✓	✓	✓	✓	✓	X	X
Nelspruit	✓	✓	✓	✓	✓	✓	X	X
Paarl	✓	✓	✓	✓	✓	✓	X	X
Pilanesberg	✓	✓	✓	✓	✓	✓	X	X
Pretoria	✓	✓	✓	✓	✓	✓	X	X
St Lucia	✓	✓	✓	✓	✓	✓	X	X

As a result, the traditional TCI formula (*Equation 4.1*) is mathematically adapted. This involved the proportional distribution of the 'S' variable of the equation across all the other variables in the equation.

$$\mathrm{TCI} = 2(5(CD) + 1.25(CA) + 2.5(R) + 1.25(W))$$

Equation 4.4: The mathematically adapted Tourism Climate Index Formula.

Where:

CD= Daytime Thermal Comfort
CA= Average Thermal Comfort
R= Total monthly Rainfall
W= Monthly average Wind Speed

Daytime Thermal comfort (CD) and Average Thermal Comfort (CA) need to be calculated and given as effective temperature in order to meet the requirements listed in *Table 4.7*. This is calculated using the formula listed under *Equation 4.2*.

Using this TCI formula (*Equation 4.3*), this study will calculate the long-term TCI score for each of the specified locations (*Table 4.8*), and TCI scores for each month of the year across the dataset and each year of the study period. To achieve this, the raw data supplied by SAWs is cleaned and processed into the correct format so as to meet the requirements of the mathematically adapted TCI formula (*Table 4.7).* The rating of the sub-indices remains the same, as does the maximum potential value. Categorisation of TCI scores is consistent with the traditional model.

Table 4.10: The sub-indices within the mathematically adapted TCI formula and their weighting (Adapted from Perch-Nielsen *et al*., 2010 and Kovács and Unger, 2014).

Sub-index	Abbreviation	Climatic Variables Required	Weight (%)
Daytime Thermal Comfort	CD	Mean monthly maximum temperature (˚C) Mean monthly minimum relative humidity (%)	50
Average Thermal Comfort	CA	Mean monthly temperature (˚C) Mean monthly relative humidity (%)	12.5
Wind	W	Monthly average wind speed (km/h)	12.5
Rainfall	R	Total monthly rainfall (mm)	25

In addition, this study will explore the trends of the TCI values over time, and the direction and magnitude of any change in the TCI values over the study period. This study will explore any changes in the TCI values for each location throughout the study period and will look for any changes on an annual, monthly and seasonal scale. The following procedures will be used to explore these trends and directional changes in the TCI values over the study period.

4.2.5. Tourism Climate Index using Rainfall as a Proxy for Sunshine Hours

The data constraints experienced during this study are constraints that many developing countries may experience. The lack of complete data can hinder the abilities of developing nations to apply and replicate studies that are conducted in regions where there are sufficient datasets. The ability to apply these studies to developing world contexts could allow for valuable knowledge to be gained in these regions. Therefore, this study decided to try and develop a TCI model that could still be used in the event of missing data. Due to the fact that there are many locations that do not have sunshine hours data or cloud cover data, this study decided to develop a model that would use rainfall as a proxy measure for sunshine hours and then use the globally accepted TCI formula to run the model.

The purpose of this exercise is to explore the potential for adapting the TCI to suit the needs of developing world contexts in the event that regions do not have complete datasets. The results of this method are not explicitly used in the study to answer the research questions. They are merely correlated to the TCI values obtained using the traditional TCI model to test how accurate this adapted method is at calculating the TCI values of locations.

For this method to work, a scale needed to be used to approximate the amount of monthly sunshine hours in that region based on its monthly rainfall. This scale is adapted from the original TCI model put forward by Mieczkowski (1985). The scale used to approximate sunshine hours based on the rainfall of a particular location is displayed in *Table 4.11*.

Table 4.11: The scale used to approximate sunshine hours based on the rainfall of a particular region, in the event that cloud cover data or sunshine hour data is not available.

Rainfall (mm)	Approximate Sunshine Hours
0.0 to 14.9	>10
15.0 to 29.9	9
30.0-44.9	8
45.0-59.0	7
60.0-74.9	6
75.0-89.9	5
90.0-104.9	4
105.0 to 119.9	3
120.0 to 134.9	2
135.0-149.9	1
>150.0	<1

Once the sunshine hours have been approximated, the TCI model can be run and the TCI for a particular location can be calculated. This rainfall proxy adaptation of the globally accepted TCI can be calculated using the formula developed by Mieczkowski (1985) and adapted by Perch-Nielsen *et al*. (2010) which stated below:

$$\mathrm{TCI} = 2(4CD + CA + 2R + 2S + W)$$

Equation 4.5: The formula used to calculate the rainfall proxy adaptation of the TCI model.

In order to calculate the rainfall proxy adapted TCI, the raw data supplied by SAWs is cleaned and processed into the correct format so as to meet the requirements of the above TCI formula (Table 4.7; Equation 4.4).

Each sub-index is rated on a scale, with W, R and being rated on a scale from 0 (unfavourable) to 5 (optimal) while CA and CD are rated on a scale from -3 to 5 (Mieczkowski, 1985; Perch-Nielsen *et al*., 2010; Kovács and Unger, 2014; Roshan *et al*., 2016). The climate readings assigned to each of these scores are outlined in *Table 4.8*, and the raw data will be filtered to meet these categories.

Table 4.12: Summary of the sub-indices within the globally accepted TCI formula and their weighting (Adapted from Perch-Nielsen *et al*., 2010 and Kovács and Unger, 2014).

Sub-index	Abbreviation	Climatic Variables Required	Weight (%)
Daytime Thermal Comfort	CD	Mean monthly maximum temperature (˚C) Mean monthly minimum relative humidity (%)	40
Average Thermal Comfort	CA	Mean monthly temperature (˚C) Mean monthly relative humidity (%)	10
Wind	W	Monthly average wind speed (km/h)	10
Rainfall	R	Total monthly rainfall (mm)	20
Sunshine	S	Approximated monthly sunshine (hour)	20

The maximum potential value of the final TCI that is calculated using the rainfall proxy adapted formula is 100 (Mieczkowski, 1985; Perch-Nielsen *et al*., 2010; Kovács and Unger, 2014). A TCI value greater than 40 is considered acceptable, a good score is greater than 60 and an excellent score is considered to be greater than 80 (Roshan *et al*., 2016*)*. The rating categories for the mathematically adapted TCI follows the same structure as the globally accepted TCI and can be seen in *Table 4.7.*

This adapted form of the traditional TCI could prove to be a useful and effective tool for developing countries that do not have access to complete and efficient weather datasets. However, this adaptation has a major limitation, which lies within the fact that it is self-referential. This could pose as a problem if there is ever a significant flaw identified in the original TCI model developed by Mieczkowski (1985) and adapted by Perch-Nielsen *et al*. (2010).

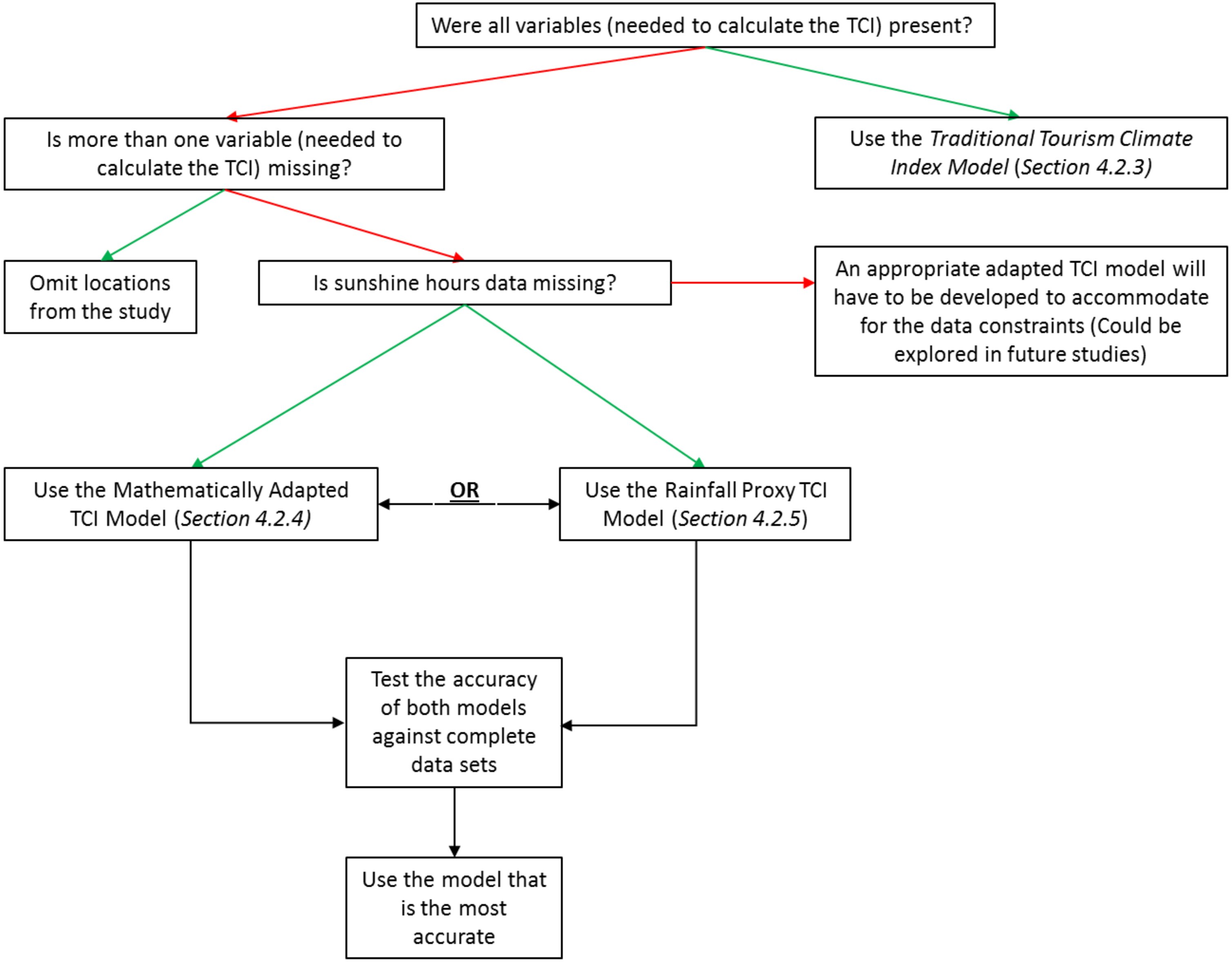


Figure 4.1. Determining the best suited TCI model to use (red arrows indicate 'no' and green arrows indicate 'yes').

4.2.6. Trends in the TCI Values over the Study Period

A study on climate variability and change and how this influences the climate suitability for tourism in various locations requires that there has been some change in the different climate variables and a change in the TCI values over the study period (Roshan *et al*., 2016). To identify the direction and strength of any trends or changes in the TCI scores over the study period, correlation analysis is used (Fitchett, 2013).

Correlation analysis identifies if there is a relationship between the independent variable, denoted as ‘y’ and the dependent variable, denoted as ‘x’ (Manly, 2009). In this study, TCI values are plotted over time and therefore, in this case, time acts as the independent variable, while TCI values act as the dependent variable. Through calculating the correlation coefficient, a value between -1 and +1 is obtained, and through this value the magnitude and direction of the change in the TCI values over time can be evaluated (Underhill and Bradfield, 2009). A correlation coefficient that is close to either -1 or +1 specifies that there is a steady change in the dependent variable over time (Underhill and Bradfield, 2009; Manly, 2009). A negative correlation coefficient in this study indicates that there is a decrease in the TCI value over time, while a positive correlation coefficient points toward an increase in TCI values over time (Palaniswamy & Palaniswamy, 2006). If a correlation coefficient value lies close to 0, there is an indication that either there is minimal change in the TCI values over time or that there is no observable pattern in the TCI values over time (Fitchett, 2013).

The Pearson correlation coefficients for the time trends of the TCI values is calculated using *Microsoft Excel*, using the following formula:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2(Y_i - \bar{Y})^2}}$$

(Underhill and Bradfield, 2009)

4.2.7. Magnitude of the Change in the TCI Values over the Study Period

After the trends in the TCI values over time have been demonstrated, it is important to identify the rate of change in TCI values of the study periods. To determine this, regression analysis was used. More specifically, linear regression will be used, which is a method of modelling the relationship between a dependent variable (y) and one or more independent variables- in this case time (Montgomery *et al*., 2012). Linear regression quantifies the rate of change of the dependent variable (TCI values). Linear regression is calculated:

$$y = ax + b$$

(Manly, 2009)

The equation for the linear regression line is calculated and produced by *Microsoft Excel* for all instances in which the rate of change in the TCI values of the study period are determined. The coefficient of x (which is denoted as 'a' in the above equation) provides an indication of the amount by which the dependent variable (TCI values) increases or decreases in response to a one-unit increase in the independent variable- the passing of one year (Fitchett, 2014). Identifying the rate of change will provide an indication of the amount and direction (positive or negative) to which the climate is changing in each location, from a tourism perspective. The results of the regression analysis are presented as a change in TCI values per year (TCI/yr).

4.2.8. Explanatory Power of the Independent Variable

It is important to consider the percentage by which changes in the independent variable (time) account for changes that occur in the dependent variable (TCI values). This is achieved through calculating the coefficient of determination (R^2):

$$R^2 = \frac{b\left(\sum XY - \frac{\sum X \sum Y}{N}\right)}{\left(\sum Y^2 - \frac{(\sum Y)^2}{2}\right)}$$

(Underhill and Bradfield, 2009; Fitchett, 2013)

This statistical tool provides a value that ranges between 0 and 1, and can be reported and presented as a percentage (Manly, 2009). Values closer to 1 represent that the majority of the change in the dependent variable is occurring as a result of changes in the independent variable (Underhill and Bradfield, 2009).

4.2.9. Calculating the Statistical Significance of the Findings

Once the strength and direction of any trends in the TCI values over time have been calculated and the amount by which TCI values are increasing or decreasing over time have been determined using the respective statistical tools, it is important to determine the statistical significance of these results. It is important to note that the larger the dataset, the higher the chance that a strong correlation calculation accurately reflects an existing strong relationship within the data (Fitchett, 2013). With regards to small datasets, the possibility that a set of values increase by chance rather than because of a larger pattern within the data is substantially higher (Fitchett, 2013).

The statistical significance of the results is measured through the calculation of the 'p value'. This value ranges from 0 to 1, with lower values increasing the chances that the results are a true indicator of the behaviour of the data for the study period (Underhill and Bradfield, 2009; Fitch, 2013). For the purpose of this study, a 'p value' that is less than 0.05 suggests that the results obtained from the above mentioned statistical procedures are statistically significant (Manly, 2009).

Furthermore, each component of the TCI will be compared for each location in order to determine groups in climate-tourism responses and to test whether there is any geographic explanation behind the clusters.

In the event that the test for linearity fails, the study will use non-linear regression and detrended component analysis. Furthermore, the TCI values will be mapped along with their net change over time, to graphically represent the change in TCI values over the study period.

4.3. Qualitative Materials and Methods

The purpose of including a qualitative component in the study is to identify how accurate the TCI is at detecting tourists' preferences of location, and to explore the responsiveness of tourists to climate change in South Africa. This, in turn, will explore the impacts it has on tourism. In order to achieve this, tourism researchers and academics were approached and asked to participate in an interview, to obtain the necessary data. The interview process followed an open and closed-ended semi-structured schedule.

The interview is split into two parts. The first part of the interview allowed the tourism researchers and academics to show which areas they perceive to have seen increases or decreases in tourism, and what those changes were caused by. Second, it allowed the tourism academics and researchers to express their perceptions about climate change in South Africa and how it is impacting tourism in the country (Reja *et al*., 2003).

Once the first part of the interview is completed, an in-depth interview will follow, took on the form of a discussion between the researcher and the tourism academic or researcher. This part of the interview will include providing the respondent with the TCI results from this study and showing them which locations, according to the Tourist Climate Index, are the most climatically suitable for tourism and how any change in climate is impacting the climate suitability of a particular location. The respondent will then be able to comment on how accurate the TCI values are for each location, based on their perception and comment on how big of a role they feel climate has on influencing tourism patterns in each location.

Each interview was recorded (with the consent of the participant) and later transcribed for the purpose of thematically analysing the perceptions of each organisation as to how tourism is changing in each location, what the reasons are for any change and what role climate change plays in terms of influencing tourism in each particular location. The thematic analysis will highlight what encourages or discourages people from certain locations and point out the effects of climate change on tourism in South Africa (Braun and Clarke, 2006).

Based on the data obtained from the questionnaires and interviews, the validity of TCIs is determined and commented on and thus provides insight into the role that climate change has on the tourism sector, and how accurate the Tourism Climate Index is as a quantitative measure of the suitability of a location's climate for tourism.

4.3.1. Acquisition of Qualitative Data

Data for this section of the study was collected from tourism researchers and academics in South Africa, who work out of different universities across the country. Tourism academics and researchers were selected as the subjects for interviewing, as these will be the first group of people to actively engage with TCI implementation and results. Tourism academics from a range of universities across South Africa, and working in positions ranging from PhD candidate to full professors were interviewed to attempt to obtain a wide ranging view.

4.3.1.1 Phase one of the Interview Process- Structured Close-Ended Questions

The first part of the interview process involves collecting data from each participant in the form of five short, close-ended questions. This first part of the interview process focuses on collecting information regarding any noticeable increases or decreases in tourism activity within the organisation over the study period, and what might have caused these changes in tourism activity and business for each location. Second, this initial part of the interview allowed participants to briefly express their perceptions about climate change in South Africa and how it is impacting tourism in the country. To obtain this information, participants will be asked the following five questions:

1. In your opinion which month/s of the year see the most tourists for each location?
2. Which locations have seen an increase in tourists over the last couple of decades (50 Years), and which have seen a decrease?
3. Which locations rely on the climate to attract tourists?
4. Which of these destinations are negatively impacted by climate?
5. Do you think any specific location should be concerned about climate change?

Close-ended questions allow the participant to express their perceptions briefly by indicating their response based on the list of answers made available to them (Reja *et al*., 2003). Although these questions were restrictive, it provides an opportunity for each participant to provide a direct answer to the questions. This allows for a direct comparison to be made across all of the organisations, based on their answers regarding their perceptions of climate change and how it is impacting the tourism industry. However, it is vital that the perceptions of these academics are explored in more detail, and therefore phase two of the interview process will use semi-structured, open-ended questions to explore these perceptions further.

4.3.1.2 Phase two of the Interview Process- Semi-Structured Open-ended Questions

Once participants complete the first phase of this process, they took part in a discussion, during which they are shown the actual TCI results from this study. These results give the academics an indication of which locations, according to the tourism climate index, are the most climatically suitable for tourism and how any change in the climate is impacting the climate suitability of a particular location. This phase of the interview process is conducted using a semi-structured schedule, during which the tourism academics and researchers are asked open-ended questions about the accuracy of the TCI values (which they validated, based on their own data, such as tourism numbers/occupancy numbers and traffic volumes etc.). The participants have the chance to comment on how big of a role they feel climate has on influencing tourism patterns in each location.

The open-ended nature of the questions in this phase of the interview process enables the researcher to gain a deeper insight into a participant's view and perception (Neuman, 1997). It allows the participant to answer the questions with more flexibility and express themselves in their own words (Vujovic, 2013). In so doing, the researcher has a greater chance of obtaining a more detailed understanding of the participant's perceptions regarding climate change and how it is impacting the tourism sector in South Africa. Therefore, this questioning style is best suited for this study.

Employing this semi-structured schedule during this phase of the interview is advantageous for a number of reasons. The use of formulated questions allowed the researcher to retain control over the interview process, and the information gathering process from participants (Bassey, 2006). Furthermore, the semi-structured schedule allowed the researcher to ask additional questions with regard to any interesting or unanticipated remarks that participants made to the formulated questions (Mitchell and Jolley, 2013). These follow-up questions gave the opportunity to gain further insight into the participant's perceptions surrounding climate change and how it is impacting the tourism industry (Hill *et al*., 2005).

Despite the numerous advantages of semi-structured interviews, there are some limitations. Namely, the fact that the follow-up questions that each of the participants are asked, are not standardised, which could lead to a data set that is not uniform and may make data analysis difficult (Mitchell and Jolley, 2013). Follow-up questions also open up the potential for personal bias from the researcher, regarding the decision to follow up on questions that they perceive to be more important than others (Mitchell and Jolley, 2013). This could result in the overall result of the interviews to be biased. Every effort is made during the interview process to remain unbiased and not tend towards selecting certain questions to follow up on.

4.3.2. Qualitative Data Analysis

To analyse the data obtained from the questionnaires, thematic content analysis is used. This method of analysing qualitative data is widely used and allows for a far greater account and understanding of the data (Braun and Clarke, 2006). Braun and Clarke (2006) stipulate that thematic analysis organises and describes the dataset in great detail. Furthermore, it identifies and analyses themes within the data to explore which themes are pertinent to answering some of the research questions (Harper and Thompson, 2011). By following the processes set forth by Braun and Clarke (2006), pertaining to thematic analysis, this study is able to ensure that this section is methodologically correct.

Table 4.13: The stages needed to conduct thematic analysis (Adapted from Braun and Clarke, 2006).

Stage	Brief Description of the Stage
Stage 1	The researcher becomes familiar with the data collected from the interviews
Stage 2	The researcher generates initial codes from the data
Stage 3	The codes are explored at a deeper level by the researcher and identifies potential themes and sub-themes from the generated codes
Stage 4	The researcher now explores the different themes more closely and decides on a more refined set of themes and sub-themes
Stage 5	The researcher then analyses these themes and ensures that the themes relate to the study
Stage 6	The researcher produces a report that that reflects the main findings of the analysis and how the data can aid in answering the research questions

Stage one requires that the researcher must actively engage and familiarise themselves with the dataset (Braun and Clarke, 2006). In order to do so, the researcher must consciously look for meanings and patterns in the data while they read through it. Braun and Clarke (2006) emphasise the need to become familiar with the data, to the point that the researcher is comfortable with the breadth and width of the content of the data. This stage is very important and forms the basis for the coding that takes place in the subsequent stages (Braun and Clarke, 2006). Stage two involves creating initial codes from the data. These codes highlight features of the data that appear most interesting to the researcher and the study (Braun and Clarke, 2006). This process of coding allows for the data to be organised into sections that are meaningful and relevant (Tuckett, 2005).

The third stage of thematic analysis begins once the researcher has completed the coding process, which was undertaken in stage two (Braun and Clarke, 2006). This stage requires the researcher to look more closely at the list of codes generated in stage two, and identify if there are any major broad themes that are emerging in the data (Braun and Clarke, 2006). This stage allows the researcher to gain an initial idea for the different themes and sub-themes within the data (Braun and Clarke, 2006). The fourth stage follows on from the identified themes in stage three and offers the researcher the opportunity to look more closely at the initial list of identified themes (Braun and Clarke, 2006). Ultimately, stage four allows the researcher to refine the themes so that any initial themes that do not have enough data to validate them are removed or moved into another set or various themes can be merged into one dominant theme (Braun and Clarke, 2006).

The fifth stage of this process requires the researcher to engage with and explore the themes at a deeper level (Braun and Clarke, 2006). This stage essentially gives the researcher the opportunity to develop a holistic and detailed understanding of each theme and how the data contributes to each theme (Vujovic, 2013). The sixth and final stage pertains to the final report write-up, and reflects the main findings related to the data that is collected and how this data can be effective in aiding in the research study (Braun and Clarke, 2006).

4.3.3. Ethical Considerations

As per the regulations of the University of the Witwatersrand, ethical clearance was obtained from the University's Ethics Committee before any interviews with organisations were carried out. Ethics clearance was granted for this study (*Appendix G*; Ethics Clearance Protocol Reference: H15/09/32).

Before interviews were conducted, all the components of the study, including the aims and purpose of the study and how the findings of the study will be published and used after the research is complete, were explained in detail to the participants. In addition, all participants were provided with an information participation sheet (*Appendix E*) which gave a detailed written explanation of all the details pertaining to the study. Furthermore, participants were asked to read and sign a formal letter of consent (*Appendix F*), which signified their agreement to participate and contribute to the study. All participants in this study were not classified as vulnerable and were all over the age of 18 years.

4.4. Conclusion

Tourism, on a global scale is one of the fastest growing sectors and has a significant role to play in many national and local economies. South Africa relies heavily on tourism as a means of promoting economic and social development within the country. It is therefore imperative that the relationship between climate change and tourism in South Africa is explored in detail. This would allow for policy makers and major tourism stakeholders to gain a deeper understanding of what impact climate change is having on tourism. To gain a deeper understanding of the relationship between climate change and tourism, certain methodologies need to be followed.

The methodology used in this study followed a mixed methods approach. The quantitative aspect of the methodology dealt with calculating the Tourism Climate Index for the various study sites on an annual and monthly scale, using the globally accepted TCI model originally developed by Mieczkowski (1985) and adapted by Perch-Nielsen *et al*. (2010). In addition, the study made use of a mathematically adapted TCI model for locations that had insufficient data to meet the requirements of the globally accepted TCI model. Furthermore, this section explored changes in the TCI values over time for each location, using correlation and linear regression analysis.

The qualitative section employed an open and closed-ended semi-structured interview style. This style allowed various organisations to communicate their perceptions of climate change and tourism in South Africa. Furthermore, it enabled the organisations to comment on the accuracy of the tourism climate index based on their own organisational data. The data obtained through these interviews was analysed using thematic analysis. This method of analysis identifies and analyses themes within the data to explore which themes are pertinent to answering some of the research questions.

By combining and utilising the results conjunctly, the validity of TCIs can be determined and commented on and thus providing insight into the role that climate change has on the tourism sector and how accurate the Tourism Climate Index is as a quantitative measure of the suitability of a location's (across South Africa) climate for tourism. In addition, this methodology allows for the accuracy of the Tourism Climate Indices in detecting tourists' behavioural responses to climate change in South Africa to be explored.

Chapter 5: Results

5.1. Introduction

The findings of this study are presented in this chapter. This chapter is split into two main sections, with each section presenting the results obtained under the different methodological approaches. The quantitative section presents the TCI scores calculated for each of the chosen study sites. This section will include the results of the mean annual TCI scores for the period 2005-2014 for each location and the mean monthly TCI scores, and will present the longest continuous TCI mean (based on the longest continuous time period for each location). The mean TCI scores that range from 2005 to 2014 will be considered the primary TCI results for this study, while the longest continuous TCI mean of each location will be presented to compare any interesting findings against those ranging from 2005-2014. The purpose of using the study period of 2005 to 2014 is that first, data restrictions did not allow for a longer set of uniform data across each location to be obtained and second, it allows for the averages of each location to be compared to each other, and thus allows for appropriate and uniform analysis across different locations. Lastly, the quantitative section will present the results of the time trend analysis of the TCI scores over time for both the periods of 2005-2014 and for the longest continuous time periods for each location. The qualitative section of this chapter presents the results that were obtained during the interviews with the tourism academics and researchers. This section will be split into sub-sections, each of which will represent a different theme that was highlighted during the interview process.

5.2. Tourism Climate Index Results

The TCI used in this study was originally developed by Mieczkowski (1985). The TCI was formulated to incorporate all three aspects of climate that are relevant to tourism, and to quantify the effects of climatic conditions on tourism (Mieczkowski, 1985; Amelung *et al*., 2007), and originally formulated to incorporate 12 climate variables, but this was later reduced to seven climate variables due to restrictions in commonly available data (Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014). The TCI is scaled according to the comfort required for the most common tourist activities such as beach and water activities, game viewing and other activities that involve low to moderate levels of physical effort (Amelung and Nicholls, 2014). The TCI was chosen for this study due to the fact that it has been widely used in international studies (Scott *et al*., 2004; Amelung and Viner, 2006; Amelung *et al*., 2007; Amelung and Nicholls, 2014; Kovács and Unger, 2014; Grant, 2015). Furthermore, the climate variables needed to calculate the TCI are standard meteorological variables and thus are generally captured by weather stations around the globe.

The TCI results are split into two sub sections: Traditional TCI results and mathematically adapted TCI results. This is primarily due to data constraints where all the study sites did not have adequate data to allow for the use of the traditional TCI.

5.2.1. Traditional Tourism Climate Index

5.2.1.1. Long Term Averages

The TCI scores that will be presented will predominantly focus on the time period of 2005-2014, as this was the longest set of uniform data across all the study sites. Using this time period enables a direct comparison and effective analysis to be made across each location, based on their long-term climate suitability for tourism. However, this only indicates that climate change may be affecting the TCI scores, as the data period is to short. In these instances, continued monitoring is strongly advised to determine if such trends persist. In addition, the longest continuous TCI mean for each location based on their longest continuous set of data, will be presented to supplement the results for the period 2005-2015, and to provide climate change analyses.

The mean annual TCI scores (*Table 5.1*) for the respective study sites range from 76.5 (very good) for Port Nolloth to 86.8 (excellent) for Polokwane. All the locations demonstrate scores in the excellent rating category, except for East London and Port Nolloth, which were classified under very good. Port Nolloth and East London each demonstrate a TCI score of 76.5 and 79.2 respectively. Interestingly, East London and Port Nolloth, which are both coastal locations, have been categorized as having a very good climatic suitability for tourism, while the two other coastal locations of Cape Town (83.5) and Port Elizabeth (80.20) have been categorized as having excellent climatic conditions for tourism. However, it is important to note that the TCI score difference between East London and Port Elizabeth is only one-unit score. Due to their relative geographical proximity and similar TCI, their climate suitability could be considered relatively similar, as opposed to being categorized into two significantly different categories.

Tourists in East London and Port Elizabeth taking part in nature-based and coastal tourism would have very good and excellent climatic conditions respectively for these types of tourist activities. In addition, the tourists in the remaining locations who take part in activities such as adventure tourism and leisure tourism activities, would have excellent climatic conditions to do so.

Table 5.1: Long-term annual average traditional TCI from 2005 to 2015 for various locations throughout South Africa.

Location	Long-term Average	Classification
Bethlehem	80.90	Excellent
Bloemfontein	84.00	Excellent
Cape Town	83.50	Excellent
East London	79.20	Very Good
Johannesburg	85.20	Excellent
Kimberley	87.40	Excellent
Polokwane	86.80	Excellent
Port Elizabeth	80.20	Excellent
Port Nolloth	76.50	Very Good

The longest continuous TCI mean for the longest continuous data set for each location (*Table 5.2*) range from 76.5 (very good) for Port Nolloth to 88.20 (excellent) for Kimberley. Comparing the annual TCI mean for the period 2005-2014 to the longest continuous mean for each of the locations, it can be seen that the climate suitability of each location has remained constant in terms of classification in the rating categories. However, there are slight, but noticeable increases or decreases in the annual average TCI scores across the different time scales.

The mean monthly traditional TCI scores, for both times periods at each location, highlight a general pattern, with the majority of the locations experiencing excellent to ideal climatic conditions for tourism during the summer months of the year (*Table 5.3*). However, East London experiences relatively lower TCI scores that range from 68 (good) for October to 79.3 (very good) for January for most of the year during both time periods. It is important to note that all the coastal cities such as East London, Port Elizabeth and Port Nolloth, with the exception of Cape Town, all experience longer periods during the middle of the year of good to very good climatic conditions for tourism, whereas the other locations only experience a dip in the climatic conditions for tourism during the autumn and winter months of the year.

Table 5.2: Long-term annual average traditional TCI for the longest continuous time period for each location.

Location	Long-term Average	Classification
Bethlehem (1981-2014)	80.35	Excellent
Bloemfontein (1992-2014)	85.39	Excellent
Cape Town (1966-2014)	81.59	Excellent
East London (1959-2014)	77.50	Very Good
Johannesburg (1992-2014)	84.48	Excellent
Kimberley (1959-2014)	88.20	Excellent
Polokwane (1993-2014)	86.64	Excellent
Port Elizabeth (1959-2014)	80.05	Excellent
Port Nolloth (1999-2014)	76.50	Very Good

The traditional TCI scores for Cape Town during the months of December to March demonstrate ideal climate conditions, with the TCI ranging from 93.12 for March to 96.5 for January. Despite these ideal climatic conditions during the summer months, Cape Town winters (particularly in June and July) are categorized as having acceptable climate conditions for tourism, with TCI scores ranging from 56.16 for July to 59.20 for August over both time periods (*Table 5.3*). This can be attributed to the winter rainfall and to a significant decrease in temperature during this time of the year. The drop in climatic suitability in Cape Town during the winter months is relatively worse than other locations due to the fact that there are multiple factors (increased rainfall and decreased temperatures) acting at the same time, whereas in other locations there is generally only one factor acting to influence the climatic suitability.

During the period 2005-2014 in Polokwane, the monthly TCI scores indicate that the majority of the year, except for November and December, had excellent to ideal climate conditions for tourism. Interestingly, in May, the start of winter, and during September, the start of spring, Polokwane had the most ideal climate conditions with TCI scores of 90.00 and 92.9 respectively for each month. These results indicate that the nature-based and adventure based tourism market in that region may benefit from excellent to ideal climate conditions for the majority of the year, even during off-peak tourism periods.

Table 5.3: Mean monthly traditional TCI scores for the period 2005-2014 and the longest continuous monthly mean TCI scores for each location.

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Bethlehem												
2005-2014	Average	74.90	82.60	83.10	81.80	78.00	68.40	71.00	76.90	86.40	80.70	78.50	77.40
1981-2014	Average	79.41	81.35	81.44	82.24	77.50	69.53	70.85	75.35	83.21	78.21	79.38	79.50
	Bloemfontein												
2005-2014	Average	83.60	84.50	86.30	85.00	82.50	69.20	74.70	79.60	90.70	87.80	83.50	85.30
1992-2014	Average	83.55	85.27	83.64	86.05	82.87	72.00	74.17	79.35	88.96	86.52	84.22	85.43
	Cape Town												
2005-2014	Average	96.50	96.40	94.10	85.70	66.10	56.20	57.40	59.20	70.10	85.10	88.40	95.10
1966-2014	Average	95.71	95.94	93.12	84.08	67.73	56.48	56.16	60.06	70.49	82.23	89.71	93.94
	East London												
2005-2014	Average	79.20	80.20	82.70	77.50	79.30	72.20	73.40	72.60	77.50	68.00	73.60	78.50
1959-2014	Average	80.59	80.44	80.06	78.87	77.41	72.96	71.62	69.84	69.69	69.31	74.84	80.84
	Johannesburg												
2005-2014	Average	79.20	87.30	82.22	80.30	80.60	75.60	76.00	82.80	87.11	86.89	85.67	78.33
1992-2014	Average	80.00	84.09	82.82	83.26	80.36	74.43	74.70	81.09	86.36	85.09	83.73	79.95
	Kimberley												
2005-2014	Average	83.80	84.20	88.30	86.50	83.10	72.10	75.80	82.00	90.10	89.00	89.80	90.50
1959-2014	Average	86.95	86.36	86.61	85.84	82.58	73.55	73.98	81.35	88.89	89.13	90.50	90.02
	Polokwane												
2005-2014	Average	84.30	89.50	85.70	86.30	90.00	84.60	81.20	86.20	92.90	86.80	79.00	78.80
1993-2014	Average	83.00	86.77	85.64	87.95	88.77	82.23	79.50	85.45	91.00	86.77	78.86	80.27
	Port Elizabeth												
2005-2014	Average	89.80	86.20	85.70	80.60	73.70	66.50	67.40	70.80	75.50	72.30	81.50	86.10
1959-2014	Average	89.16	88.14	85.86	81.79	75.20	68.79	69.34	68.18	71.43	73.91	81.57	87.77
	Port Nolloth												
2005-2014	Average	87.50	87.40	83.60	78.00	70.50	68.00	71.00	67.70	71.50	74.20	80.40	87.10
1999-2014	Average	86.50	86.81	83.38	77.13	70.50	69.40	70.63	67.94	70.94	74.00	80.43	85.57

The monthly TCI scores for Bloemfontein, across both time periods, indicate that the majority of the year (excluding winter- May, June and July) have excellent climate conditions for tourism (*Table 5.3*). Therefore, individuals will be able to take part in adventure tourism activities under excellent climate conditions.

Looking at the two different time periods for each location, it can be seen that the monthly TCI averages remain fairly similar in terms of classification into the rating categories, but there are slight variations in the actual TCI.

5.2.1.2. Traditional Tourism Climate Index Time Trends

Correlation analysis allowed for the relationship between TCI scores and time to be determined for each of the study sites (Manly, 2009). The correlation analysis highlighted the direction and strength of the relationship between TCI scores and time for each of the respective locations. Once a significant trend was identified between the two variables (TCI and time), regression analysis was used to determine the rate of change in TCI scores for the study period (Montgomery *et al*., 2012). Due to the increased threat of climate change, and the heavy reliance on the natural environment and climate for tourism in South Africa (Falk *et al*., 2014; Roshan *et al*., 2016; Rosselló-Nadal, 2014), it is important to have an understanding of how tourism is influenced by climate variation and change and therefore it is imperative that the direction and magnitude of the change in the TCI at different locations for the maximum possible time period is documented and analysed to detect early signs of progressive changes in climatic conditions and their suitability for tourism. Climate change analysis ideally requires data periods of greater than 30 years, and therefore analyses for data periods for shorter than this are tentative in nature and reflect progressive climate variability rather than climate change. The use of the common period does, however, facilitate the comparison of discretion and strength of trend between each of the towns.

For the period 2005-2014, the annual TCI score in Port Nolloth demonstrates a highly statistically significant positive trend, with a correlation coefficient of 0.76 ($p<0.005$) (*Table 5.4*). This trend equates to an increase in the TCI score of 0.93units/yr (*Table 5.4*). *A*n interesting 2-year cycle is apparent in the TCI scores for Port Nolloth, during the period 2005-2014(*Figure 5.1*). This trend is predominantly controlled by fluctuations in the day time thermal comfort (CD), which incorporates mean monthly maximum temperature (˚C) and mean monthly minimum relative humidity (%) to obtain an effective temperature (˚C) which is then used to run the TCI model.

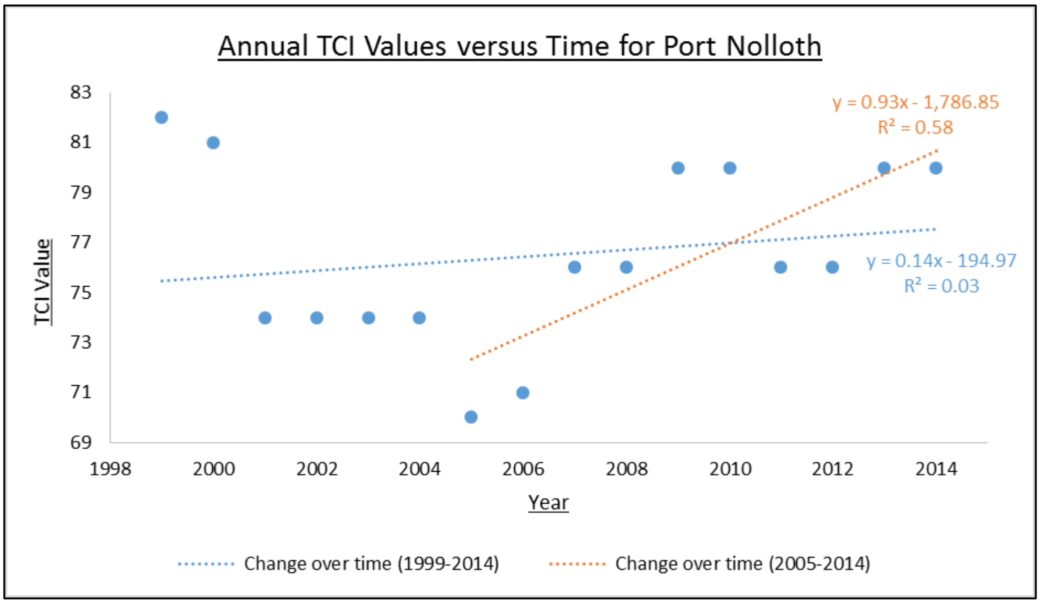


Figure 5.1: The correlation between annual traditional TCI scores for Port Nolloth and time for the period 2005-2014 and 1999-2014.

In contrast, insignificant trends in annual TCI scores for the period 2005-2014, are demonstrated at Bethlehem, Bloemfontein, Cape Town, East London and Kimberley, with correlation coefficients of -0.55 (p=0.20), 0.09 (p=0.40), -0.18 (p=0.30), 0.11 (p=0.30), and -0.32 (p=0.20) respectively (*Table 5.4*). Although statistically insignificant, the annual TCI scores for the period 2005-2014, in Johannesburg (r=0.41; p=0.10), Polokwane (r=-0.39; p=0.10) and Port Elizabeth (r=-0.47; p=0.10) have slightly stronger correlation coefficients then the other locations that are considered statistically insignificant for the same time period (*Table 5.4*).

Table 5.4: Statistical values representing the correlation between annual traditional TCI and time for the various locations throughout South Africa from 2005-2014.

Location (Time Period)	Rate of Change (TCI Score/per year)	R^2 Value	r-value	p-value	Significance
Bethlehem	-0.54	0.30	-0.55	0.20	Non-Significant
Bloemfontein	0.08	0.01	0.09	0.40	Non-Significant
Cape Town	-0.18	0.03	-0.18	0.30	Non-Significant
East London	0.15	0.01	0.11	0.40	Non-Significant
Johannesburg	0.35	0.35	0.41	0.10	Non-Significant
Kimberley	-0.28	0.10	-0.32	0.20	Non-Significant
Polokwane	-0.18	0.15	-0.39	0.10	Non-Significant
Port Elizabeth	-0.51	0.17	-0.47	0.10	Non-Significant
Port Nolloth	0.93	0.58	0.76	0.005	Significant

The annual TCI trends over longer periods at each location are considerably different when compared to the trends demonstrated over the shorter time period from 2005-2014. The annual TCI scores for the period 1999-2014 at Port Nolloth demonstrate a statistically insignificant positive trend, with a 0.14units/yr increase in the TCI score ($r=0.18$; $p=0.2$; *Table 5.5*). Over a longer time period (1966-2014), the annual TCI score in Cape Town demonstrates a highly statistically significant positive trend with a correlation coefficient of 0.34 ($p=0.005$) (*Table 5.5*). This trend results in an annual increase of 0.08 units in the TCI score for Cape Town over this same period. In addition, East London and Johannesburg demonstrate statistically significant positive trends in their TCI scores over the periods 1959-2014 and 1992-2014 respectively. The positive trend in East London has a correlation coefficient of 0.55 ($p=0.0005$) and equates to a 0.11units/yr increase in the TCI score over the period 1959-2014. For the period 1992-2014 in Johannesburg, the annual TCI score increased at a statistically significant rate of 0.20units/yr ($r=0.34$; $p\leq0.05$; *Table 5.5*). The annual TCI trends over time in Bethlehem (1981-2014), Bloemfontein (1992-2014), Kimberley (1959-2014), Polokwane (1993-2014) and Port Elizabeth (1959-2014) remained insignificant over the longer time periods (*Table 5.5*).

Table 5.5: Statistical values representing the correlation between annual traditional TCI scores and time for the various locations throughout South Africa, using the longest continuous time period for each location.

Location (Time Period)	Rate of Change (TCI score/per year)	R^2 Value	r-value	p-value	Significance
Bethlehem (1981-2014)	0.05	0.03	0.16	0.20	Non-Significant
Bloemfontein (1992-2014)	-0.03	0.01	-0.07	0.40	Non-Significant
Cape Town (1966-2014)	0.08	0.11	0.34	0.005	Significant
East London (1959-2014)	0.11	0.21	0.55	0.0005	Significant
Johannesburg (1992-2014)	0.20	0.12	0.34	0.05	Significant
Kimberley (1959-2014)	-0.0	0.00	0.01	0.40	Non-Significant
Polokwane (1993-2014)	0.06	0.02	0.15	0.20	Non-Significant
Port Elizabeth (1959-2014)	0.01	0.00	0.07	0.30	Non-Significant
Port Nolloth (1999-2014)	0.14	0.03	0.18	0.20	Non-Significant

For the period 2005-2014 in Bethlehem, the TCI scores for July and December reveal a strong negative trend, with each month demonstrating a statistically significant correlation coefficient of -0.74 (p=0.005) and -0.66 (p=0.025) respectively. These trends equate to monthly decreases in the TCI scores of 0.70units/yr for July and 1.44units/yr for December (*Table 5.6*). The negative trend demonstrated by the TCI scores in December is influenced by rain, with an average monthly rainfall of 113.01mm in December in Bethlehem from 2005-2014. The same negative trends in the TCI scores exist in Bethlehem during January and December over the period 1981-2014, with correlation coefficients of -0.33 (p=0.025) and -0.31 (p=0.025). Both these trends reveal decreases in the TCI scores of 0.26units/yr for January and 0.21units/yr for December (*Table 5.6*). The TCI for October in Bethlehem during the period 2005-2014 and 1981-2014 reveal a positive trend with both demonstrating a statistically significant correlation coefficient of 0.54 (p=0.05) and 0.36 (p=0.025) respectively.

Located within the same province, and within relative proximity of each other, the TCI trends observed in Bloemfontein for the month of October are very similar to those demonstrated in Bethlehem. The monthly TCI in Bloemfontein for October for the period 2005-2014 and 1992-2014 reveals positive trends that equate to an increase in the monthly TCI score of

0.92units/yr (r=0.54; p=0.05) and 0.36units/yr (r=0.42; p=0.025) respectively over both periods (*Table 5.6*).

With tourism in Cape Town being the busiest during the summer months from October to January, it is interesting to see a positive trend in the monthly TCI score for January, October and December for the period 1966-2014 (*Table 5.6*). These trends equate to increase in the TCI scores of 0.05units/yr (r=0.31; p=0.01) for January, 0.10units/yr (r=0.22; p=0.05) for October and 0.05units/yr (r=0.29; p=0.025) for December. (*Table 5.6*). For the period 1959-2014, the monthly TCI score in East London reveal interesting trends over various months. During the winter months of May and July in East London for the period 1959-2014, the TCI demonstrates a positive trend that reveals an increase in the monthly TCI scores of 0.26units/yr (r=0.47; p=0.0005) and 0.14units/yr (r=0.25; 0.05) respectively (*Table 5.6*). In direct contrast to this, the summer months of January and December in East London (which are busy tourist periods for this area) for the period 1959-2014, reveals statistically significant negative trends in the monthly TCI. These negative trends demonstrate a decrease in the monthly TCI scores of 0.08units/yr (r=-0.20; p=0.05) for January and 0.11units/yr (r=-0.26; p=0.11) for December (*Table 5.6*).

For the period 2005-2014 in Kimberley, the monthly TCI scores demonstrate a statistically significant negative trend for the months June, July and September, with correlation coefficients of -0.58 (p=0.05), -0.64 (p=0.025) and -0.63 (p=0.025; *Table 5.6*). These trends suggest monthly TCI score decreases of 0.93units/yr for June, 1.01units/yr for July and 0.52units/yr for September (*Table 5.6*). The negative monthly TCI trends demonstrated in June, July and September are predominantly driven by decreasing effective temperatures (CA-Mean monthly temperature (˚C) and mean monthly relative humidity (%)).

Nature-based tourism is one of the predominant tourism activities in the Polokwane region. It is, therefore, of concern that the monthly TCI scores for the month of January in this region demonstrate a considerable decrease (r=-0.72; p=0.01). This decrease equates to a reduction in the monthly TCI of 1.56units/year over the period 2005-2014 (*Table 5.6*). The decrease was strongly driven by large amounts of rain in the region during January for the period 2005-2014. In contrast, for the same time period in Polokwane, the monthly TCI scores for February demonstrate a statistically significant positive trend, with a correlation coefficient of 0.52

(p=0.05; *Table 5.6*). This trend suggests an increase of 1.46units/yr for the monthly TCI scores in February. The increase in the monthly TCI score for February is influenced by a decrease in rainfall for that month from the previous month, with a 19.18mm decrease in average rainfall from January to February during the period 2005-2014.

Data for the period 2005-2014 in Port Elizabeth, reveals a statistically significant decrease in monthly TCI scores for April and July of 0.87units/year (r=-0.51; p=0.001) and 1.78units/yr (r=-0.54; p=0.05) respectively (*Table 5.6*). In both instances, the TCI score was influenced by rain over those months with a monthly average rainfall of 55.96mm for April and 53.04mm for July, over the period 2005-2014. Port Elizabeth receives the least amount of rainfall during January, and this holds true for the period 2005-2014, where Port Elizabeth received a monthly average 27.72mm of rain for January. As a result, the monthly TCI for January during the period 2005-2014 reveals a statistically significant positive trend, with a correlation coefficient of 0.84 (p=0.001; *Table* 5.6). This trend equates to an increase in the monthly TCI score of 1.24units/yr for January. With January being a busy tourism period in Port Elizabeth, this increase in climate suitability for tourism will be beneficial to all the beach and nature-based tourists.

The climate suitability for tourism in Port Nolloth for the period 2005-2014 reveals significant increases during the months of February, April and November. The statistically significant increase in the monthly TCI scores reveal correlation coefficients of 0.61 (p=0.025) for February, 0.71 (p=0.01) for April and 0.75 (p=0.025) for November (*Table 5.6*). These positive trends equate to an increase in the monthly TCI score of 0.85units/yr for February, 1.89units/yr for April and 1.18units/yr for November (*Table 5.6*).

Table 5.6: Correlation between mean annual traditional TCI scores and time and the correlation between the longest continuous mean annual TCI scores for the various locations throughout South Africa. Highlighted cells represent statistically significant trends.

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Bethlehem												
2005-2014	Strength of Trend (r)	-0.09	0.32	0.14	-0.06	0.09	-0.06	-0.74	-0.11	-0.34	0.54	0.21	-0.66
	Rate of Change (unit/yr)	-0.20	0.79	0.21	-0.13	0.18	-0.08	-0.70	-0.24	-0.82	1.52	0.43	-1.44
	R^2	0.01	0.10	0.02	0.00	0.01	0.00	0.55	0.01	0.11	0.29	0.04	0.44
	p- value	0.40	2.00	0.30	0.40	0.40	0.40	0.005	0.30	0.20	0.05	0.30	0.025
1981-2014	Strength of Trend (r)	-0.33	0.02	0.16	0.03	-0.12	-0.07	0.01	0.16	0.12	0.36	-0.01	-0.31
	Rate of Change (unit/yr)	-0.26	0.01	0.09	0.03	-0.08	-0.03	0.00	0.11	0.11	0.28	0.00	-0.21
	R^2	0.11	0.00	0.02	0.00	0.01	0.01	0.00	0.03	0.02	0.13	0.00	0.10
	p- value	0.025	0.40	0.20	0.40	0.20	0.30	0.40	0.20	0.20	0.025	0.40	0.025
	Bloemfontein												
2005-2014	Strength of Trend (r)	0.44	0.01	0.23	0.39	0.30	-0.26	-0.34	0.04	-0.31	0.54	0.03	-0.44
	Rate of Change (unit/yr)	1.35	0.02	0.47	0.85	0.75	-0.63	-0.41	0.07	-0.18	0.92	0.08	-1.01
	R^2	0.20	0.00	0.05	0.15	0.09	0.07	0.11	0.00	0.10	0.29	0.00	0.20
	p- value	0.44	0.40	0.30	0.10	0.20	0.20	0.20	0.40	0.20	0.05	0.40	0.10
1992-2014	Strength of Trend (r)	0.19	-0.03	0.28	-0.12	-0.05	-0.40	0.03	0.03	0.03	0.42	-0.01	-0.16
	Rate of Change (unit/yr)	0.24	-0.04	0.30	-0.12	-0.04	-0.37	0.02	0.02	0.02	0.36	-0.01	-0.17
	R^2	0.04	0.00	0.08	0.01	0.00	0.16	0.00	0.00	0.00	0.18	0.00	0.03
	p- value	0.20	0.40	0.10	0.30	0.40	0.025	0.40	0.40	0.40	0.025	0.40	0.20

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Cape Town												
2005-2014	Strength of Trend (r)	0.06	-0.24	-0.61	0.60	0.50	-0.42	0.14	-0.12	-0.32	-0.09	0.05	0.58
	Rate of Change (unit/yr)	0.02	-0.11	-0.43	0.83	0.93	-0.82	0.45	-0.32	-1.02	-0.15	0.06	0.25
	R^2	0.00	0.06	0.37	0.36	0.25	0.17	0.02	0.02	0.10	0.01	0.00	0.34
	p- value	0.40	0.20	0.025	0.025	0.10	0.10	0.30	0.30	0.20	0.40	0.40	0.05
1966-2014	Strength of Trend (r)	0.31	0.14	0.05	0.17	0.06	0.03	0.04	-0.06	0.01	0.22	-0.09	0.29
	Rate of Change (unit/yr)	0.05	0.02	0.01	0.08	0.03	0.02	0.03	-0.03	0.00	0.10	-0.03	0.05
	R^2	0.10	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.08
	p- value	0.01	0.20	0.30	0.10	0.30	0.40	0.40	0.30	0.40	0.05	0.30	0.025
	East London												
2005-2014	Strength of Trend (r)	0.63	0.31	-0.27	-0.13	0.26	-0.12	-0.30	0.32	0.41	-0.46	0.37	-0.46
	Rate of Change (unit/yr)	1.30	0.68	-0.58	-0.32	0.79	-0.35	-0.96	0.88	0.92	-1.82	1.14	-1.06
	R^2	0.40	0.10	0.07	0.02	0.07	0.01	0.09	0.11	0.17	0.21	0.14	0.21
	p- value	0.025	0.20	0.20	0.30	0.20	0.30	0.20	0.20	0.10	0.10	0.10	0.10
1959-2014	Strength of Trend (r)	-0.20	0.02	0.13	0.17	0.47	0.13	0.25	0.17	0.37	0.14	0.07	-0.26
	Rate of Change (unit/yr)	-0.08	0.01	0.06	0.09	0.26	0.06	0.14	0.09	0.19	0.08	0.03	-0.11
	R^2	0.04	0.00	0.02	0.03	0.22	0.02	0.06	0.03	0.14	0.02	0.01	0.07
	p- value	0.05	0.40	0.20	0.10	0.0005	0.20	0.05	0.10	0.00	0.20	0.30	0.025

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Johannesburg												
2005-2014	Strength of Trend (r)	0.36	0.28	0.43	-0.29	0.58	0.26	0.20	0.29	0.05	0.21	-0.06	-0.44
	Rate of Change (unit/yr)	1.03	0.58	1.05	-0.87	1.48	0.42	0.23	0.33	0.13	0.54	-0.15	-0.69
	R^2	0.13	0.08	0.18	0.08	0.33	0.07	0.04	0.08	0.00	0.04	0.00	0.19
	p- value	0.20	0.20	0.10	0.20	0.05	0.20	0.30	0.20	0.40	0.30	0.40	0.10
1992-2014	Strength of Trend (r)	0.18	0.31	0.06	-0.28	0.16	0.24	0.31	0.47	-0.06	0.34	0.40	0.00
	Rate of Change (unit/yr)	0.25	0.39	0.08	-0.37	0.18	0.16	0.14	0.31	-0.07	0.35	0.44	0.00
	R^2	0.03	0.10	0.00	0.08	0.03	0.06	0.10	0.22	0.00	0.12	0.16	0.00
	p- value	0.20	0.10	0.40	0.10	0.20	0.10	0.10	0.01	0.40	0.05	0.025	0.40
	Kimberley												
2005-2014	Strength of Trend (r)	0.06	-0.10	0.10	0.18	0.05	-0.58	-0.64	-0.27	-0.63	0.44	0.07	-0.43
	Rate of Change (unit/yr)	0.13	-0.28	0.14	0.35	0.10	-0.93	-1.01	-0.45	-0.52	0.73	0.08	-1.02
	R^2	0.00	0.01	0.01	0.03	0.00	0.33	0.41	0.07	0.40	0.20	0.01	0.19
	p- value	0.40	0.40	0.40	0.30	0.40	0.05	0.025	0.20	0.025	0.10	0.40	0.10
1959-2014	Strength of Trend (r)	-0.16	-0.15	0.01	0.31	0.37	0.13	0.19	0.18	-0.15	0.07	0.07	-0.15
	Rate of Change (unit/yr)	-0.07	-0.07	0.01	0.14	0.15	0.04	0.05	0.06	0.05	0.02	0.02	-0.06
	R^2	0.03	0.02	0.00	0.09	0.14	0.02	0.03	0.03	0.02	0.00	0.00	0.02
	p- value	0.10	0.10	0.30	0.01	0.003	0.20	0.10	0.10	0.10	0.30	0.30	0.10

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Polokwane												
2005-2014	Strength of Trend (r)	-0.72	0.52	0.13	-0.31	0.01	-0.01	-0.51	-0.12	-0.02	-0.27	0.63	-0.17
	Rate of Change (unit/yr)	-1.56	1.46	0.26	-0.88	0.01	-0.01	-0.56	-0.17	-0.02	-0.64	1.12	-0.40
	R^2	0.51	0.27	0.02	0.10	0.00	0.00	0.26	0.01	0.00	0.07	0.40	0.03
	p- value	0.01	0.05	0.40	0.20	0.40	0.40	0.05	0.40	0.40	0.20	0.025	0.30
1993-2014	Strength of Trend (r)	0.03	0.27	0.09	-0.19	0.29	0.26	0.18	0.23	0.40	-0.03	0.20	-0.13
	Rate of Change (unit/yr)	0.03	0.41	0.09	-0.20	0.20	0.20	0.10	0.15	0.20	-0.02	0.18	-0.13
	R^2	0.00	0.08	0.01	0.04	0.08	0.07	0.03	0.05	0.16	0.00	0.04	0.02
	p- value	0.40	0.10	0.30	0.20	0.10	0.10	0.20	0.20	0.03	0.40	0.20	0.20
	Port Elizabeth												
2005-2014	Strength of Trend (r)	0.84	-0.16	-0.06	-0.51	0.20	-0.43	-0.54	0.00	-0.36	-0.30	-0.17	-0.47
	Rate of Change (unit/yr)	1.24	-0.21	-0.10	-0.87	0.66	-1.41	-1.78	0.00	-0.65	-1.04	-0.43	-0.59
	R^2	0.70	0.03	0.00	0.26	0.04	0.18	0.29	0.00	0.13	0.09	0.03	0.22
	p- value	0.001	0.30	0.40	0.05	0.30	0.10	0.05	-	0.10	0.20	0.30	0.10
1959-2014	Strength of Trend (r)	0.06	-0.20	-0.07	0.03	0.11	-0.13	-0.14	0.09	0.17	-0.03	-0.09	-0.39
	Rate of Change (unit/yr)	0.02	-0.06	-0.02	0.01	0.06	-0.07	-0.07	0.04	0.07	-0.01	-0.04	-0.13
	R^2	0.00	0.04	0.00	0.00	0.01	0.02	0.02	0.01	0.03	0.00	0.01	0.15
	p- value	0.30	0.10	0.30	0.40	0.20	0.20	0.20	0.20	0.10	0.40	0.20	0.0025

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Port Nolloth												
2005-2014	Strength of Trend (r)	0.43	0.61	0.11	0.71	0.34	-0.22	0.25	0.46	0.44	0.45	0.75	0.46
	Rate of Change (unit/yr)	0.90	0.85	0.16	1.89	0.48	-0.24	0.45	0.45	0.55	0.56	1.18	0.68
	R^2	0.18	0.37	0.01	0.50	0.11	0.05	0.06	0.21	0.19	0.20	0.56	0.21
	p- value	0.3	0.025	0.3	0.01	0.2	0.3	0.2	0.1	0.1	0.1	0.005	0.1
1999-2014	Strength of Trend (r)	0.30	0.39	0.05	0.49	0.07	-0.54	0.15	-0.08	0.25	0.14	0.28	0.39
	Rate of Change (unit/yr)	0.39	0.34	0.05	0.69	0.07	-0.42	0.16	-0.08	0.23	0.11	0.25	0.51
	R^2	0.09	0.15	0.00	0.24	0.01	0.29	0.02	0.01	0.06	0.02	0.08	0.15
	p- value	0.10	0.05	0.40	0.025	0.40	0.01	0.30	0.40	0.20	0.30	0.10	0.05

5.3. Adapted Index Results

5.3.1. Validation of Mathematically Adapted Model Tourism Climate Index Model

To test the accuracy of this adapted TCI model, it was run against the locations in *section* 5.2, which had a full data set. The results of the traditional TCI model were then correlated against the results of the mathematically adapted model in order to determine the level of accuracy of the mathematically adapted TCI model. The results (*Table 5.7*) indicate the level of accuracy of the mathematically adapted results.

Table 5.7: Correlation between the annual results of the traditional TCI and the annual results of the mathematically adapted TCI for the locations that had complete sets of data.

Location (Time Period)	Pearson Correlation Coefficient	p-value	Significance
Bethlehem (1981-2014)	0.99	0.0005	Significant
Bloemfontein (1992-2014)	0.95	0.0005	Significant
Cape Town (1966-2014)	0.99	0.0005	Significant
East London (1959-2014)	0.94	0.0005	Significant
Johannesburg (1992-2014)	0.99	0.0005	Significant
Kimberley (1959-2014)	0.96	0.0005	Significant
Polokwane (1993-2014)	0.96	0.0005	Significant
Port Elizabeth (1959-2014)	0.98	0.0005	Significant
Port Nolloth (1999-2014)	1.00	0.0005	Significant

The correlation between the results of the two models for each location reveal high correlation coefficients that all range above 0.94, which is indicative of a strong statistically significant positive relationship (*Table 5.7*). In addition, these statistically significant correlation coefficients demonstrate that the mathematically adapted TCI results are relatively accurate and that they could be used as an alternative model to the traditional TCI.

5.3.2. Rainfall Proxy Tourism Climate Index Model

Due to the lack of sunshine hours data for some of the locations, the traditional TCI was adapted using the rainfall data obtained from SAWS as a proxy for the sunshine hours.

For this method to work, a scale needed to be used to approximate the amount of monthly sunshine hours in that region based on its monthly rainfall. This scale is adapted from the original TCI model put forward by Mieczkowski (1985). *Table 4.11* below indicates the scale used to approximate sunshine hours based on the rainfall of a particular location.

Table 5.8: The scale used to approximate sunshine hours based on the rainfall of a particular region, in the event that cloud cover data or sunshine hours data is not available.

Rainfall (mm)	Approximate Sunshine Hours
0.0 to 14.9	>10
15.0 to 29.9	9
30.0-44.9	8
45.0-59.0	7
60.0-74.9	6
75.0-89.9	5
90.0-104.9	4
105.0 to 119.9	3
120.0 to 134.9	2
135.0-149.9	1
>150.0	<1

Once the sunshine hours have been approximated, the TCI model can be run and the TCI for a particular location can be calculated. This rainfall proxy adaptation of the globally accepted TCI can be calculated using the formula developed by Mieczkowski (1985) and adapted by Perch-Nielsen *et al*. (2010) (*Equation 5.1*).

To test the accuracy of this adapted TCI model, it was run against the locations in *section 5.2*, which had a full data set. The results of the traditional TCI model were then correlated against the results of the rainfall proxy adapted model in order to determine the level of accuracy of the rainfall proxy adapted TCI model. The results in *Table 5.8* below indicate the level of accuracy of the mathematically adapted results.

Table 5.9: Correlation between the annual results of the traditional TCI and the annual results of the mathematically adapted TCI for the locations that had complete sets of data.

Location (Time Period)	Pearson Correlation Coefficient	p-value	Significance
Bethlehem (1981-2014)	0.93	0.0005	Significant
Bloemfontein (1992-2014)	0.89	0.0005	Significant
Cape Town (1966-2014)	0.95	0.0005	Significant
East London (1959-2014)	0.91	0.0005	Significant
Johannesburg (1992-2014)	0.90	0.0005	Significant
Kimberley (1959-2014)	0.90	0.0005	Significant
Polokwane (1993-2014)	0.92	0.0005	Significant
Port Elizabeth (1959-2014)	0.94	0.0005	Significant
Port Nolloth (1999-2014)	0.98	0.0005	Significant

The correlation between the results of the two models for each location reveal high correlation coefficients that all range from 0.89 to 0.98, which is indicative of a strong statistically significant positive relationship (*Table 5.8*). In addition, these statistically significant correlation coefficients demonstrate that the mathematically adapted TCI results are relatively accurate and that they could be used as an alternative model to the traditional TCI.

5.3.3. Final Model Selection

Both the mathematically adapted TCI (*Table 5.7*) and the rainfall proxy adapted TCI (*Table 5.8*) demonstrated very highly statistically significant correlation coefficients. Both models can be considered as acceptable alternatives to the traditional TCI, in the event of missing data that is essential to the traditional TCI. However, this study will use the mathematically adapted model as the alternative to the traditional TCI for the remaining study sites for the following reasons. Firstly, because the mathematically adapted TCI demonstrated higher correlation coefficients across all the locations compared to the rainfall proxy adapted TCI. Secondly, the rainfall proxy TCI has a fundamental flaw, in that it is self-referential and therefore, any errors in the rainfall data would necessarily be carried through into the proxy sunshine hours and would ultimately influence the accuracy of the model's output.

5.4. Mathematically Adapted Tourism Climate Index Results

5.4.1. Long Term Average TCI

The mean annual mathematically adapted TCI scores range from 74.88 (very good) for Belfast to 93.00 (ideal) for Pilanesberg, for the period 2005-2014 (*Table 5.9*). The majority of the locations demonstrate scores in the excellent rating category, except for Belfast, which was classified under the very good category, and Pilanesberg which was classified as having an ideal TCI score (*Table 5.9*). With a mean annual mathematically adapted TCI score of 93.00, tourists taking part in nature-based and/or adventure tourism, would have ideal climate conditions to do so. All the coastal cities, such as, Durban, Knysna and St Lucia, all revealed a mean annual TCI score categorized under the excellent rating with scores ranging from 84.17 for Durban to 85.5 for Knysna (*Table 5.9*). This would suggest that beach tourism and adventure tourism would benefit from excellent climatic conditions. The relatively lower mean annual TCI score in Belfast for the period 2005-2014, was strongly influenced by lower effective temperatures calculated under the average thermal comfort (CA) sub –index of the TCI formula (*Equation 5.2*).

Table 5.10: Annual mean mathematically adapted TCI scores from 2005 to 2015 for selected locations throughout South Africa.

Location	Long-term Average	Classification
Belfast	74.88	Very Good
Durban	84.17	Excellent
Knysna	85.5	Excellent
Ladysmith	87.75	Excellent
Nelspruit	87.08	Excellent
Paarl	88.25	Excellent
Pilanesberg	93.00	Ideal
Pretoria	87.5	Excellent
St. Lucia	84.3	Excellent

Comparing the mean annual TCI scores for the period 2005-2014 to the longest continuous mean annual TCI scores for each of the locations, it can be seen that the climate suitability of each location has remained constant in terms of classification in the rating categories (*Table 5.9* and *Table 5.10*). However, there are slight, but noticeable increases or decreases in the annual average TCI scores across the different time scales.

Table 5.11: Long-term annual average mathematically adapted TCI for the longest continuous time period for each location.

Location	Long-term Average	Classification
Belfast (2005-2014)	74.88	Very Good
Durban (1956-2014)	84.39	Excellent
Knysna (1997-2014)	85.69	Excellent
Ladysmith (1994-2014)	87.5	Excellent
Nelspruit (1995-2014)	87.63	Excellent
Paarl (1997-2014)	86.88	Excellent
Pilanesberg (1996-2014)	91.64	Ideal
Pretoria (2002-2014)	88.08	Excellent
St. Lucia (1983-2014)	80.74	Excellent

The monthly mean mathematically adapted TCI in Belfast for the majority of the months for the period 2005-2014, demonstrate a climate suitability that is classified as very good, with the TCI score ranging from 68.75 (July) to 79.58 (September) (*Table 5.11*). However, February in Belfast, for the period 2005-2014, reveals a TCI score of 85.97, which suggests that climatic conditions during this month are excellent for tourism. For the period 2005-2014, the monthly mathematically adapted TCI score in Durban reveals that the months from January to September demonstrate excellent to ideal climate conditions for tourism (*Table 5.11*). However, for the same period in Durban, the months of October, November and December demonstrate a long term monthly TCI score of 79.5, 77.38 and 79.75 respectively. These values suggest that the climate suitability for tourism during October, November and December would be classified as very good for the period 2005-2014 in Durban.

The mean monthly mathematically adapted TCI scores in Knysna for the period 2005-2014 and 1997-2014 highlights a general trend, with excellent to ideal climate conditions being experienced for tourism over the summer months of the year, while the winter and spring months of the year have only very good climate suitability for tourism (*Table 5.11*). With large portions of tourism activity occurring in Knysna during the summer months of the year, these results can be viewed as a positive indicator for tourism stakeholders and tourists in this region. May and September in Nelspruit, during the period 2005-2014 and 1994-2014, both demonstrate ideal climatic conditions for tourism with the TCI score above 90.00 in each respective month (*Table 5.11*). The TCI score for both these months over both time periods, indicate that Nelspruit experiences its best climatic conditions for tourism during autumn and spring periods of the year. Pretoria experiences its best climatic conditions for tourism during autumn and spring, with both April and September demonstrating a mean monthly TCI scores of above 90.00 during the period 2005-2014 and 2002-2014 (*Table 5.11*).

Table 5.12: Mean monthly mathematically adapted TCI scores for the period 2005-2014 and the longest continuous mean monthly TCI scores for each location.

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Belfast												
2005-2014	Average	76.11	85.97	78.13	73.75	74.38	68.88	68.75	72.63	79.58	72.64	69.72	75.88
	Durban												
2005-2014	Average	80.75	84.38	82.38	87.88	91.38	87.88	88.50	86.25	83.63	79.50	77.38	79.75
1956-2014	Average	79.80	82.72	83.43	87.48	89.30	86.82	83.31	84.38	83.18	80.25	80.87	81.06
	Knysna												
2005-2014	Average	92.13	93.13	90.50	87.50	79.13	69.38	67.50	68.75	78.13	75.63	82.13	90.25
1997-2014	Average	90.83	92.78	87.08	87.01	79.65	72.57	67.64	68.82	77.99	78.33	83.54	89.38
	Ladysmith												
2005-2014	Average	79.13	88.38	87.38	88.63	87.25	79.63	78.88	84.38	90.38	86.63	89.38	83.25
1994-2014	Average	80.81	85.81	86.25	89.93	87.13	80.06	77.26	85.42	89.52	87.26	87.08	82.44
	Nelspruit												
2005-2014	Average	78.91	83.19	84.44	86.00	90.00	82.64	80.00	86.09	93.93	88.39	86.25	76.72
1995-2014	Average	83.26	84.14	84.54	88.25	90.66	83.82	80.49	86.94	92.19	88.09	84.69	81.39
	Paarl												
2005-2014	Average	96.75	98.25	97.63	92.25	69.63	55.50	61.50	59.50	76.38	93.38	91.50	98.50
1997-2014	Average	96.46	97.85	97.50	90.90	72.43	57.64	59.72	58.75	75.00	92.08	92.22	97.78
	Pilanesberg												
2005-2014	Average	86.50	89.88	90.50	89.50	93.25	89.63	87.08	92.78	96.67	95.75	89.58	85.50
1996-2014	Average	84.21	86.74	88.55	88.68	91.71	90.00	86.25	92.85	96.03	92.70	89.10	85.14
	Pretoria												
2005-2014	Average	79.75	87.25	87.88	91.13	87.00	74.25	74.63	84.38	93.63	89.63	85.38	82.25
2002-2014	Average	81.35	85.58	87.40	91.83	87.69	74.23	74.90	84.71	94.04	90.19	86.73	83.46
	St. Lucia												
2005-2014	Average	80.00	77.75	80.00	82.38	88.50	83.50	89.00	88.00	86.75	77.63	82.64	82.50
1983-2014	Average	78.98	77.70	80.79	81.29	85.32	77.15	77.62	82.89	83.47	78.20	80.04	81.08

Tourists visiting Paarl from January to April and from October to December for the period 2005-2014 and 1997-2014, would experience ideal climatic conditions for tourism, with the TCI scores during these months ranging from 92.08 for October to 98.5 for December (*Table 5.11*). However, the TCI score drops considerably in Paarl from May to August over the same time periods, with the TCI score ranging from 55.50 (acceptable) for June to 76.38 (very good) for September (*Table 5.11*). This decrease in the long term monthly TCI during these months can be attributed to the winter rainfall that Paarl receives, and a drop in temperature during this time of the year, similar to Cape Town. Pilanesberg, for the period 2005-2014 and 1996-2014, experiences excellent to ideal climatic conditions for tourism all year round with TCI scores ranging from 84.21 (excellent) for January to 96.67 (ideal) for September. These climate conditions in the region during the two time periods, suggest that the nature-based tourism market could benefit significantly.

5.4.2. Mathematically Adapted Tourism Climate Index Time Trends

The regression was calculated for the mathematically adapted TCI scores and for the traditional TCI scores (*Section 5.2.1.2*), and the results are as follows. For the period 2005-2014, the annual mathematically adapted TCI scores in Knysna demonstrates a statistically significant positive trend, with a correlation coefficient of 0.50 (p=0.05; *Table 5.12*). This positive trend equates to an increase in the TCI score for Knysna over this period, of 0.76units/yr (*Table 5.12*). This positive increase in the Knysna TCI is strongly controlled by good, steady readings in the day time thermal comfort (CD), which incorporates mean monthly maximum temperature (˚C) and mean monthly minimum relative humidity (%) to obtain an effective temperature (˚C) which is then used to run the TCI model, and by a lack of unpleasant winds during the period 2005-2014. St Lucia, another coastal city, experienced statistically significant increases in the mathematically adapted TCI scores during the period 2005-2014. The TCI scores increased at a rate of 0.50units/yr (r=0.55; p=0.05; *Table 5.12*). These positive trends are largely influenced by good effective temperatures which fall under the daytime thermal comfort (CD) and average thermal comfort (CA) sub-indices of the TCI index.

In contrast, insignificant trends in the annual mathematically adapted TCI scores are demonstrated at Belfast (r=-0.26; p=0.20), Durban (r=0.25; p=0.20), Ladysmith (r=0.12; p=0.30), Nelspruit (r=0.06; p=0.40), Paarl (r=-0.12; p=0.30) and Pretoria (r=0.26; p=0.20), for the period 2005-2014 (*Table 5.12)*. Pilanesberg demonstrated a high annual mean TCI score of 93 for the period 2005-2014, suggesting that the region has ideal climatic conditions for tourism (*Table 5.9*). However, despite being statistically insignificant, Pilanesberg demonstrated a negative trend over the period 2005-2014, with a correlational coefficient of -0.30 (p=0.2; *Table 5.12*). This negative trend reveals a statistically insignificant decrease in the annual mean TCI score of 0.29units/yr. For the short-term periods of 2005-20104, climate variability needs to be monitored, to detect progressive climate change.

Table 5.13: Statistical values representing the correlation between annual mean mathematically adapted TCI scores and time for the selected locations from 2005-2014.

Location (Time Period)	Rate of Change (TCI/per year)	R^2 Value	r-value	p-value	Significance
Belfast	-0.42	0.07	-0.26	0.2	Non-Significant
Durban	0.28	0.06	0.25	0.2	Non-Significant
Knysna	0.76	0.25	0.50	0.05	Significant
Ladysmith	0.11	0.01	0.12	0.3	Non-Significant
Nelspruit	0.10	0.00	0.06	0.4	Non-Significant
Paarl	-0.11	0.01	-0.12	0.3	Non-Significant
Pilanesberg	-0.29	0.09	-0.30	0.2	Non-Significant
Pretoria	0.26	0.07	0.26	0.2	Non-Significant
St. Lucia	0.50	0.30	0.55	0.05	Significant

The annual mathematically adapted TCI trend in St Lucia remained positive over the longer time period of 1983-2014, with a correlation coefficient of 0.58 (p=0.0005; *Table 5.13*). The statistically significant positive trend suggests that the annual TCI score is increasing by 0.29units/yr. This positive trend is still predominantly influenced by excellent effective temperature readings for both the daytime thermal comfort (CD) and average thermal comfort (CA) sub-indices of the TCI index. Despite demonstrating an insignificant trend for the period 2005-2014 (*Table 5.12*), Paarl, over the longer period of 1997-2014, has demonstrated a statistically significant positive trend (*Table 5.13*). This trend reveals an increase of 0.24units/yr (r=0.36; p= 0.05) in the annual mathematically adapted TCI score for the region (*Table 5.13*). The annual TCI trend in Knysna over the longer period of 1997-2014, shifted to a statistically insignificant negative trend (r=0.06; p=0.2), as opposed to the statistically significant trend demonstrated over the period 2005-2014

The longest continuous annual mean mathematically adapted TCI trends over time in Ladysmith (1994-2014), Nelspruit (19954-2014), Pilanesberg (1996-2014), Pretoria (2002-2014), and Durban (1956-2014) remained insignificant, even over longer time periods (*Table 5.13*).

Table 5.14: Statistical values representing the correlation between longest continuous annual mean mathematically adapted TCI scores and time for the selected locations.

Location (Time Period)	Rate of Change (TCI/per year)	R^2 Value	r-value	p-value	Significance
Belfast (2005-2014)	-0.42	0.07	-0.26	0.2	Non-Significant
Durban (1956-2014)	0.01	0.01	0.08	0.3	Non-Significant
Knysna (1997-2014)	0.04	0.00	0.06	0.4	Non-Significant
Ladysmith (1994-2014)	0.08	0.03	0.18	0.2	Non-Significant
Nelspruit (1995-2014)	0.00	0.00	0.00	0.4	Non-Significant
Paarl (1997-2014)	0.24	0.13	0.36	0.05	Significant
Pilanesberg (1996-2014)	0.20	0.10	0.32	0.1	Non-Significant
Pretoria (2002-2014)	-0.13	0.02	-0.15	0.3	Non-Significant
St. Lucia (1983-2014)	0.29	0.33	0.58	0.0005	Significant

For the period 2005-2014 in Belfast, the mean monthly TCI for March and October reveals a negative trend, with each month demonstrating a statistically significant correlation coefficient of -0.55 (p=0.05) and -0.66 (p=0.025) respectively (*Table 5.14*). These trends equate to monthly decreases in the mathematically adapted TCI score of 1.46units/yr for March and 2.58units/yr for October (*Table 5.14*). In both instances the rate of change in the monthly TCI is alarmingly high and could have a major negative impact on the nature-based tourism and adventure tourism market during these months of the year.

For the period 1956-2014, the longest continuous mean monthly TCI score in Durban, during the months of May, June and August, all revealed statistically significant positive trends, with correlation coefficients of 0.29 (p=0.01), 0.27 (p=0.01), and 0.28 (p=0.01) respectively (*Table 5.14*). This could be beneficial to tourism stakeholders trying to boost tourism numbers in the winter season in Durban. These positive trends in the longest continuous mean monthly mathematically adapted TCI scores equate to an increases of 0.14units/yr for May, 0.12units/yr for June and 0.13units/year for August (*Table 5.14*). The positive trends demonstrated in these months is influenced largely by the lack of strong winds that could impact the experience of a tourist while participating in an activity in the region. A statistically significant increase in the mean monthly TCI score in Knysna during December is demonstrated for the period 2005-2014 (*Table 5.14*). This statistically significant increase equates to an increase in the monthly TCI score of 0.85units/yr (r=0.51; p=0.05). With peak tourism periods occurring in Knysna during December, this positive trend has led to an increase in preferential climate conditions for coastal and adventure tourism in this region.

Located within the same province and same general climate characteristics as Durban, St Lucia demonstrates some interesting trends in the mean monthly TCI scores. As observed for Durban, St Lucia revealed statistically significant increases in the monthly TCI scores for the winter months of June, July and August. The trends revealed strong correlation coefficients of 0.61 (p=0.0005) for June, 0.45 (0.005) for June, and 0.45 (0.005) for August (*Table 5.14*). With these trends equating to increases of 0.82units/yr for June, 0.65units/yr for July, and 0.44units/yr for August in the monthly TCI scores, the winter tourism climate could potentially draw more tourists to enjoy improved climate suitability in St Lucia (*Table 5.14*).

The long-term monthly TCI trends in Ladysmith for the periods 2005-2014 and 1994-2014 over each month all demonstrate statistically insignificant trends, with the exception of November over the period 1994-2014. This statistically significant positive trend during the month of November is characterized by a 0.46units/yr (r=0.38; p=0.05) increase in the longest continuous mean monthly TCI scores (*Table 5.14*).

As for Durban, Nelspruit too demonstrated a statistically significant increase in the long term monthly TCI score during June for the period 2005-2014. This positive trend equates to a 0.99units/yr (r=0.69; p=0.01) increase in the monthly TCI score and enhances the climate suitability of the region during this month for tourism activities (*Table 5.14*). However, for the period 1995-2014, February and December in Nelspruit demonstrated statistically significant negative trends in their longest continuous mean monthly TCI scores, with correlation coefficient of -0.25 (p=0.05) and -0.43 (p=0.025) respectively (*Table 5.14*). These trends suggest that there are significant decreases in the climate suitability of the region during these months, which could pose negative impacts to the tourism market of the region.

The monthly average TCI score for the summer months in Paarl were all very high and revealed excellent to ideal climatic conditions (*Table 5.11*). However, for the period 2005-2014, the mean monthly TCI for February demonstrates a statistically significant decrease, with a correlation coefficient of -0.51 (p=0.05; *Table 5.14*). This trend reveals a decrease in the February TCI of 0.35units/yr (*Table 5.14*). In contrast, December in Paarl for the period 1997-2014, demonstrates a statistically significant increase in the monthly TCI of 0.15units/ year (r=0.4; p=0.05; *Table 5.14*).

With mean monthly TCI averages all revealing excellent to ideal climatic conditions in Pilanesberg over the period 2005-2014, it is interesting to note two statistically significant decreases in the mean monthly TCI scores for March and October. These trends suggest that the TCI is decreasing at a rate of 2.27units/yr for March and 0.59units/yr for October (*Table 5.14*). Interestingly though, for the period 1996-2014 in Pilanesberg, January, May and September demonstrate statistically significant increases in their monthly TCI scores of 0.47units/yr (r=0.36; p=0.05), 0.32units/yr (r=0.45; p=0.025), and 0.15units/yr (r=0.42; p=0.025) respectively (*Table 5.14*). These trends suggest that over the longer period from 1996-2014 the climate suitability for tourism is becoming better during these months. This could potentially benefit the nature-based tourism market in this region.

Table 5.15: Correlation between mean monthly mathematically TCI scores and time and the correlation between longest continuous mean monthly TCI for the selected locations. Highlighted cells represent statistically significant trends.

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Belfast												
2005-2014	Strength of Trend (r)	0.06	0.36	-0.55	-0.28	0.13	0.14	0.04	0.10	0.08	-0.66	-0.26	-0.38
	Rate of Change (unit/yr)	0.19	0.76	-1.46	-0.55	0.25	0.19	0.03	0.20	0.25	-2.58	-0.64	-1.17
	R^2	0.00	0.13	0.31	0.08	0.02	0.02	0.00	0.01	0.01	0.43	0.07	0.14
	p- value	0.400	0.20	0.05	0.20	0.30	0.30	0.40	0.40	0.40	0.025	0.20	0.100
	Durban												
2005-2014	Strength of Trend (r)	-0.04	0.70	0.28	0.35	0.09	0.34	-0.18	0.05	-0.05	-0.34	0.21	0.27
	Rate of Change (unit/yr)	-0.08	1.80	0.77	0.95	0.17	1.02	-0.48	0.12	-0.16	-0.76	0.37	0.65
	R^2	0.00	0.49	0.08	0.12	0.01	0.11	0.03	0.00	0.00	0.11	0.04	0.07
	p- value	0.40	0.01	0.20	0.20	0.40	0.20	0.30	0.40	0.40	0.20	0.30	0.20
1956-2014	Strength of Trend (r)	0.00	-0.01	0.07	0.03	0.29	0.27	0.11	0.28	0.10	-0.12	-0.07	-0.09
	Rate of Change (unit/yr)	0.00	-0.01	0.03	0.01	0.14	0.12	0.07	0.13	0.05	-0.04	-0.03	-0.04
	R^2	0.00	0.00	0.00	0.00	0.08	0.07	0.01	0.08	0.01	0.01	0.01	0.01
	p- value	0.40	0.40	0.40	0.40	0.01	0.01	0.20	0.01	0.20	0.200	0.40	0.40

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Knysna												
2005-2014	Strength of Trend (r)	0.24	0.24	0.30	0.26	0.32	0.20	-0.17	0.42	0.28	-0.26	0.24	0.51
	Rate of Change (unit/yr)	0.42	0.28	0.65	0.71	1.13	0.36	-0.53	1.45	0.66	-0.89	0.77	0.85
	R^2	0.06	0.06	0.09	0.07	0.10	0.04	0.03	0.17	0.08	0.07	0.06	0.26
	p- value	0.20	0.20	0.200	0.30	0.20	0.30	0.30	0.10	0.20	0.20	0.20	0.05
1997-2014	Strength of Trend (r)	0.34	0.23	0.50	0.16	0.08	-0.35	-0.07	0.11	-0.03	-0.42	-0.06	0.10
	Rate of Change (unit/yr)	0.35	0.16	0.75	0.22	0.18	-0.56	-11.00	0.23	-0.03	-0.71	-0.09	0.11
	R^2	0.11	0.05	0.25	0.02	0.01	0.12	0.00	0.01	0.00	0.18	0.00	0.01
	p- value	0.10	0.20	0.025	0.30	0.40	0.10	0.40	0.30	0.40	0.05	0.40	0.300
	Ladysmith												
2005-2014	Strength of Trend (r)	0.43	0.01	0.48	-0.47	-0.06	-0.10	-0.34	-0.10	-0.32	0.34	0.70	-0.35
	Rate of Change (unit/yr)	1.02	0.02	1.36	-1.25	-0.15	-0.20	-0.80	-0.20	-1.02	0.72	1.45	-0.98
	R^2	0.19	0.00	0.23	0.22	0.00	0.01	0.12	0.01	0.10	0.12	0.49	0.12
	p- value	0.10	0.40	0.10	0.10	0.40	0.40	0.20	0.40	0.20	0.20	0.01	0.20
1994-2014	Strength of Trend (r)	-0.08	0.31	0.31	-0.24	0.02	-0.05	0.10	-0.13	-0.10	0.17	0.38	0.02
	Rate of Change (unit/yr)	-0.09	0.38	0.34	-0.24	0.02	-0.05	0.16	-0.12	-0.14	0.18	0.46	0.02
	R^2	0.01	0.10	0.09	0.06	0.00	0.00	0.01	0.02	0.01	0.03	0.15	0.00
	p- value	0.40	0.10	0.10	0.10	0.40	0.40	0.30	0.30	0.30	0.20	0.05	0.400

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Nelspruit												
2005-2014	Strength of Trend (r)	0.21	-0.36	-0.24	0.03	0.41	0.69	0.16	0.37	0.31	-0.40	-0.44	-0.07
	Rate of Change (unit/yr)	0.47	-0.85	0.07	0.08	0.91	0.99	0.25	0.52	0.34	-0.50	-0.75	-0.13
	R^2	0.04	0.13	0.00	0.00	0.17	0.48	0.03	0.13	0.10	0.16	0.20	0.00
	p- value	0.30	0.20	0.20	0.40	0.10	0.01	0.30	0.10	0.20	0.10	0.10	0.40
1995-2014	Strength of Trend (r)	-0.19	-0.25	0.05	-0.21	0.14	-0.14	-0.04	-0.01	0.20	-0.05	0.19	-0.43
	Rate of Change (unit/yr)	-0.28	-0.34	-0.54	-0.27	0.14	-0.10	-0.03	-0.01	0.16	-0.05	0.22	-0.61
	R^2	0.04	0.06	0.06	0.04	0.02	0.02	0.00	0.00	0.04	0.00	0.03	0.19
	p- value	0.20	0.05	0.40	0.20	0.30	0.30	0.40	0.40	0.20	0.40	0.200	0.025
	Paarl												
2005-2014	Strength of Trend (r)	-0.08	-0.51	-0.44	0.14	0.49	-0.27	-0.18	-0.03	-0.28	-0.11	0.03	0.28
	Rate of Change (unit/yr)	-0.11	-0.35	-0.52	0.18	1.48	-0.56	-0.68	-0.11	-1.11	-0.11	0.05	0.11
	R^2	0.01	0.26	0.20	0.02	0.24	0.07	0.03	0.00	0.08	0.01	0.00	0.08
	p- value	0.40	0.05	0.10	0.30	0.10	0.20	0.30	0.40	0.200	0.30	0.40	0.20
1997-2014	Strength of Trend (r)	0.00	0.06	-0.13	0.31	-0.05	-0.17	0.08	0.01	0.02	0.04	0.01	0.40
	Rate of Change (unit/yr)	0.00	0.04	-0.09	0.26	-0.10	-0.34	0.17	0.03	0.05	0.03	0.01	0.15
	R^2	0.00	0.00	0.02	0.09	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.16
	p- value	0.40	0.40	0.30	0.10	0.400	0.20	0.40	0.40	0.40	0.40	0.40	0.05

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Pilanesberg												
2005-2014	Strength of Trend (r)	0.08	0.07	-0.68	-0.26	0.10	0.02	-0.27	0.20	0.05	-0.51	-0.34	-0.40
	Rate of Change (unit/yr)	0.21	0.20	-2.27	-0.74	0.08	0.02	-0.50	0.17	0.02	-0.59	-0.71	-1.23
	R^2	0.01	0.00	0.46	0.07	0.01	0.00	0.08	0.04	0.00	0.26	0.11	0.16
	p- value	0.40	0.40	0.01	0.20	0.30	0.40	0.20	0.30	0.40	0.05	0.200	0.10
1996-2014	Strength of Trend (r)	0.36	0.32	0.00	0.06	0.45	-0.11	0.15	0.06	0.42	0.30	0.05	-0.11
	Rate of Change (unit/yr)	0.47	0.49	-0.01	0.16	0.32	-0.07	0.12	0.03	0.15	0.31	0.06	-0.17
	R^2	0.13	0.10	0.00	0.00	0.20	0.01	0.02	0.00	0.18	0.09	0.00	0.01
	p- value	0.05	0.10	0.40	0.40	0.025	0.30	0.30	0.40	0.025	0.10	0.40	0.30
	Pretoria												
2005-2014	Strength of Trend (r)	0.50	-0.09	-0.07	0.03	0.40	0.11	-0.08	0.05	-0.07	-0.12	-0.10	-0.78
	Rate of Change (unit/yr)	1.06	-0.24	-0.23	0.04	0.74	0.20	-0.13	0.11	-0.10	-0.31	-0.16	-1.65
	R^2	0.25	0.01	0.01	0.00	0.16	0.01	0.01	0.00	0.01	0.01	0.01	0.61
	p- value	0.05	0.40	0.40	0.40	0.10	0.30	0.40	0.40	0.40	0.30	0.30	0.005
2002-2014	Strength of Trend (r)	-0.06	0.21	-0.03	-0.24	0.04	0.08	-0.16	-0.04	-0.22	-0.17	-0.43	-0.61
	Rate of Change (unit/yr)	-0.10	0.42	-0.06	-0.28	0.05	0.10	-0.19	-0.06	-0.21	-0.31	-0.63	-1.17
	R^2	0.00	0.04	0.00	0.06	0.00	0.01	0.02	0.00	0.05	0.03	0.18	0.37
	p- value	0.40	0.20	0.40	0.20	0.40	0.40	0.30	0.40	0.20	0.30	0.05	0.01

Time Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	St Lucia												
2005-2014	Strength of Trend (r)	0.23	0.28	0.14	0.50	0.14	0.59	-0.18	0.20	-0.12	-0.37	0.71	-0.18
	Rate of Change (unit/yr)	0.71	0.89	0.39	1.25	0.39	2.03	-0.58	0.35	-0.35	-0.81	1.92	-0.44
	R^2	0.05	0.08	0.02	0.25	0.02	0.35	0.03	0.04	0.01	0.14	0.50	0.03
	p- value	0.2	0.2	0.3	0.05	0.3	0.05	0.3	0.2	0.2	0.1	0.01	0.3
1983-2014	Strength of Trend (r)	0.00	0.13	-0.03	0.02	0.13	0.61	0.45	0.45	0.09	0.04	0.27	0.01
	Rate of Change (unit/yr)	0.00	0.11	-0.02	0.02	0.13	0.82	0.65	0.44	0.09	0.03	0.20	0.01
	R^2	0.00	0.02	0.00	0.00	0.02	0.38	0.21	0.21	0.01	0.00	0.07	0.00
	p- value	0.00	0.20	0.40	0.400	0.20	0.0005	0.005	0.005	0.30	0.40	0.05	0.40

For the period 2002-2014 in Pretoria, November and December demonstrate significant decreases in their long term monthly TCI scores, with correlation coefficients of -0.43 (p=0.05) and -0.61 (p=0.01) respectively (*Table 5.14*). These trends suggest that the monthly TCI score in November decreases by 0.63units/yr while the TCI score in December decreases by 1.17units/yr over the same time period (*Table 5.14*). Similarly, December in Pretoria for the period 2005-2014, demonstrates a statistically significant decrease in the monthly TCI score of 1.65units/yr (r=-0.78; p=0.005). However, for the same period, January in Pretoria demonstrates a large and statistically significant increase in the monthly TCI score of 1.06units/yr (r=0.5; p=0.05; *Table 5.14*). To some extent, this increase in January counteracts the decrease in December and allows tourism stakeholders to adjust their tourism product offerings to slightly different times of the year when climate suitability is better for tourism.

5.5. Identification of Peaks in Annual Tourism Climate Suitability (2005-2014)

Scott and McBoyle (2001) argue that the tourism climate resources for any destination can be categorized into one of six annual TCI distributions. These 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). None of the selected locations across South Africa in this study fall into the categories of dry season peak conditions, year-round optimal conditions or year-round poor conditions.

The bimodal-shoulder peak distribution is observed for 56% of the locations in this study (*Figure 5.2*). These locations have winter temperatures that are too cold for tourism, but the temperatures and other climatic conditions are more suitable during spring or autumn. It is interesting to note that all the locations that fall under this distributional category, are locations that are situated inland and therefore experience far greater extreme temperature differences between winter and summer due to the effects of continentality.

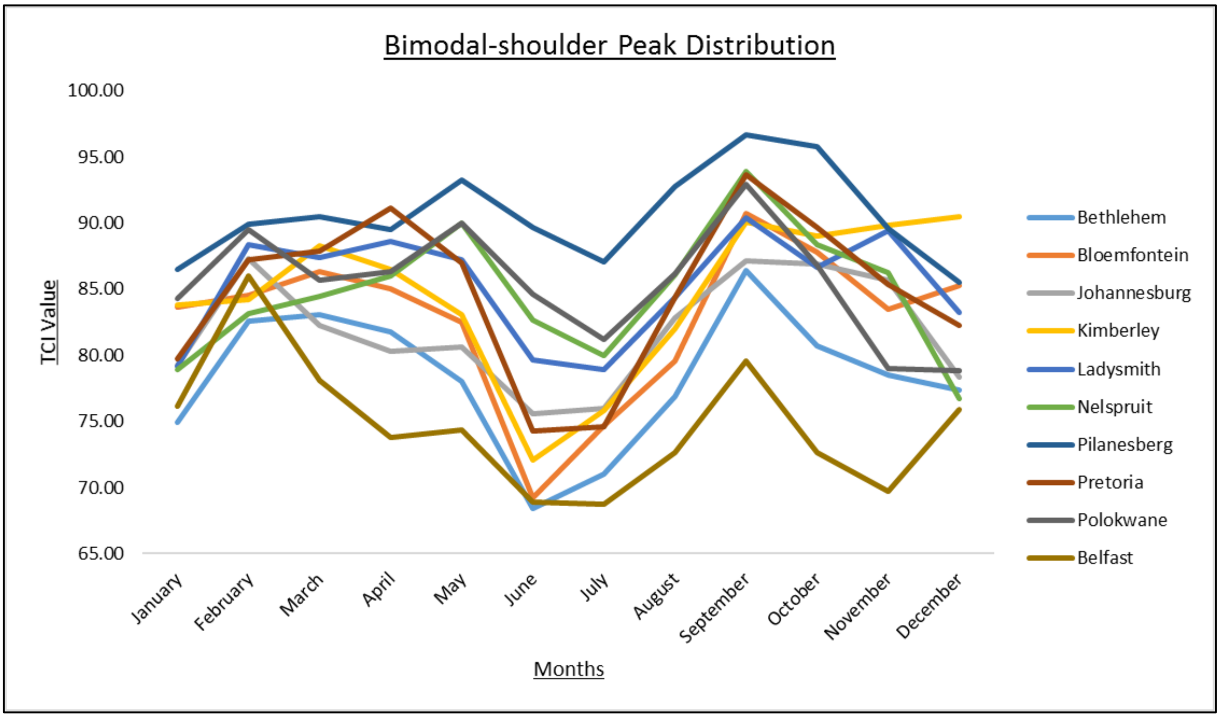


Figure 5.2: The locations that are categorized as having a bimodal-shoulder peak tourism climate distribution.

The summer-season peak distribution is observed for 33% of the locations in this study (*Figure* 5.3). These locations have climate conditions in winter that are not favorable to tourism, with Cape Town and Port Nolloth and Port Elizabeth receiving winter rainfall. However, the temperatures and other climatic conditions in summer are more suitable for tourism. The locations that have been categorized under the summer peak seasonal distribution occur along the south-western and western coasts of South Africa, where the ocean currents are cold and do not regulate the winter temperatures such as the coasts along the east of the country.

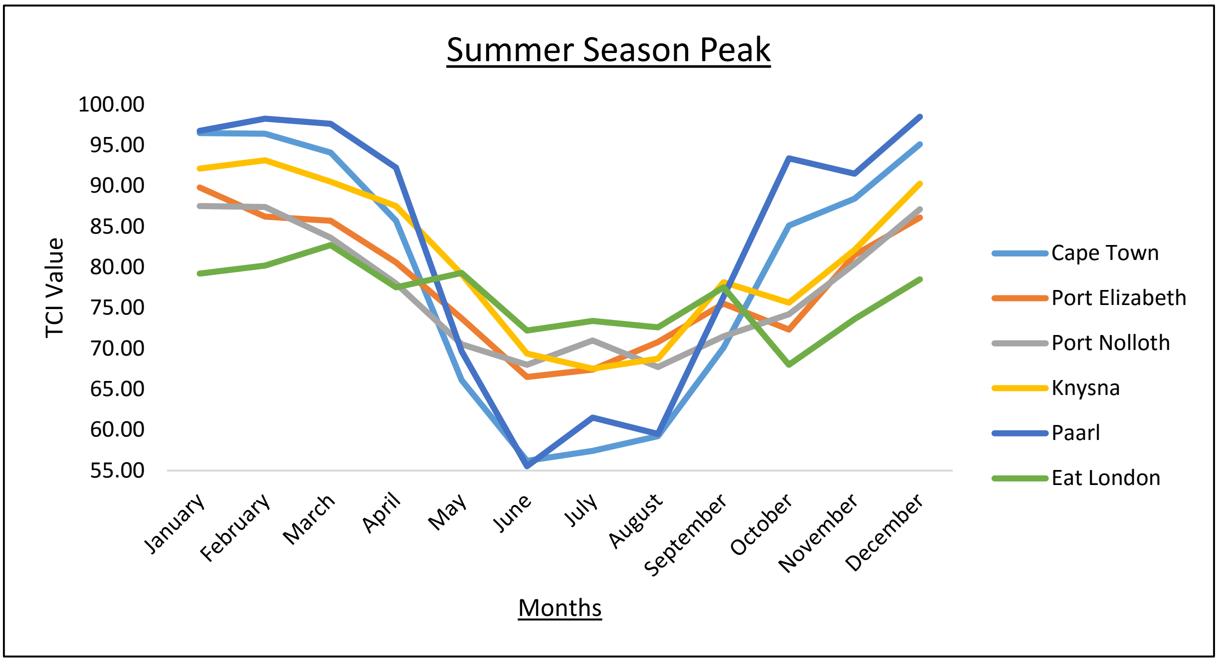


Figure 5.3: The locations that are categorized as having a summer season peak tourism climate distribution.

The winter-season peak distribution is observed for the remaining 11% of the locations (*Figure 5.4*). This distribution indicates that the climate conditions in winter are the most suitable for tourism. These regions experience warm temperatures in winter due to the regulating effect of the warm oceans. Furthermore, the rainfall during winter is minimal and therefore adding to the suitability of these locations for winter tourism. The temperatures in these regions in summer, are very hot and experience summer rainfall which reduces the attractiveness of these places for tourism in summer.

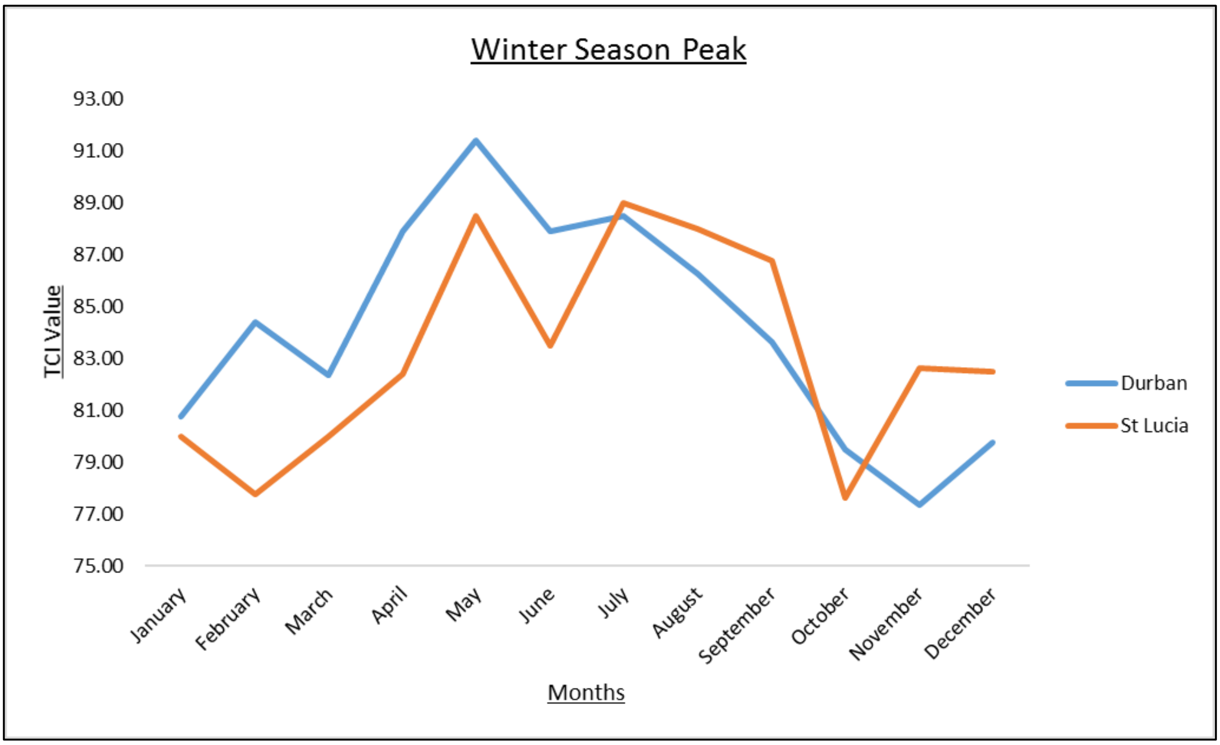


Figure 5.4: The locations that are categorized as having a winter season peak tourism climate distribution.

5.6. Qualitative Results

The purpose of the qualitative section of this study was to ascertain, the tourism academics and researchers level of concern of climate change threats to tourism among tourism academics and researchers in South Africa, and their perceptions of the accuracy of TCI results. Tourism academics and researchers were selected as the subjects to be interviewed, as these will be the first group of people to actively engage with TCI implementation and results. Ideally, it is researchers that will pass down both methods and results to key players in the tourism sector. Tourism academics from a range of universities across South Africa, and working in positions ranging from PhD candidate to full professor were interviewed to attempt to obtain a wide-ranging view. While ideally a larger number of academics would have been interviewed, despite being qualitative research, which does not require a large sample size, there appears to be a reluctance to engage in issues of climate change and tourism. This lack of interest, it can be argued, is as a result in itself and maybe hints towards the lack of urgency in terms of understanding the impact of climate change on South African tourism.

Table 5.16: Positions held by the respondents and which institutions they are from.

Respondent Number	Institution	Position	Field of Tourism Research
1	Cape Peninsula University of Technology	Professor	Sustainable Tourism and Macro Tourism
2	Cape Peninsula University of Technology	Professor	Sports Tourism
3	Stellenbosch University	Professor	Second Homes
4	University of Johannesburg	Professor	Local Economic Development
5	University of Johannesburg	Senior Lecturer	Boutique Hotels and Guest Houses
6	University of Johannesburg	PhD Candidate	Timeshares and Climate Change and Tourism

5.6.1. Tourism Academics Awareness of Climate Change

All of the respondents were aware of climate change and were conscious of the fact that it could have major negative impacts on the whole country. Their participation in the study in itself is a reflection of their concern regarding the potential impacts of climate change on the tourism sector. However, all of the respondents acknowledged that climate change is currently not having a significant influence on the country, and that it is an issue that is likely to influence the country in the near future. Respondent 5 stated "*there are bigger and more serious issues in South Africa other than climate change at the moment*". There was a general consensus among all the respondents that many locations in South Africa rely on climate to attract tourism, with most respondents pointing out that many of the study sites for this study, such as Belfast, Cape Town, Durban, East London, Knysna, Port Elizabeth, Pilanesberg, Paarl and St Lucia are reliant on the climate to attract tourism. Based on the fact that these and many other locations are reliant on climate to attract tourism, respondent 1 stated:

> *It is therefore important to understand the extent and magnitude of future climate change and its impacts in South Africa, at a national and regional scale.*

This sentiment demonstrates that the tourism academics and researchers understand that climate is a major factor that influences the attractiveness of a destination. In addition, respondents 4 and 6 both agreed that coastal regions are particularly susceptible to the negative impacts of climate change, with respondent 6 stating "*coastal regions are the most vulnerable to climate change*" and respondent 4 said that "*coastal regions should be particularly concerned about the impacts of climate change because they are the most* *vulnerable*". None of the respondents disputed this sentiment. However, respondent 5 stated "*all regions and individual locations should be concerned about the impacts of climate change, but destinations that experience an increase in extreme events (like flooding and droughts) should be more concerned about climate change*". These perceptions about the vulnerability of different locations to climate change, highlights the fact that tourism academics and researchers are aware that the distributional impacts of climate change are unevenly spread and that the extent and magnitude of any resultant impacts of climate change can vary at each destination (Mendelsohn *et al*., 2006). To further reinforce the understanding displayed by the tourism academics and researchers about the distributional variations of climate change impacts, respondent 6 said:

> *Each location in South Africa needs its own individual risk assessment, in order to specifically identify the extent of the impacts of climate change at each particular location*.

Lastly, some respondents stipulated that a destination's infrastructure will play an important role in determining how well it adapts to and deals with the impacts of climate change in the future. This speaks to the fact that the adaptive capacity of a destination or tourism stakeholder is not only characterized by the proactive or reactive stance that is taken, but that it is characterized by the ability to draw from financial and infrastructural resources (Amelung and Nicholls, 2014). This section demonstrates that the respondents understanding of climate change is reasonably in-depth.

5.6.2. Tourism Academics' Perceptions of Climate Change and Tourism in South Africa

Most respondents stipulated that the South African tourism sector is not threatened by climate change as of yet, with respondent 4 stating "*climate change has a very marginal influence on an individual's choice of holiday destination*". Respondent 5 stated "*presently, the tourism product offerings that destinations in South Africa have to offer, outweigh the influence of climate change*". The majority of the respondents that did answer perceived there to be an increase in tourism at all locations over the last couple of decades. Respondent 4 said "*there is a definite upward trend in tourism growth in South Africa over the last two decades*". Respondent 4 mentioned that since 2008, when the global financial crisis occurred, tourism numbers have decreased slightly and have stabilized since then. This considerable growth in tourism during post-apartheid South Africa has potentially masked any effects that climate change may have had on the tourism industry in the last couple of decades.

The same respondents indicated that although climate change is not posing a significant threat at the moment, it will become a major threat to the country's tourism sector in the near future. Respondent 6 stated:

> *In order for climate change to be considered a threat to the tourism sector in South Africa, the changing climate needs to reach a threshold, where anything above that threshold becomes too uncomfortable for tourism*.

Respondent 5 stated "*there will have to be something drastic that happens in South Africa, that would damage the country's tourism image",* but until then, respondent 6 perceives that *"The country and the tourism sector in particular is going to continue to follow business as usual patterns*". Additionally, respondent 1 said:

> *The coastal destinations in South Africa are particularly sensitive to of future climate change and are therefore at great risk of being negatively impacted on by climate change*.

None of the respondents provided a timeline for when they think climate change will start being an issue in South Africa. The fact that most of the respondents do not perceive climate change to be a current issue that is impacting the tourism sector, may highlight why there is a lack of urgency to research the impacts of climate change on tourism in South Africa. However, Respondent 3 perceived the current climate in South Africa to be a threat to the tourism sector. Furthermore, respondent 3 acknowledged that future climate change is going to pose a serious threat to climate change and said "*climate change is going to be a big threat to the tourism sector, especially if there is a continued occurrence of extreme events back on back*". This perception may result in increased urgency to assess the extent and magnitude of climate change (Scott *et al*., 2008). The main threats that were identified included flooding and drought. In addition, it was mentioned by some of the respondents that these threats will not only impact on the climate suitability of tourism, but these threats, particularly flooding, may negatively impact the tourism infrastructure, resulting in a loss of tourism to the region.

Respondent 6 stated "*I perceive climate change to be a bigger threat to the tourism sector then what the tourism stakeholders perceive it to be*". In line with this sentiment, all the respondents acknowledged an urgent need for further research into the extent, timing and impact that climate change may potentially have on the country's tourism sector. Respondent 2 stated:

> *Due to the major role that tourism plays in driving social and economic development in South Africa, there is a definite need for more research that explores the impacts of climate on tourism, and that it is important to understand the dynamics between climate change and the tourism sector in the country.*

All of the respondents perceived that increased research into the potential impacts of future climate change would enhance the ability of tourism stakeholders to respond and adapt to these impacts. Despite the perceptions that climate change is a distant issue for the South African tourism sector to deal with, and the call from tourism academics and researchers for increased research into the relationship between climate change and tourism in South Africa, there still remains a limited amount of research exploring this relationship. This lack of urgency to explore the impacts of climate change on the tourism sector suggests that the extent of the current impacts is not considered severe enough to warrant considerable research. However, Respondent 3 said:

> *The tourism sector cannot rid the country of climate change, but the tourism sector is going to have to become more resilient to the impacts of climate change by adapting effectively.*

Although respondent 6 agreed that there is an urgent need for increased research efforts in the tourism sector, regarding climate change, respondent 6 said:

> *South Africa is traditionally more responsive than proactive in terms of adaptation, and in the tourism sector, this is mainly due to the cost of adapting to and improving infrastructure in the event of a potential negative event.*

This demonstrates the fact that there is a conscious awareness amongst tourism researchers and academics of the different limitations that are hindering the ability of tourism stakeholders and government to adapt to the impacts of climate change. In addition, there were numerous occasions in which respondents indicated that it is important that barriers to the successful planning and implementation of adaptation strategies need to be removed. Consequently, in relation to communication between science and the people on the ground, Respondent 5 said:

> *The extent and magnitude of future climate change impacts need to be clearly communicated to tourism stakeholders, in order to help facilitate cost effective and efficient adaptation measures.*

These results indicate that the majority of the tourism academics perceive climate change as a distant threat and one that is set to impact the country in the future, although none of the respondents could indicate when climate change is set to impact the tourism sector in the country. However, this demonstrates that the tourism academics are conscious of the threat to the tourism sector and to the need for adaptive and mitigation strategies to be formulated now.

5.6.3. The Perceived Need for a TCI in South Africa

Some of the respondents were not aware of TCIs, despite their extensive coverage in tourism literature. For many of the respondents the concept of a TCI and the working of the equation needed to be explained before any questions could be answered. One respondent had read up on TCIs prior to the interview but confessed that it was difficult to understand. The majority of the respondents believe that there is a need to be able to quantify the impacts of climate change on tourism. Respondent 3 said:

> *There is limited research on climate change and tourism in South Africa, but South Africa is very dependent on its climate to attract tourists, therefore the TCI could be used as an effective tool to use in future research in the country*.

Furthermore, respondent 2 stated:

> *The TCI could be an important tool to use to assess the extent of climate change impacts on the climate suitability of destinations in South Africa, particularly due to the tourism sector relying heavily on the climatic resources to attract tourists*.

Respondent 6 stated "*climate change and tourism research in South Africa is in its infancy, and therefore the TCI could act as a good foundation for future similar research in the country*". However, within the minority, respondent 4 very bluntly stated: "*The TCIs are nutty*".

There was a general reluctance among the respondents to comment extensively on the role that the TCI or other similar climate-tourism indices may play in future tourism research, due to their limited knowledge of such indices and the quantitative sciences. However, the fact that tourism academics and researchers perceive the need for the TCI in future research, reflects their willingness to engage with the issue of climate change and tourism in South

Africa. Furthermore, the majority of the respondents emphasized the fact that the TCI or any similar models cannot be used as the primary research tools for tourism and climate research in the future. Respondent 5 said:

> *Although the TCI and similar models may be potentially valuable to the climate change and tourism research efforts, it cannot be used in isolation, there needs to be a multi-dimensional approach to tourism and climate research in South Africa*.

Respondent 6 made it clear that the TCI cannot be used in isolation, and said "*the TCI is only as useful as the research that surrounds it or that makes use of it*". Respondent 1 held a similar perception and stated:

> *The tourism climate index can definitely add value to the current research, but must be used to supplement the already existing and future research on climate change and tourism in South Africa*.

Despite acknowledging that the TCI could add value to the current climate-tourism research in South Africa, a couple of respondents highlighted a perceived limitation to the model. The respondents commented on the fact that it takes no account of how climate is influencing actual tourist numbers at each location. Respondent 2 stated "*future work can look at finding a relationship between the TCI results and actual tourism numbers*", while respondent 6 shared the same sentiment and said "*it would be interesting to see how the TCI results relate to the actual tourist numbers at each location*". It is notable given these perceptions that the respondents were not willing to engage in this component of my questionnaire. This study intended to do exactly that, and quantitatively test the efficacy of TCIs. However, counts of tourist numbers are difficult to obtain and are often unreliable. If respondents are unwilling to provide an estimate of these numbers, then it becomes very difficult to achieve this. Nevertheless, the respondents' need for an integrated model that can account for the influence of climate change on tourism by accounting for the change in actual tourist numbers in response to the changing climate conditions, demonstrates a conscious awareness that the TCI or a similar model can be effectively used to increase the adaptive capacity of the tourism sector in South Africa.

There was one respondent that was strongly opposed to the use of the TCI and saw no value in the TCI as a supplementary tool to the current tourism and climate change research in South Africa. The respondent stated "*I am very skeptical about the TCI and don't believe it to be a promising tool that can be used in conjunction with the current or future tourism* *research*". The respondent did not provide an alternative tool to incorporate the climate sciences and tourism studies in a quantitative manner to be able to determine areas under greatest threat.

5.6.4. Other factors Perceived to be Drivers of Tourism Flows in South Africa

All the respondents held the perception that the tourism product offering in South Africa at each location was the main determinant that drives tourism flows in the country. Respondent 4 stated "*the fundamental determinant is whether or not there are decent tourism product offerings at a particular location*", while respondent 2 said:

> *South Africa has a wide variety of tourism destinations, each with multiple types of tourist activities, and this is what makes the country an attractive tourism destination*.

Issues such as crime, safety and security, political stability in the country, quality of infrastructure and cost of the experience were all mentioned by the respondents. The majority of the respondents stated that these issues are considered as threats to the tourism product offerings and not so much a determinant to tourism flows in the country. Respondent 1 stated "*at each location, there will be threats to the tourism product and the tourist will make trade-offs based on those threats*". Beach and water activities are often the main tourism offerings at coastal destinations, while other regions rely on nature-based tourism to attract tourism, however, none of the respondents perceive the success of those offerings as relying on climate. Furthermore, respondents noted that other issues may impact tourism, like the quality of infrastructure, which could be damaged during flooding.

Two of the respondents touched on the issue of destination marketing and highlighted the importance of it. The respondents both indicated that destination marketing is particularly important for attracting international tourism markets. Respondent 3 stated "*it is important to get markets abroad to know about the tourism products in South Africa*". Neither respondent commented on the influence of climate change for marketing strategies, nor whether marketing would be sufficient to draw in tourists who have been deterred by climate change.

From the perspective of climate change mitigation, the majority of the respondents acknowledged that the international tourism flows, particularly from Europe to South Africa could be potentially impacted on because of the European Union's attempt to cut down the level of carbon dioxide emissions being released during long haul flights. Respondent 5 stated:

> *South Africa could lose a portion of the European tourism market, due to the European Union's regulations on carbon emissions, which attempt to reduce the level of long haul flights*.

However, at the same time respondent 5 said:

> *Airlines are also adapting their aircrafts to be more efficient, and they are becoming more conscious of global climate change, and therefore people see and appreciate their efforts and continue to take the long hauls flights*

Respondent 1 shared the same sentiment and said:

The technological advances that airlines are making to improve their fuel efficiency are improving all the time, therefore this issue will not have a significant impact on the tourism market in South Africa.

These perceptions held by the respondents regarding the influence of adapting travel behavior within the tourism sector, elude to the bilateral relationship between climate change and tourism. It demonstrates that tourism is a contributor to global climate change, while simultaneously trying to reduce the impacts so as to not be impacted by the effects of the same issue. Furthermore, it highlights the awareness within the tourism sector of the importance of adaptation and how it can effectively reduce the negative influence of climate change.

It was mentioned that the European markets and tourism destinations are conscious of climate change. Respondent 5 added "*South Africa needs to market itself as a climate change conscious destination because if we don't, we could lose a significant share of the international tourist market*". However, respondent 2 held a contrasting perception and said:

South Africa would lose no tourists due to a lack a climate change consciousness due to the very fact that South Africa is a very attractive tourist destination.

5.7. Conclusion

The mean annual traditional TCI scores for the respective locations for the periods 2005-2014 and for the longest continuous time period, predominantly demonstrate TCI scores above 80 and are classified as having excellent climatic conditions for tourism. However, for both time periods, the coastal locations of East London and Port Nolloth demonstrate relatively low TCI scores, ranging from 76.50 to 79.20, when compared to the other coastal locations, such as

Cape Town and Port Elizabeth. It is important to note that despite these two locations having a lower TCI score then the other locations, their climate suitability is still considered very good for tourism. These results indicate that at an annual scale, these locations can still offer different tourist products, such as beach and water activities, adventure tourism and nature-based tourism activities, without being negatively impacted by negative climatic changes. Mean monthly traditional TCI scores indicate that the majority of the locations see a decline in the TCI scores during the winter months of the year, where the climatic conditions go from excellent to ideal during the summer months to very good in winter. Cape Town experiences a considerable drop in TCI scores during winter, where the climate suitability drops from excellent and ideal to being considered acceptable. This is predominantly due to the compounding effects of multiple negative climate controls, specifically increased rainfall and cold temperatures.

The mean annual mathematically adapted TCI scores for the respective locations for the periods 2005-2014 and for the longest continuous time period, mostly demonstrate TCI scores above 80 and are classified as having excellent climatic conditions for tourism. The TCI score in Belfast suggests that the climate suitability of the area for tourism is very good, while the TCI score for Pilanesberg which is above 90 for both time periods, indicates that the climate suitability for tourism in that region is ideal. The mean monthly mathematically adapted TCI scores demonstrate similar patterns to those of the mean monthly traditional TCI results. The mean monthly mathematically adapted TCI scores indicate that the majority of the locations experiences very good climate conditions during winter, while conditions during summer are considered excellent to ideal. However, Pilanesberg demonstrates monthly TCI scores that suggest the climate suitability for tourism is excellent to ideal all year round. The mean monthly TCI scores in Nelspruit indicate that the best climatic conditions for tourism during the year are autumn and spring. Paarl demonstrates very similar patterns to Cape Town in terms of monthly TCI score classifications, with the winter months being classified as having acceptable climate conditions, while the rest of the year is considered to have ideal climate conditions with TCI scores above 90.

For the period 2005-2014, the majority of the trends between the annual traditional TCI scores and time demonstrate decreases in the TCI scores. These trends were all statistically insignificant. However, the remaining locations of Bloemfontein, East London, Johannesburg and Port Nolloth all demonstrate positive trends over the same time period, with only Port Nolloth demonstrating a statistically significant positive trend of 0.93units/year. The majority of the annual trends for the mathematically adapted TCI scores were increasing over the period 2005-2014, with Knysna and St Lucia both demonstrating statistically significant increases of 0.76units/yr and 0.50units/year respectively. For the same period, Belfast, Paarl and Pilanesberg all demonstrate statistically insignificant decreases in their TCI scores for that period.

In light of that, respondents were aware of climate change and demonstrated a reasonably in-depth understanding of climate change. In saying that, the majority of the respondents perceived climate change to be a distant threat to the South African tourism sector and that under current climatic conditions tourism would not be negatively impacted. In addition, all of the respondents noted that the tourism sector would be negatively impacted when there are major increases in extreme events, such as flooding and droughts. However, none of the respondents could provide a time frame for when they thought the impacts of climate change would start being felt in South Africa. In light of that, all the respondents acknowledged the need for more research surrounding climate change and tourism in the country, due to the major role that the tourism sector plays in the country. However, the respondents did perceive climate change to be a small issue at the moment, compared to other issues such as crime and poverty that face the country at the moment.

The majority of the tourism academics and researchers who were interviewed were not familiar with the TCI, despite their extensive coverage in tourism literature. However, the majority of them did think there was a need for and value in incorporating a quantitative tool into the current tourism and climate change research agenda. The majority of the respondents found it useful to quantify the impacts of climate change on the tourism sector and said that future research should make use of such tools to understand the climate change threats that the tourism sector faces.

Some of the respondents highlighted the need for the TCI results to be compared to actual tourist numbers, which was an original aim of this study. However, this study cannot quantitatively state how accurate the TCI results are, because the respondents did not want to engage with whether or not they perceived the results to be accurate based on their perceptions, because of their limited knowledge of the TCI model. For places that are demonstrating negative TCI trends, this indicates that the theoretical climate suitability for tourism is declining. However, some of the respondents noted that all locations are seeing an increase in tourism numbers. This highlights that there are enough drivers that are still attracting tourist to South Africa, despite some locations seeing a decrease in climate suitability for tourism.

Chapter 6: Discussion

6.1. Introduction

The aim of this study was to quantify the influence of climate change on the South African tourism sector, by determining the climate suitability of various destinations across the country for tourism, using the TCI. In addition, this study aims to make an important contribution to the regional and global understanding of climate suitability shifts and the rate at which these shifts are taking place in response to a changing climate. The need for this research is emphasized through the knowledge gaps that were identified in *Chapter 2 (Literature Review)*. The results of the TCI scores and the perceptions held by the tourism academics are presented in *Chapter 5 (Results).* This chapter will critically analyze and discuss the results of this study in comparison to the results obtained in other studies pertaining to TCI scores and climate change and tourism.

This discussion will be split into three broad sections. The first third of the discussion will assume the TCI results to be accurate, and will explore the spatial and seasonal patterns in tourism suitability of climate in South Africa. The second third of the discussion will interrogate the accuracy and validity of the TCI results and the use of the TCI model in the South Africa context. The final part of this chapter discusses the limitations in this study, from data constraints and adapting to those constraints, through to major restrictions regarding the reluctance of tourism stakeholders to engage with this study. Lastly, this chapter provides suggestions for future work on tourism and climate change in South Africa, and the need for research to extend to other developing nations in Africa that rely heavily on tourism to drive social and economic development.

6.2. Spatial Patterns in Tourism Suitability of Climate in South Africa

6.2.1. Spatial Patterns in Mean Annual TCI Scores

In a broad-based global study, Amelung *et al*. (2007) calculated the TCI for all destinations across the globe for the 1970s. The TCIs that were calculated for the 1970s during this study by Amelung *et al*. (2007), were used to represent current conditions at the time of the study, and were based on historical meteorological data. Despite the study having calculated the TCI for every month of every year based on the historical meteorological data, the results focused on the TCI scores calculated for the months of June, July and August during the period of the 1970s (Amelung *et al*., 2007). Amelung *et al*. (2007), obtained relatively low resolution results across the globe, and indicated that most of South Africa in June, July and August during the 1970s were considered to have an excellent to acceptable climate suitability for tourism (Figure 6.1).

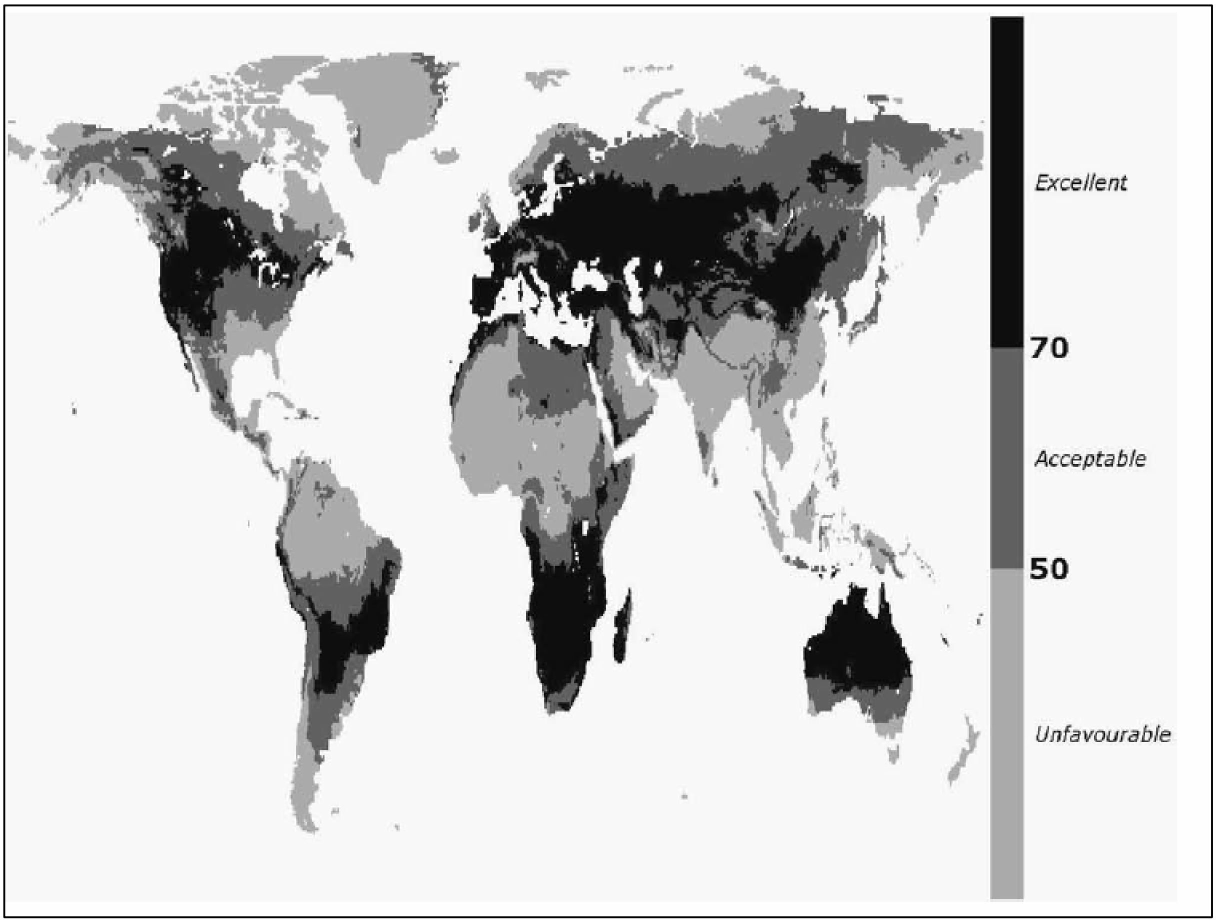


Figure 6.1: The TCI scores for June, July and August during the 1970s (Amelung *et al*., 2007).

However, the distributional impacts of climate change are not evenly spread across the globe, and can vary at a regional or even local scale (Mendelsohn *et al*., 2006; Mertz *et al*., 2009). More importantly, it has been stipulated that the distribution of tourists temporally throughout the year and the environmental context in which tourism occurs is greatly influenced by climate (Moreno, 2010; Scot and Lemieux, 2010). That said, the results of this study (*Figure 6.2* and *6.3*) demonstrate that the climate suitability for tourism at destinations across South Africa vary, which indicates that the changing climate is having a different impact at each individual destination. *A*llocating a general TCI score or classification at a regional scale for a country, specifically South Africa in this case, can greatly misrepresent the climate suitability of specific individual destinations, with the annual mean TCI scores in this study ranging from 74.88 for Belfast to 93.00 for Pilanesberg (*Figure 6.2*). Although the majority of the destinations all demonstrate excellent climate conditions for tourism (*Figure 6.2 and 6.3*), tourists and other tourism stakeholders can evaluate the magnitude and extent to which each destination is considered to be excellent and can make planning decision based on destinations specific data. Ultimately, the results obtained by Amelung *et al*. (2007) provide a distorted representation of the impacts of climate change on tourism at different destinations around the globe. However, the TCI results in this study are calculated at a far greater resolution and provide tourism stakeholders with a far better opportunity to plan and implement destination specific adaptation strategies (Simpson *et al*., 2008; Amelung and Nicholls, 2014). The destination specific TCI results of this study allow for the distributional impacts of climate change to be assessed, which will consequently allow government and tourism planning bodies to better prepare for, and deal with the, impacts of climate change on the tourism sector in South Africa (Simpson *et al*., 2008; UNWTO and UNEP, 2008).

The mean annual TCI scores for the period 2005-2014 and for the longest continuous period at each study site (Figure 6.2; Figure 6.3) do not demonstrate any clear spatial patterns, other than the fact that the majority of the study sites, both coastal and inland have excellent to ideal climate conditions for tourism. Although East London, Belfast and Port Nolloth all demonstrate very good climate conditions, with TCI scores ranging from 74.88 for Belfast to 79.20 for East London, it still does not indicate any clear spatial patterns between the different study sites. Two of the respondents interviewed in this study, perceived coastal regions to be particularly vulnerable to climate change and stated that these regions should be concerned about the future changes in climate. Two out of the three study sites (East London and Port Nolloth) that demonstrated relatively lower TCI scores were situated along the coastal regions of South Africa (Figure 6.2). These TCI results suggest that the perceptions of the two respondents, regarding the vulnerability of coastal regions to climate change, are accurate to some extent and that climate change is negatively influencing the climate suitability for tourism at coastal regions more so than at inland destinations of the country.

Nevertheless, the favourable climate conditions for tourism experienced at the majority of the study sites suggest that there is an opportunity for increased participation by tourists in outdoor activities in South Africa (*Figure 6.2* and *Figure 6.3*). Outdoor activities form one of the most prominent tourism markets in South Africa due to the South Africa’s high levels of biodiversity and pristine landscapes, such as going to the beach, visiting national parks, camping, hiking, and other activities that involve moderate to low levels of activity (Spenceley and Goodwin, 2007; Stevens *et al*., 2014; Hoogendoorn *et al*., 2016).

It is important to note at this stage, and reiterate that which was mentioned previously, the TCI was originally developed to quantify the climate suitability of destinations, and to determine when is the best time of the year in terms of climate to visit a destination (Amelung and Nicholls, 2014). It was not developed to be used as a tool to predict tourist arrivals at destinations (Amelung *et al*., 2007; Fang and Yin, 2015). Therefore, the calculated TCI scores at Cape Town, Paarl, Knysna, Port Elizabeth, Durban, Ladysmith, St Lucia, Bloemfontein, Bethlehem, Kimberley, Pretoria, Johannesburg, Nelspruit and Polokwane, which indicate excellent climate conditions for tourism, will not necessarily have high levels of tourists visiting those destinations. Similarly, Belfast, Port Nolloth and East London demonstrate relatively lower TCI scores compared to the rest of the study sites over the period 2005-2014, but this does not translate into lower levels of tourists visiting those destinations.

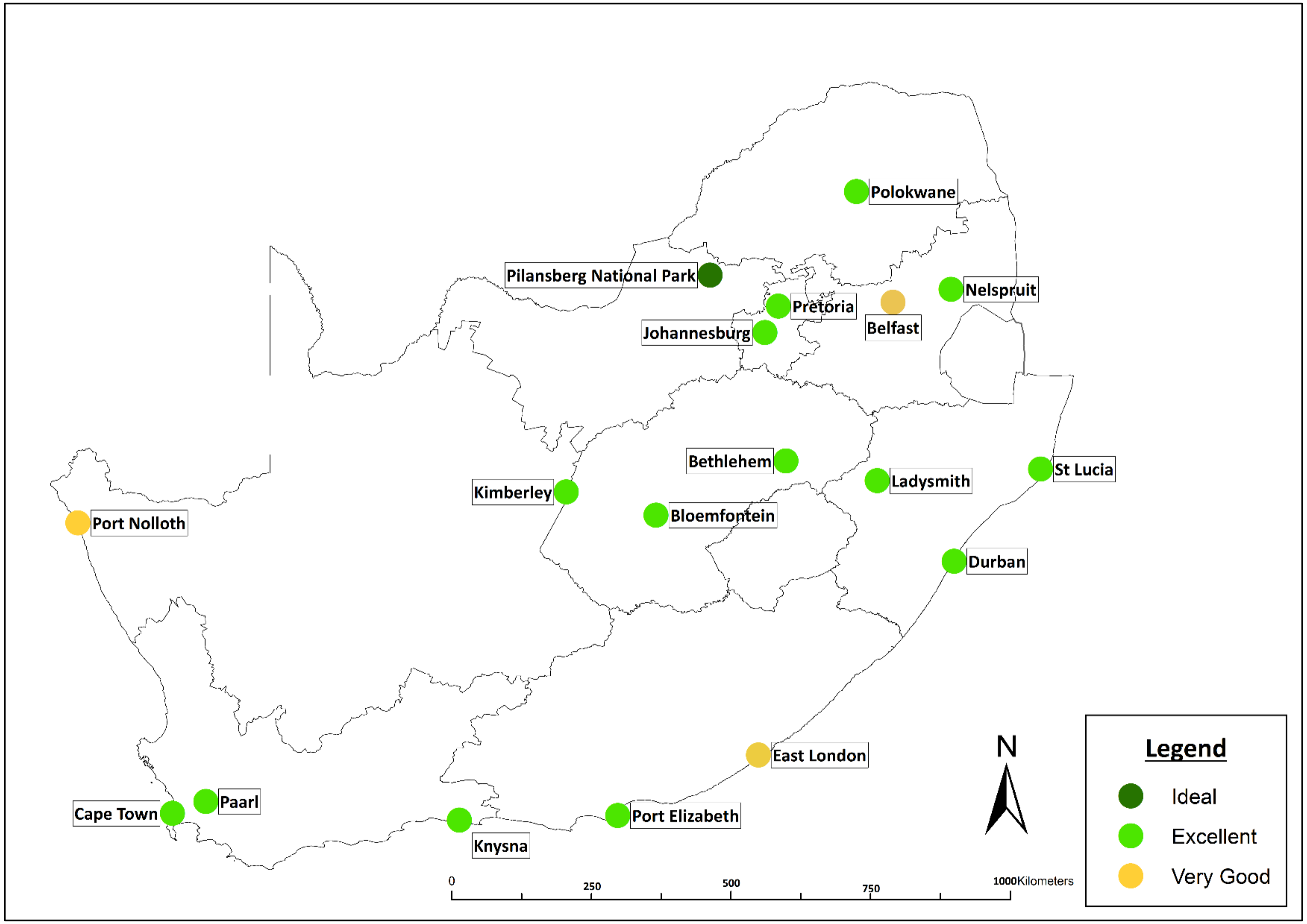


Figure 6.2: The climate suitability for tourism of each of the study sites, based on the mean annual TCI scores for the period 2005-2014.

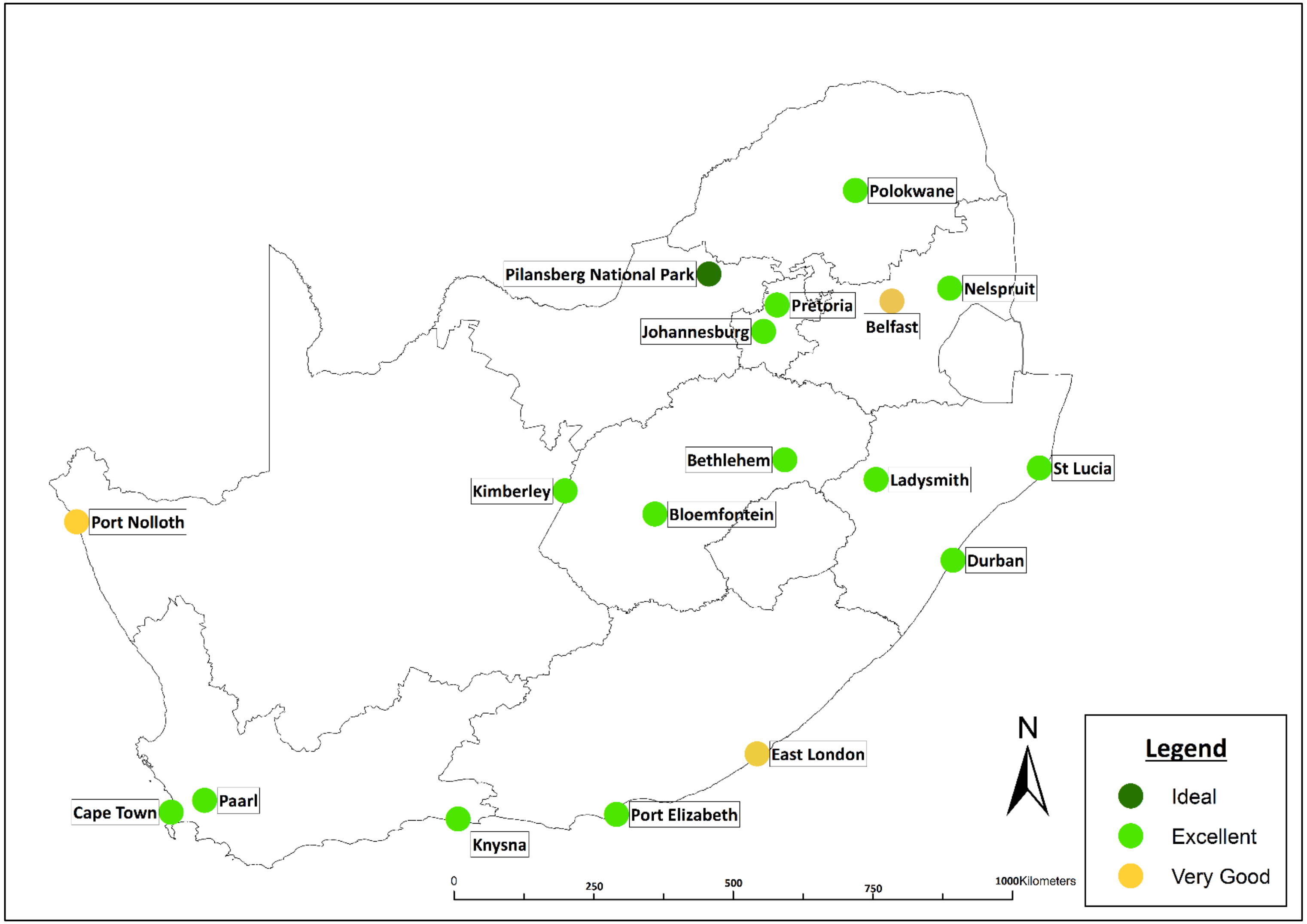


Figure 6.3: The climate suitability for tourism of each of the study sites, based on the mean annual TCI scores for the longest continuous period.

For a place to be considered a successful tourist destination it must have a range of factors, from quality transport that provides ease of access, infrastructure, a safe environment, appealing tourist attractions, and not just a favourable climate (Amelung and Nicholls, 2014; Olya and Alipour, 2015). The majority of the respondents that were interviewed in this study acknowledged that the climate suitability of a destination is not the sole factor that draws tourists to a destination. However, the respondents all perceived the tourism product offerings of an area to be the main determinant in an individual's choice of destination, and that other factors such as the quality of infrastructure, crime and transport, could be seen as threats to the tourism products and will therefore be traded off against the tourism product offerings (Scot and Lemieux, 2010).

Due to the fact that the mean annual climate suitability for tourism classification at each location remained constant over the period 2005-2014 and the longest continuous time period at each location, and with only slight increases or decreases in the mean annual TCI scores across both periods, the subsequent section of this discussion will only make reference to the TCI scores for the period 2005-2014.

6.2.2. Spatial Patterns of Climate Factors Influencing the Mean Annual TCI Scores

Although there were no obvious spatial patterns in the TCI scores for the period 2005-2014 across South Africa, there are far more obvious spatial patterns when looking at the meteorological factors that had the most negative influence on the mean annual TCI scores for the period 2005-2014. Rainfall has a strong negative influence on the TCI scores at destinations along the coastal regions of South Africa, particularly on the eastern coast and at some destinations over the northern interior (*Figure 6.3*). The generally warmer climate and warm Agulhas current that flows along the east coast of the country, plays a major role in bringing increased levels of rainfall to regions along the east coast, while warm temperatures and moist air pushing down from the ITCZ in summer brings rainfall to the northern parts of the country (Dyson, 2015). Similar results in Northern Cyprus indicate that increased levels of rainfall result in a negative influence on the TCI score of a destination or region (Olya and Alipour, 2015). Although, the climate of Northern Cyprus is considered Mediterranean, and the majority of their rainfall occurs in winter, the results along with results from similar studies (c.f. De Freitas *et al*., 2008; Day *et al*., 2013; Jeuring and Becken, 2013) suggest that rainfall is a factor that greatly reduces the comfort of tourists. Therefore, it can be noted that TCI scores at destinations in South Africa that are negatively influenced by rainfall, are likely to experience a decrease in climate suitability as a result and the tourists overall comfort will consequently decrease due to the negative influence of rainfall.

The future rainfall projections under all emission scenarios indicate that rainfall all across South Africa is set to decrease by 10% to 15% (Jawtusch, 2014). Although this may pose some negative threats to South Africa (Nhemachena *et al*., 2014; Araujo *et al*., 2014), it also suggests that destinations whose climate suitability are negatively influenced by rainfall across South Africa (*Figure 6.3*) may see an improvement in their TCI scores as a result of the projected decrease in rainfall in the future. This decrease in rainfall will allow these destinations to market themselves as more climatically attractive, which may draw more tourists and ultimately boost local economic development in those South African regions.

It is also interesting to note that Paarl, which has a Mediterranean climate, demonstrated similar results to the study by Olya and Alipour (2015) in the northern parts of Cyprus. As for the northern parts of Cyprus, Paarl receives the majority of its rainfall in winter, and similarly rainfall was found to be the factor that negatively influenced the climate suitability of the region the most (*Figure 6.3*). However, Cape Town, which exhibits a Mediterranean climate demonstrated contrasting results to the study by Olya and Alipour (2015), with the average thermal comfort (CA) being the factor in the TCI that most negatively influences climate. In fact, both the western coast study sites climate suitability of Cape Town and Port Nolloth were negatively influenced by average thermal comfort (*Figure 6.3*). The average thermal comfort component of the TCI formula is calculated as an effective temperature and utilises mean daily temperature and mean daily relative humidity to arrive at the resultant effective temperature, and represents conditions of thermal comfort over 24 hours of the day (Perch-Nielsen *et al.,* 2010; Rosselló-Nadal, 2014). Mieczkowski (1985) stipulated that the diurnal differences are an important comfort factor, and additionally stated that:

> The Physiological effect of a cool night/ hot day sequence is important in daytime comfort because after a comfortable night one is better able to stand up to an uncomfortable day.
>
> [Mieczkowski, 1985: 225]

Therefore, the climate suitability is negatively influenced in Cape Town and Port Nolloth due to the cooler climate and moderating effects of the cold Benguela which make the temperatures too cool for tourists to feel comfortable at all times during the day. Over the central interior and northern parts of the country, Bethlehem, Bloemfontein, Kimberley, Johannesburg, Belfast and Polokwane are most negatively affected by the average thermal comfort component of the TCI in terms of their climate suitability for tourism (Figure 6.3). Unlike Cape Town and Paarl, these destinations are not influenced by the cooling effects of the Benguela current, but are rather influenced by greater variations in their diurnal temperature ranges as a result of the effects of continentality. The effects of continentality make the average daily temperature in these regions much cooler than the temperatures that are considered comfortable for tourists according to the TCI.

The future temperature projections indicate that temperatures throughout South Africa will increase considerably, which suggests that Cape Town and Port Nolloth and the destinations over the central and northern interior will have increased average daily temperatures and will consequently have an improved average thermal comfort (CA). Ultimately, the increase in temperature will potentially raise the temperature to a point that is considered comfortable according to the TCI model, and thus resulting in an improved climate suitability for those regions.

The climate suitability at the majority of the study sites, barring Port Nolloth and Belfast, are all positively influenced by the daytime thermal comfort (CD) component of the TCI (*Figure 6.4*). The daytime thermal comfort component of the TCI employs maximum daily temperature and minimum daily relative humidity (both of which usually occur between 12h00 and 16h00) to obtain a reading given as an effective temperature in degrees Celsius (Perch-Nielsen *et al.,* 2010; Kovács and Unger, 2014). The CD, given as an effective temperature represents the temperature that tourists usually experience when they tend to be most active during the day between 12h00 and 16h00 (Mieczkowski, 1985).

The locations that indicate that CD has the most positive influence on their climate suitability for tourism, could be negatively influenced by future increases in temperature (Karmalkar *et al*., 2012; Ziervogel *et al*., 2014; *Figure 6.4*). The climate suitability of all the locations in Figure 6.4 that are depicted as being most positively influenced by CD are already all experiencing temperatures that are within the optimal temperature range or just below and are considered favourable and all have received a rating of between 4.5 and 5, with five being the highest possible rating for this component of the TCI (Perch-Nielsen *et al.,* 2010; Table 6.1). The highest optimal threshold for the CD component of the TCI is 26°C, anything above that is considered to have a negative influence on the thermal comfort of tourists (Mieczkowski, 1985). Current projections indicate that temperatures throughout South Africa are set to increase by 4.3°C by 2090 (Ziervogel *et al*., 2014).

Based on the current temperature projections, the climate suitability of Bloemfontein, East London, Johannesburg, Kimberley, Knysna, Nelspruit and Paarl by 2090 will still be most positively influenced by the daytime thermal component of the TCI model, and the effective temperature will remain within the optimal temperature range which is most comfortable for tourists according to the TCI model developed by Mieczkowski (1985) and adapted by Perch-Nielsen *et al. (*2010) (*Table 6.1*). The future temperature increases by 2090 will result in the CD effective temperature shifting into the optimal temperature range for daytime thermal comfort in Bethlehem, Cape Town and East London. Consequently, the climate suitability in these regions will further improve and the CD component of the TCI model will become an increasingly more positive influence on the climate attractiveness of these particular regions. The future CD ratings for all the places that indicate that CD is the most positive influence on their climate suitability, and the resultant future effective temperature and CD rating under the future 4.3°C temperature increase based on projections for 2090 (*Table 6.1* and *Figure 6.4*).

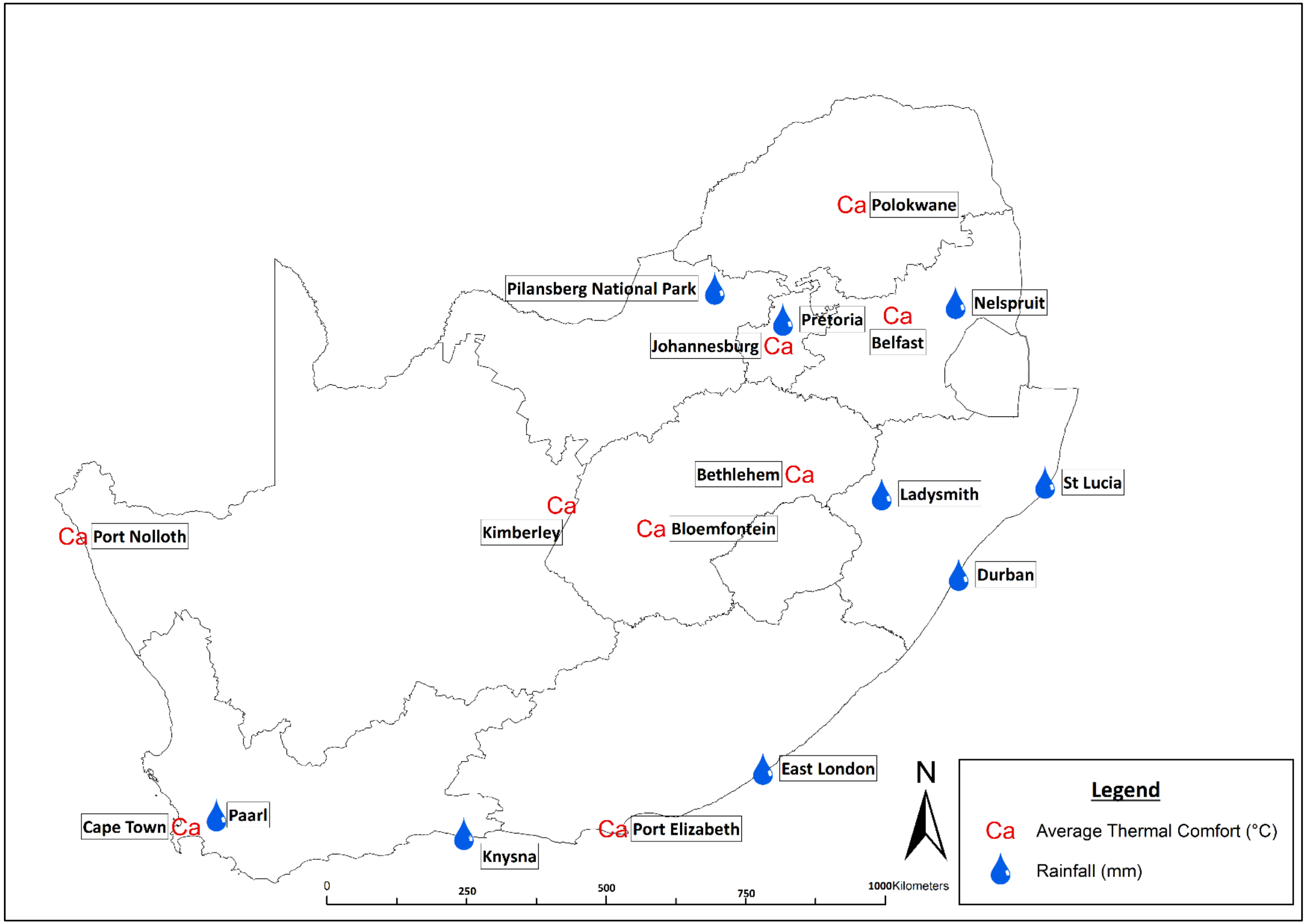


Figure 6.4: Components of the TCI model that have the most negative influence on the mean annual TCI score for the period 2005-2014.

Table 6.1: The current effective temperature readings for the daytime thermal comfort (CD) component of the TCI. (Green represents an increase in CD rating and red represents a decrease CD rating based on shifts from current to future temperature projections).

Location	Current Effective Temperature (°C)	Future Effective Temperature (°C)	Future CD Rating (0-5)
Bethlehem	19.75	24.05	5
Bloemfontein	21.28	25.58	5
Cape Town	19.75	24.05	5
East London	20.04	24.34	5
Johannesburg	20.19	24.49	5
Kimberley	21.45	25.75	5
Port Elizabeth	19.95	24.25	5
Polokwane	21.78	26.08	4.5
Durban	22	26.3	4.5
Knysna	20.61	24.91	5
Ladysmith	21.87	26.17	4.5
Nelspruit	21.43	25.73	5
Paarl	21.49	25.79	5
Pilanesberg	23.48	27.78	4.5
Pretoria	22.08	26.38	4.5
St Lucia	22.98	27.28	4.5

However, the effective temperature for the CD component of the TCI model in Polokwane, Durban, Ladysmith, Pilanesberg, Pretoria and St Lucia, by 2090, will increase to an extent that exceeds the optimal temperature range that is considered to be comfortable for tourists (Perch-Nielsen *et al.,* 2010). Although, CD may remain the most positive factor influencing the climate suitability in these regions, the extent to which it has a positive influence on the climate suitability may diminish over time. This should be continually monitored, and future studies using TCI results based on future climate change modelled data should explore the extent to which these results would differ.

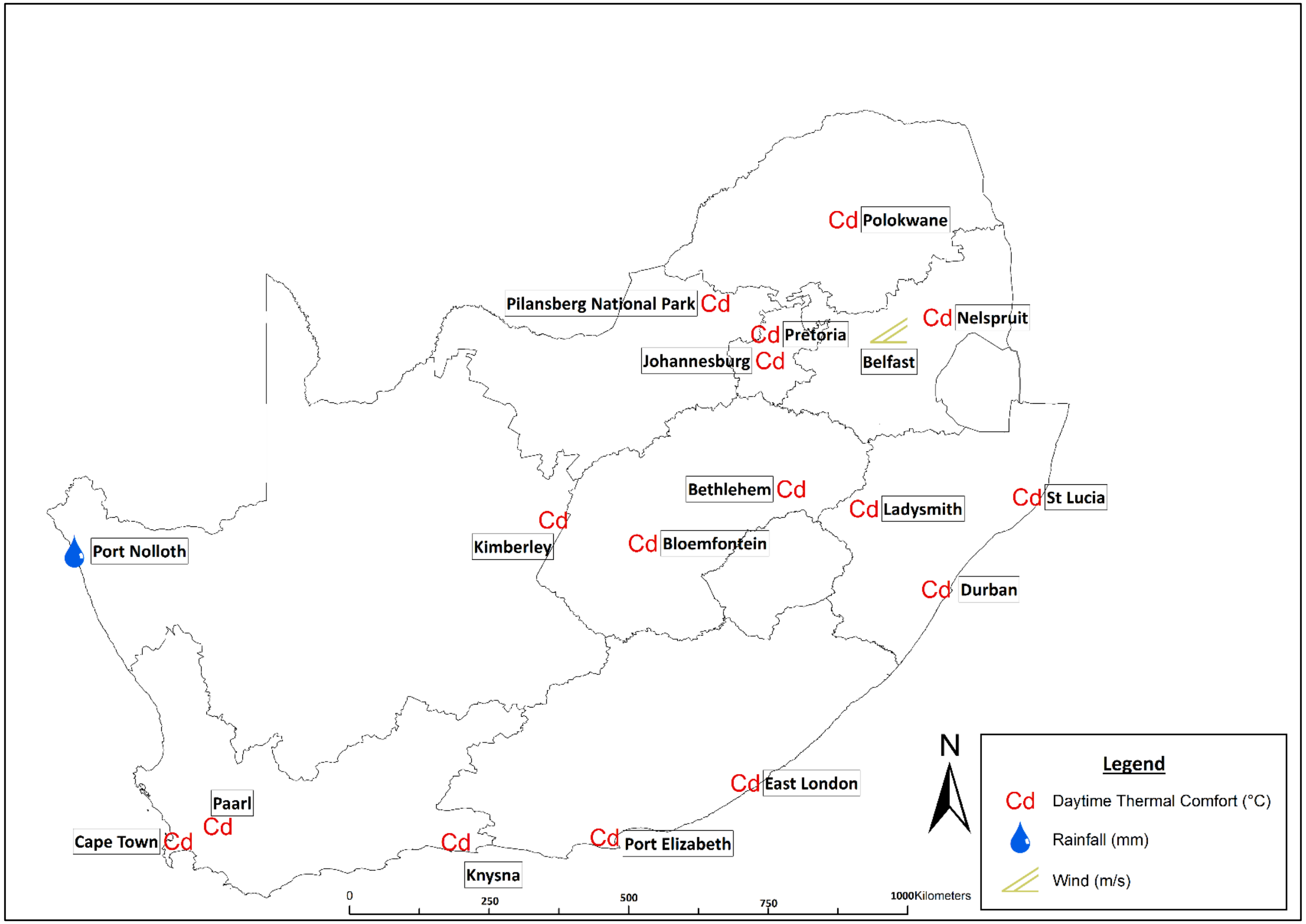


Figure 6.5: Components of the TCI model that have the most positive influence on the mean annual TCI score for the period 2005-2014.

6.3. Seasonal Patterns in Tourism Suitability of Climate in South Africa

6.3.1. Winter

Winter in South Africa occurs from May to July (Brand South African, 2015). There is a clear latitudinal gradation in the climatic suitability during the winter season in South Africa, with the worst climate conditions for tourism occurring in the south of the country at Cape Town, and improvement in conditions over the eastern and northern regions of the country where climate suitability for tourism becomes excellent (Figure 6.5).

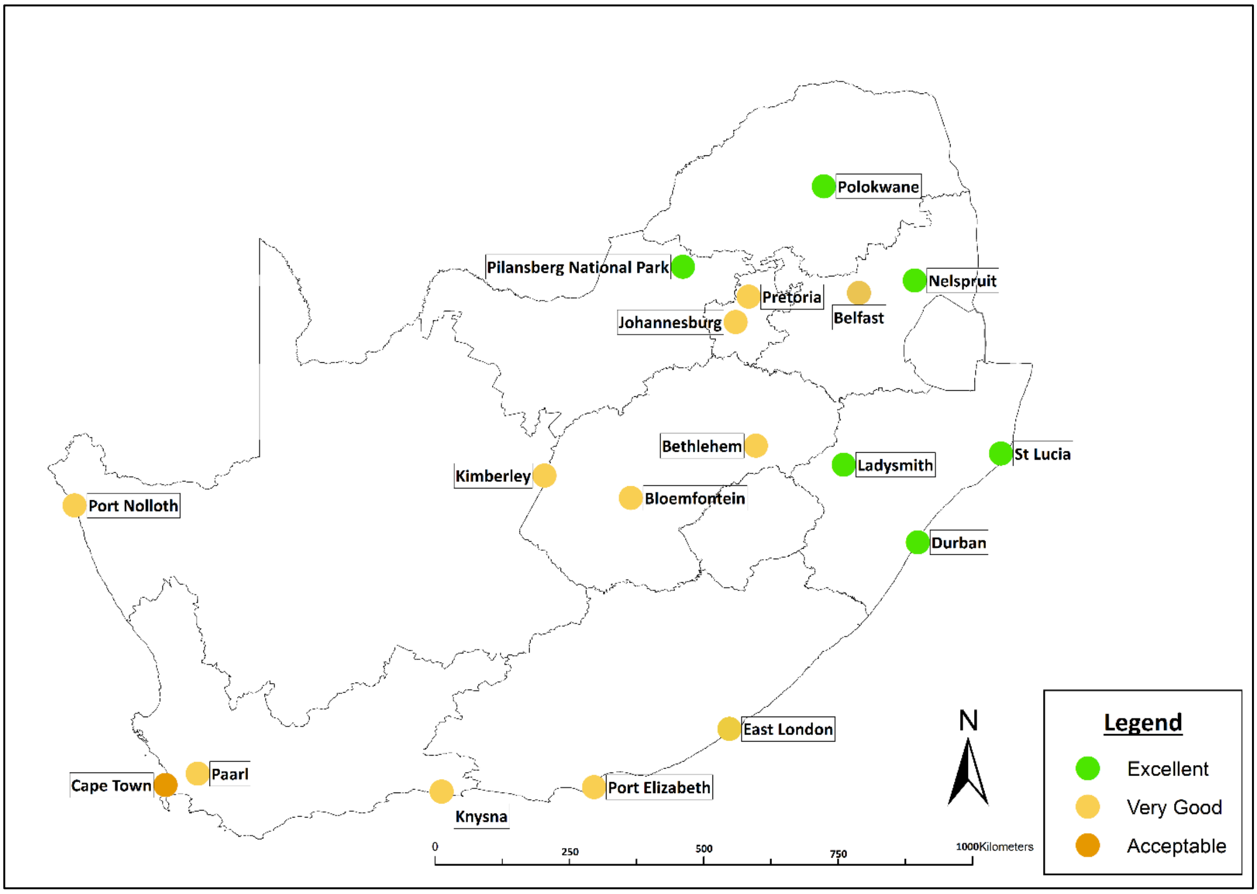


Figure 6.6: The climate suitability for tourism of each study site during winter based on the mean monthly TCI scores for the period 2005-2014.

Winter over KwaZulu-Natal is often characterised by hot and humid conditions, and therefore is usually ideal for tourism during this time of the year (Brand South African, 2015). The excellent conditions experienced over the eastern region of the country in KwaZulu-Natal, with Ladysmith, Durban and St Lucia demonstrate excellent climate suitability for tourism during winter (*Figure 6.6*). Nelspruit has excellent climate conditions for tourism during winter and this is due to the warmer temperatures over the Lowveld. This suggests that nature-based tourism, which forms a prominent part of the tourism sector in this region, would thrive under these excellent conditions (Hoogendoorn *et al*., 2016; *Figure 6.6*). In Iran, the highest TCI score that was calculated during the start of winter (December) was 88.9 for Chabahar, a city located in the southern regions of the country, where the warm winter is considered to also have favourable conditions for tourism, similar to Durban, Ladysmith, St Lucia, Polokwane, Nelspruit and Pilanesberg (Roshan *et al.*, 2016; *Figure 6.6*). However, the highest TCI score calculated for winter in South Africa in this study was 91.38 and indicates that the warm conditions in the eastern parts of South Africa during winter offer slightly better climate conditions for tourism than the southern parts of Iran during the same season (Roshan *et al*., 2016).

The rest of the destinations are all classified as having very good to acceptable climate conditions for tourism (*Figure 6.6)*. This is due to the cold rainy conditions experienced over the south eastern and western coast of the country, while destinations over the central and northern interior are influenced by extremely cold temperatures which are considered uncomfortable for tourism according to the TCI model developed by (Mieczkowski 1985).

The lowest TCI score calculated in Iran for period 1961-2010 during winter, was for Anzali (39.4) which is situated along the northern coast of the country along the Caspian Sea. In addition, a study found that in the three capitals of the South Caucasus Countries of Georgia, Armenia and Azerbaijan, the lowest TCI scores in all three cities fell below 48 units and all the lowest TCI scores occurred during winter (Amiranashvili *et al*., 2014). This suggests that although South Africa, has relatively low TCI scores at many destinations across the country during winter, with Cape Town having the lowest score of 57.40, there are still other destinations around the world that have considerably greater unfavourable conditions for tourism during winter. This could potentially make South Africa a more attractive destination to travel to in winter, especially for international tourists. Data such as those conveyed in *Figure 6.6* would allow tourism stakeholders in South Africa the chance to identify that climate suitability for tourism in many parts of the country may not be suitable for outdoor tourism activities. This would then allow them to possibly adapt their tourism product offerings to tourism activities that are more orientated to indoors where conditions may be more favourable for tourism (Simpson *et al*., 2008).

6.3.2. Spring

The west coast and south eastern coasts in South Africa, such as many places in Iran (Roshan *et al*., 2016), experience a decrease in precipitation and an increase in temperatures in spring (Roshan *et al*., 2016). The warmer temperatures in spring bring more favourable conditions to most of the country, particularly destinations such as Kimberley, Bloemfontein and Bethlehem, over the central interior and Johannesburg and Pretoria over the northern interior (*Figure 6.7*). Despite most of the destinations having excellent climate suitability for tourism during spring in South Africa, destinations such as East London, Port Elizabeth, Knysna, Cape Town, Paarl and Port Nolloth, all still experience some rainfall and therefore the climate suitability still remains only very good during spring (Figure 6.7). The climate suitability for tourism of these destinations along the western and south eastern coast of South Africa during spring, are similar to the climate suitability experienced at destinations along the Caspian coast in Iran during the same season. This is due to the fact that they experience similar climate conditions during spring, with some rainfall still occurring during this time of year. However, the TCI scores for these regions in South Africa still remain considerably higher during spring than the destinations with similar climate conditions in Iran, and still make these destinations more climatically attractive in spring.

The overall climate suitability for tourism in China in spring is considered to be good (TCI ranging between 60-79) to acceptable (TCI score ranging between 40-59) for the period 1981-2010 (Fang and Yin, 2015). This suggests that during spring the overall climate suitability of South Africa can be considered more attractive for tourism than China, due to the fact that large parts of the country have excellent climate suitability for tourism (Fang and Yin, 2015). Having this sort of information, would allow tourism stakeholders to better market their tourism product offerings and destinations against competitive markets.

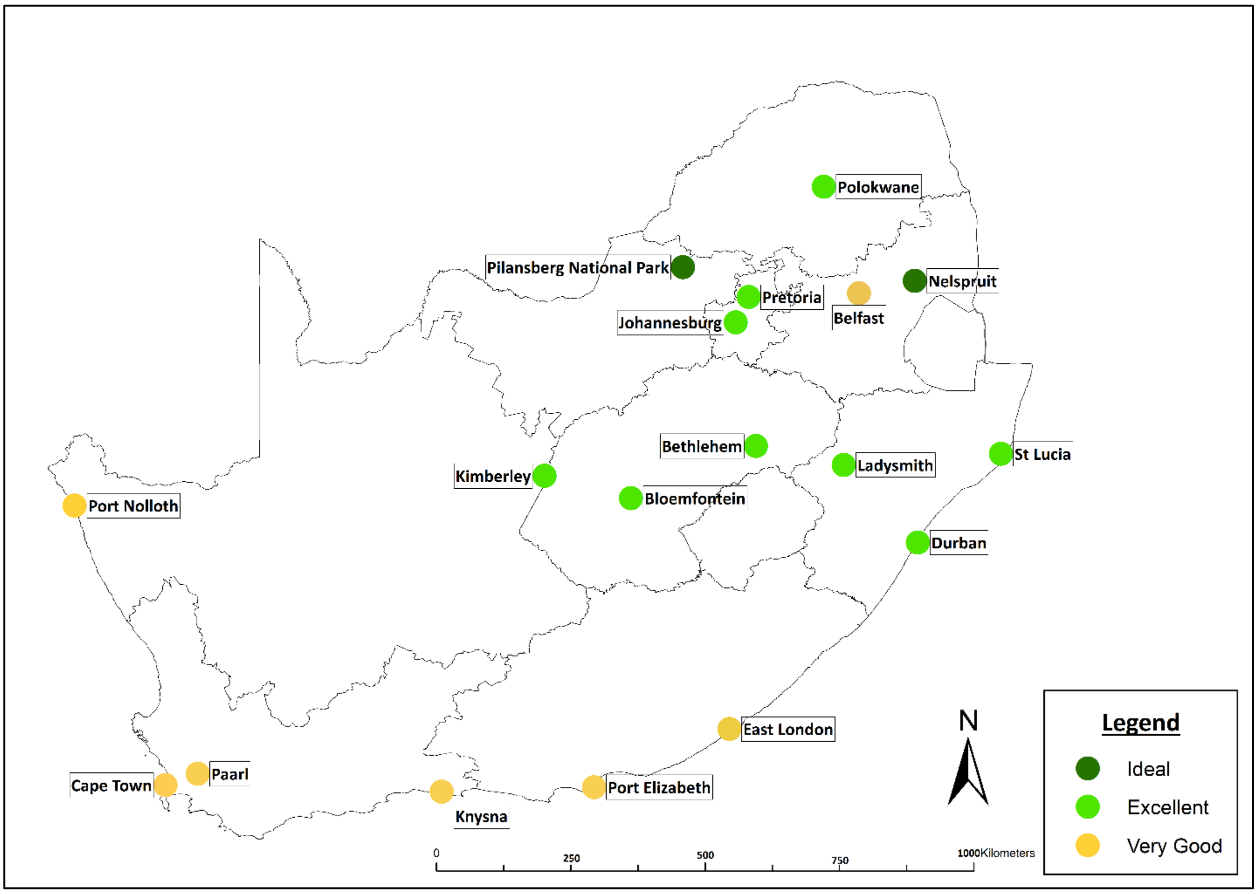


Figure 6.7: The climate suitability for tourism of each study site during spring based on the mean monthly TCI scores for the period 2005-2014.

6.3.3. Summer

Most of South Africa is characterised by hot weather and clear skies in summer, with chances of rain over the central, eastern and northern regions of the country (Brand South African, 2015). This warm weather and clear skies makes the majority of the destinations in South Africa climatically attractive, with the majority of the locations being characterised as having excellent climate conditions for tourism and a few even having ideal climate conditions for tourism (Figure 6.8). There are no discernible spatial distributional patterns of climate resources in South Africa during summer. However, in Iran there is a major shift in in terms of favourable climate conditions for tourism from the south to north in summer due to the dominance of the Subtropical High that makes cities in the south too hot and humid to be considered comfortable for tourists (Roshan *et al.*, 2016). Additionally, Amelung and Nicholls (2014), found that in Australia during summer there was a distinct latitudinal gradation in climatic resources with the best conditions occurring in the south and the worst occurring in the north during the 1970s. By contrast, there seems to be a latitudinal gradation in climatic resources in China, with the best climate conditions for tourism occurring in the north and the worst occurring in the south (Fang and Yin, 2015). However, from this study, it seems that, in South Africa there are no major seasonal shifts or variations across the country such as seen in Iran from winter to summer, and there does not seem to be any noticeable latitudinal shifts in the climate attractiveness of destinations across the country such as those that are experienced in China and Australia. Rather, the country as a whole in summer is considered to be climatically attractive, even at different latitudes.

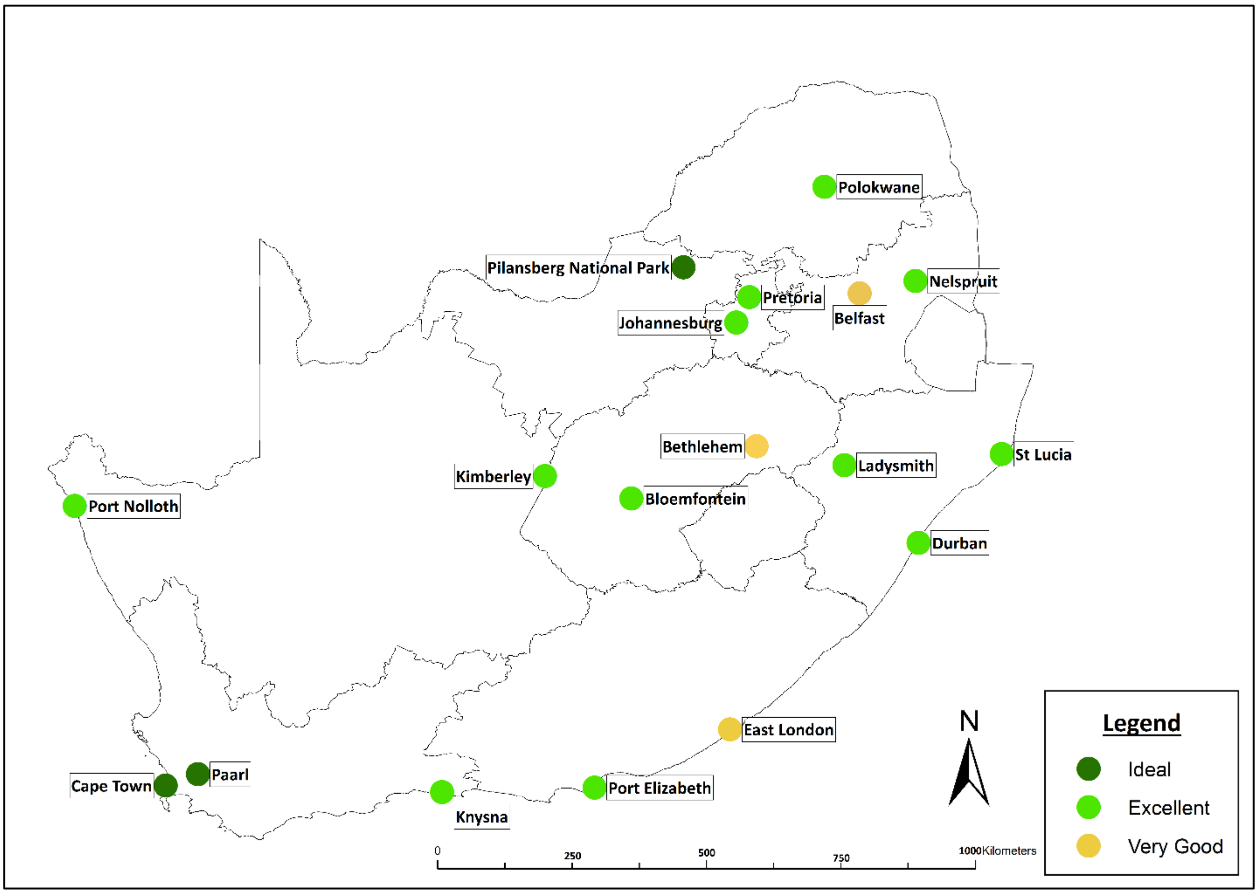


Figure 6.8: The climate suitability for tourism of each study site during summer based on the mean monthly TCI scores for the period 2005-2014.

In Iran for the period 1961-2010, the highest TCI score that was observed during summer was 94 for Tabriz (Roshan *et al.*, 2016). In addition, a study found that in the three capitals of the

South Caucasus Countries of Georgia, Armenia and Azerbaijan, the highest TCI scores in all three cities was 96 for Baku and occurred during summer (Amiranashvili *et al*., 2014). Again, such as in the case of winter, the highest TCI score in South Africa during summer was 98.50 for Paarl and was higher than all the destinations' summer temperatures. This again suggests that South Africa is a more climatically attractive destination for tourism during summer.

6.3.4. Autumn

Conditions over South Africa during autumn are characterised by less intense high temperatures and overall warm conditions across the whole country, however the temperatures decrease as the season progresses. In addition, there is minimal rainfall across the country during this time of the year. Consequently, it is not surprising that most of the destinations in South Africa, barring Belfast, have excellent to ideal climate conditions for tourism (Figure 6.9). The warm, but not too hot temperatures and lack of rain make the climate conditions very comfortable for tourists, therefore this time of the year is seen as the most climatically attractive season based on the TCI scores for most parts of the country.

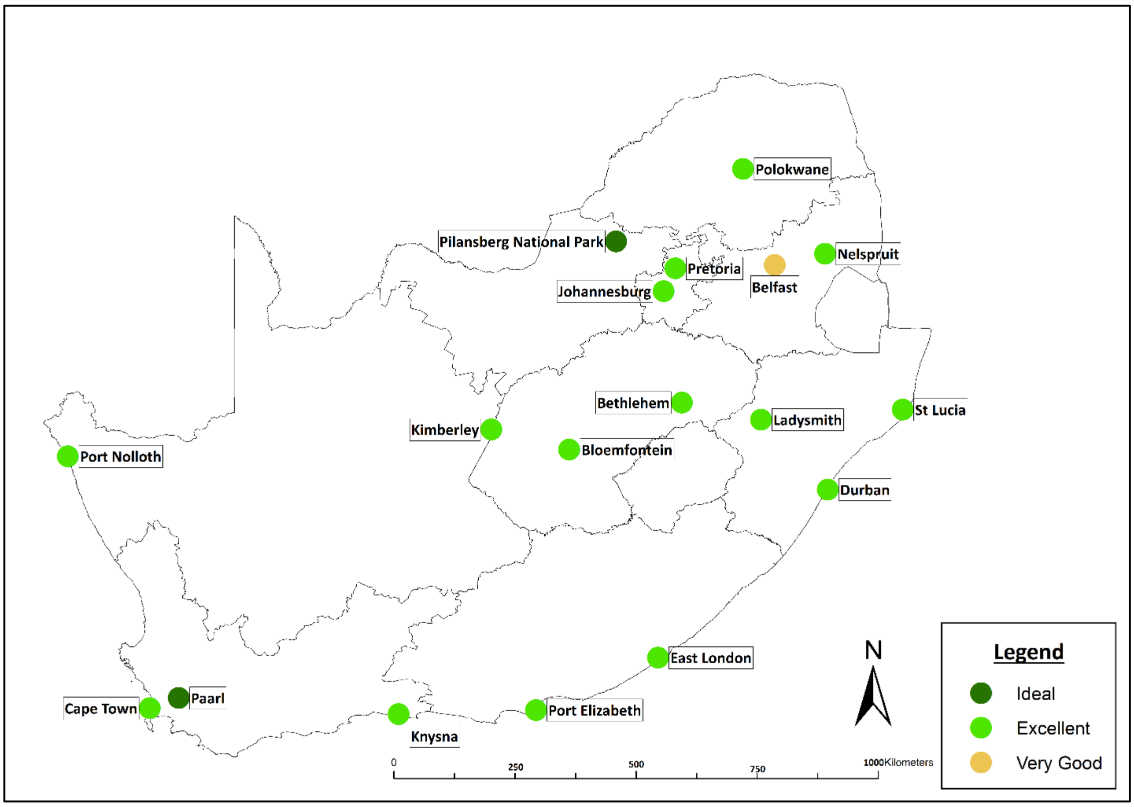


Figure 6.9: The climate suitability for tourism of each study site during autumn based on the mean monthly TCI scores for the period 2005-2014.

However, the same cannot be said for Iran, where these is still a clear spatial variation in climatic attractiveness of destinations across the country, with some places in the south having TCI scores of 95.4, while places in the north have scores of 40 during autumn, during the period 1961-2010 (Roshan *et al*., 2016). This suggests that, as a whole, South Africa could be considered more climatically attractive for tourism during autumn than Iran would be. Similarly, the overall climate suitability for tourism in China in autumn is considered to be good (TCI ranging between 60-79) to acceptable (TCI score ranging between 40-59) for the period 1981-2010 (Fang and Yin, 2015). This suggests that during autumn the overall climate suitability of South Africa can be considered more attractive for tourism than China, due to the fact that large parts of the country have excellent to ideal climate suitability for tourism (Fang and Yin, 2015).

In light of the seasonal distributions that have been discussed above, *Table 6.2*, shows that the best destination to travel to in South Africa during the majority of summer and the whole of autumn is Cape Town and Paarl. This would be expected, due to the warm temperatures that are moderated by the cold Benguela current in summer, and due to the fact that the negative influence of rain is avoided due to the lack of rain in these regions during summer. As summer is the busiest tourist period in and around Cape Town, these destinations will benefit greatly from the added benefit of having ideal climate conditions for tourism at the same time. Due to the warm conditions experienced at St Lucia during winter, when the rest of the country is experiencing cold and some regions cold and wet conditions, this makes it an ideal place to visit in July. The winter temperatures are regulated by the warm Agulhas current and with minimal rainfall in this region during winter (Lamont *et al*., 2016), offers a pleasant and favourable experience in terms of climate comfort for tourism. Pilanesberg is considered the best destination to visit during the remainder of the year, which includes the months of May, June, August, September and October. The climate suitability is very attractive due to the warm winter temperatures and lack of rain. The nature-based tourism sector in this location will benefit greatly from the ideal climate conditions for tourism in the colder period of the year.

Table 6.2: Destinations that have the most favourable climate conditions for tourism for each month of the year based on the mean monthly TCI score for the period 2005-2014.

Month of the year	Destination	TCI Score
January	Cape Town	96.75
February	Paarl	98.25
March	Paarl	97.63
April	Paarl	92.25
May	Pilanesberg	93.25
June	Pilanesberg	89.63
July	St Lucia	89.00
August	Pilanesberg	92.78
September	Pilanesberg	96.67
October	Pilanesberg	95.75
November	Paarl	91.50
December	Paarl	98.50

6.3.5. Spatial Patterns of Climate Factors Influencing the Mean Monthly TCI Scores

The ability to identify the seasonal patterns and distributions in the climatic attractiveness of a destination is important, but it is also important to be able to identify which climatic factor has the most negative influence on that climate attractiveness in order to fully understand how future climate change can potentially impact the climate suitability of destinations for tourism.

It is also clear that there are noticeable trends in the factors that most positively and most negatively influence the monthly climate suitability of the destinations in this study. The most obvious pattern that is observed when looking at these factors, is that the daytime thermal comfort (°C) component of the TCI model, holds a positive influence at the majority of the destinations during summer, spring and autumn. This indicates that the thermal comfort at all the destinations, when tourists are considered to be most active during the day are very favourable for tourism according to the TCI models used in this study (Mieczkowski, 1985; Perch-Nielsen *et al.,* 2010; *Table 6.3*).

Table 6.3: Components of the TCI model that have the most positive influence on the mean monthly TCI scores over the period 2005-2014.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Belfast	CD	CD	CD	WIND	RAINFALL	RAINFALL	RAINFALL	RAINFALL	WIND	CD	CD	CD
Bethlehem	CD	CD	CD	WIND	RAINFALL	RAINFALL	RAINFALL	WIND	CD	CD	CD	CD
Bloemfontein	CD	CD	CD	CD	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CD	CD	CD
Cape Town	CD	CD	CD	CD	WIND	WIND	WIND	WIND	RAINFALL	CD	CD	CD
Durban	CD	CD	CD	CD	CD	WIND	WIND	WIND	CD	CD	CD	CD
East London	CD	CD	CD	CD	CD	CD	RAINFALL	CD	CD	CD	CD	CD
Johannesburg	CD	CD	CD	CD	RAINFALL	RAINFALL	RAINFALL	RAINFALL	WIND	CD	CD	CD
Kimberley	CD	CD	CD	CD	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CD	CD	CD	CD
Knysna	CD	CD	CD	CD	CD	WIND	WIND	WIND	WIND	CD	CD	CD
Ladysmith	CD	CD	CD	CD	WIND	WIND	WIND	WIND	CD	CD	CD	CD
Nelspruit	CD	CD	CD	CD	WIND	WIND	WIND	WIND	WIND	CD	CD	CD
Paarl	CD	CD	CD	CD	WIND	WIND	WIND	WIND	WIND	WIND	CD	CD
Pilanesberg	CD	CD	CD	WIND	WIND	WIND	RAINFALL	RAINFALL	RAINFALL	CD	CD	CD
Polokwane	CD	CD	CD	CD	CD	RAINFALL	RAINFALL	RAINFALL	CD	CD	CD	CD
Port Elizabeth	CD	CD	CD	CD	CD	WIND	WIND	WIND	CD	CD	CD	CD
Port Nolloth	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL
Pretoria	CD	CD	CD	CD	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CD	CD	CD	CD
St. Lucia	CD	CD	CD	CD	CD	CD	CD	CD	CD	CD	CD	CD

With the future temperatures expected to increase throughout South Africa, the day time thermal comfort at some of the destinations may exceed the optimal threshold (26°C) that is considered comfortable and could result in daytime thermal comfort for tourists becoming increasingly uncomfortable. Consequently, this would have a negative impact on the overall climate suitability at these destinations during the respective months of the year. It is therefore important that this is continually monitored over time.

The lack of wind and rainfall during winter and some of the spring season are the two prominent factors that have the most positive influence on destinations at these times of year (*Table 6.3*). The future rainfall projections under all emission scenarios indicate that rainfall all across South Africa is set to decrease by 10% to 15% (Jawtusch, 2014). Although this may pose some negative threats to South Africa, it also suggests that destinations, particularly in winter in this case, will experience less rainfall in the winter, which will further enhance their climate suitability for tourism. However, although this decrease in rainfall may have a direct positive influence on destinations' climate suitability in winter across the country, the reduced rainfall could potentially result in indirect negative affects to the destination, which may have a detrimental impact on their appeal as a tourist destination (Agnew and Viner, 2001; Reddy, 2011).

Looking at the meteorological factors that most negatively influence the climate suitability for tourism at a monthly scale at each destination, it is clear that rainfall and wind are the most negative especially during the summer months and during some of autumn (Table 6.4). Again, the future rainfall projections for South Africa suggest that the impact that rainfall has on the climate suitability of most destinations during summer will decrease. However, it is important that the extent to which it decreases should be continually monitored and reassessed in the future as climate change projections are always changing with improved technology.

Table 6.4: Components of the TCI model that have the most negative influence on the mean monthly TCI scores over the period 2005-2014.

Locations	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Bethlehem	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Bloemfontein	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Belfast	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Cape Town	WIND	WIND	WIND	CA	RAINFALL CA	RAINFALL CA	RAINFALL CA	RAINFALL CA	CA	CA	WIND	WIND
Durban	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL	RAINFALL
East London	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Johannesburg	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Kimberley	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	WIND	WIND	WIND
Knysna	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Ladysmith	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Nelspruit	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Polokwane	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Port Elizabeth	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	CA	WIND
Port Nolloth	CA	CA	CA	CA	CA	CA	CA	CA	CA	CA	CA	CA
Paarl	CD	WIND	CD	RAINFALL	RAINFALL CA	RAINFALL CA	RAINFALL CA	RAINFALL CA	RAINFALL CA	CA	RAINFALL	RAINFALL
Pilanesberg	RAINFALL	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
Pretoria	RAINFALL	RAINFALL	RAINFALL	CA	CA	CA	CA	CA	CA	RAINFALL	RAINFALL	RAINFALL
St. Lucia	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL	WIND	RAINFALL	RAINFALL	RAINFALL	RAINFALL	RAINFALL

During the winter months at most destinations, the average thermal (CA) component of the TCI model is the factor that has the most negative influence on the climate suitability for tourism. This indicates that the average temperatures during winter in these regions are too cold and therefore not comfortable for tourists, according to Mieczkowski (1985) and Perch-Nielsen *et al.* (2010). At this stage it is important to take note that at Cape Town and Paarl (places which are considered some of the best destinations to visit during the summer in South Africa, (*Table 6.2*) are negatively influenced by the compounding effects of two climate variables, namely the average thermal comfort (°C) and rainfall (*Table 6.4*).

As mentioned previously, the future rainfall projections for South Africa hold some positive outlook for the impact that it will have on the climate suitability of regions that are negatively influenced by it, including Cape Town and Paarl. Due to the fact that Pilanesberg, Cape Town and Paarl are considered the best destinations to travel to in terms of their climate suitability during different months of the year (*Table 6.2*). It is important to investigate what influence the future temperature increases in South Africa will have on the climate suitability of these destinations during winter, namely the months of May, June and July. The optimal threshold for the average thermal comfort component of the TCI model is 26°C, therefore the closer that those temperatures can get to this threshold the more chance that it can have a positive influence on the overall climate suitability of these destinations during winter. Current projections indicate that temperatures throughout South Africa are set to increase by 4.3°C by 2090 (Ziervogel *et al*., 2014).

The average thermal comfort (CA) component of the TCI model will undergo a positive shift into a higher CA rating category, by 2090 under the 4.3°C increase in temperature (*Table 6.5*). Subsequently, Cape Town, Paarl and Pilanesberg will all see an overall improvement in their climate conditions for tourism during winter. The compounding effects of rainfall and low temperature will be considerably reduced, which suggests that the future climate suitability of Cape Town and Paarl will significantly improve under the current climate change projections. This is increasingly positive for the region, as it could have the opportunity in the future to be a destination that can be visited all year round if these projections hold true. It is, therefore, important that this is consistently monitored, so that tourism stakeholders and governments can adapt their product offerings and associated marketing campaigns according to the improved climate conditions of the region during the winter period.

Table 6.5: Future effective temperature of the average thermal comfort component of the TCI under future temperature increases of 4.3°C by 2090, for the winter months in Cape Town, Paarl and Pilanesberg (Green represents an increase in CA rating based on shifts from current to future temperature projections).

	Months	Current Effective Temperature (°C)	Future Effective Temperature (°C)	Future CA Rating (0-5)
	May	14.81	19.11	4.5
Cape Town	June	12.88	17.18	3.5
	July	12.23	16.53	3.0
	May	15.62	19.92	4.5
Paarl	June	12.93	17.23	3.5
	July	12.55	16.85	3.0
	May	15.25	19.55	4.5
Pilanesberg	June	12.87	17.17	3.5
	July	12.18	16.48	3.0

6.4. Implications of Spatial and Temporal Patterns of Climate Resources for Tourism in South Africa

Based on the theoretical classifications of annual tourism climate put forward by Scott and Mc Boyle (2001), the climate resources in South Africa are distributed throughout the country during the year (*Figure 6.9*). The spatial distribution of the annual tourism seasonality type is ultimately affected by climate (Moreno, 2010). Overall, the spatial distribution across South Africa reveals a latitudinal gradation, with the western and south eastern regions up to Port Elizabeth having a summer peak distribution. The hot to warm temperatures and no rain in summer make it the most favourable place in terms of climate to visit during summer. While further north and to the east, Durban and St Lucia have a winter peak distribution, due to the warm temperature in winter and minimal rainfall (Scott and Mc Boyle, 2001; *Figure 6.9*). Lastly, over the central and northern parts of the country, the climate resources are classified as having a bimodal-shoulder peak distribution. This indicates that these regions have the most favourable climate conditions for tourism during spring and autumn. This is largely due to the decreased levels of rainfall over the interior during these period of the weather and because of milder temperatures, which make it far more comfortable for tourists (Scott and Mc Boyle, 2001; *Figure 6.9*)

Two interviewees in this study indicated that marketing a destination effectively is important and can play an influential role in attracting tourists to South Africa. Therefore, using the spatial and temporal patterns of TCI scores that provide an indication of where tourists can experience favourable weather conditions for tourism and at which period of the year, enable marketing agencies, governments and tourism stakeholders (predominantly on the supply side) to better market destination-specific tourism products (Olya and Alipour, 2015). The seasons that are the most climatically suitable for tourism at each location, can be used to further improve the marketing abilities of governments and tourism businesses (*Figure 6.9*). Second, the ability to access information present in *Figure 6.9* will allow tourism stakeholders the ability to better adapt their tourism product offerings to capitalise on the good climate conditions, as this is a major factor that tourists consider when deciding on a destination to visit (March *et al*., 2014). In addition, being able to identify times of year when climate suitability for tourism will decrease at specific locations will enable tourism business and stakeholders to adapt their product offerings in such a way so as to keep their tourism businesses operating during off-peak seasons.

Using the TCI results from this study, travel agents, governments and other tourism stakeholders would be able to determine when the climate of the different destinations are most suitable for outdoor or indoor activities, and can then market the destination accordingly. Such information would provide tourists with more awareness as to the different climates they could expect at different destinations across the country. From the tourist perspective, being able to identify which destinations are the best to visit at different times of the year would allow them to visit a destination and have the best possible climatic experience at that destination, which is very important in terms of their overall enjoyment of the place (Moreno and Amelung, 2009; Simpson *et al*., 2008). *Table 6.2*, provides examples based on the TCI data from this study for the period 2005-2014, of how it is possible to indicate which destinations have the best climate conditions for tourism at different times of the year.

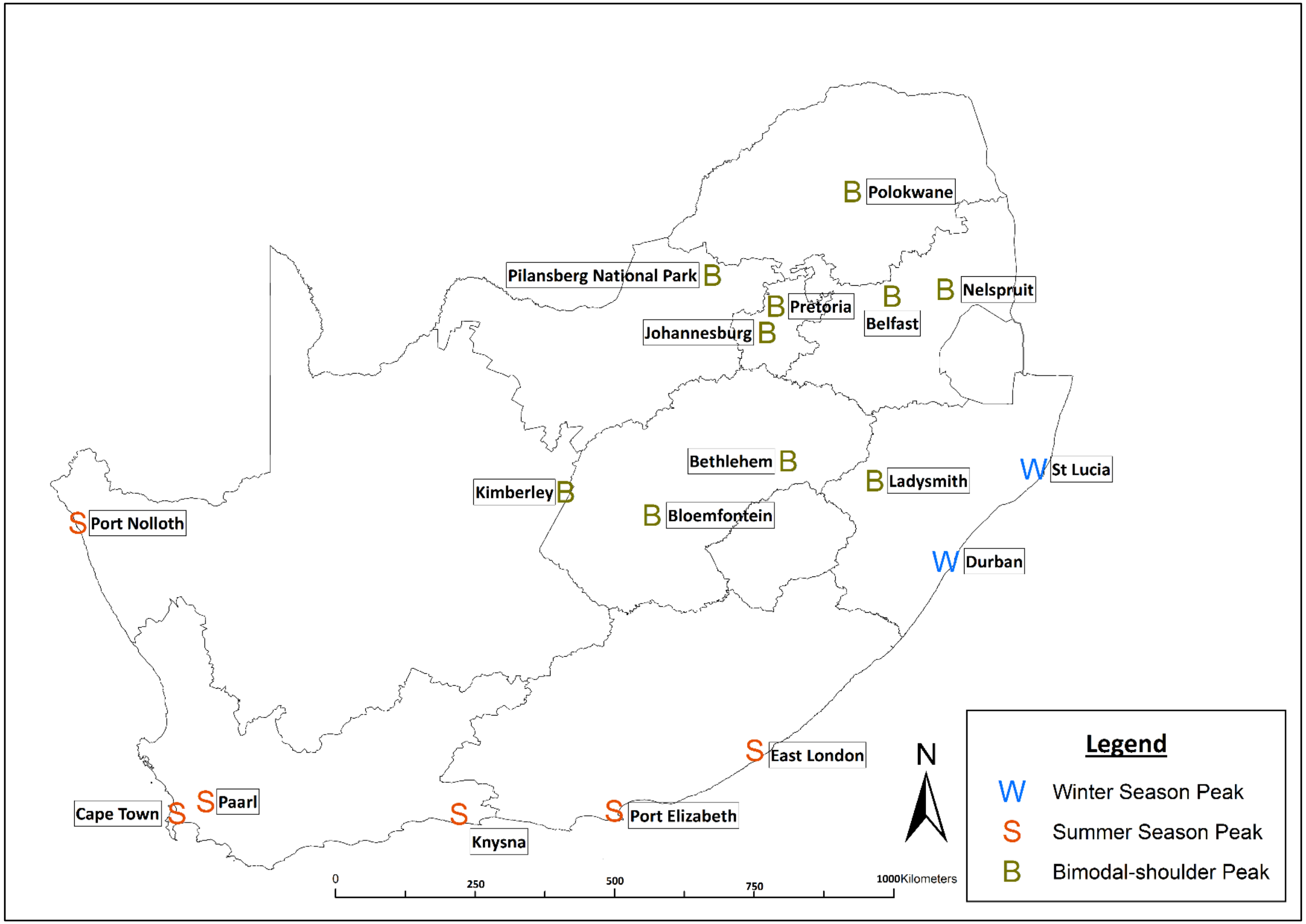


Figure 6.10: The spatial distribution of annual tourism seasonality, based on the classification scheme developed by Scott and Mc Boyle (2001).

This could prove to be very useful, as a study in Scandinavia found that disinformation regarding the climate of destinations influenced the relationship between a tourist's perception and their intention to return. Although the same results have not yet been found in South Africa, future work could find a similar relationship within the context of the country. However, through the continued communication of spatial and temporal patterns of climate suitability, any such negative relationships can be avoided. In addition, the mapped spatial and temporal TCI results in this study allow tourism stakeholders in South Africa to plan more effectively and efficiently for tourism development and management, which would ultimately have a positive influence on their ability to coordinate tourism facilities and infrastructure at different periods of the year (Olya and Alipour, 2015).

6.5. Impact of Climate Change Over Recent Decades on Tourism in South Africa

Climate change has the potential to have wide and far reaching negative impacts on global tourism (Moreno, 2010; March *et al*., 2014). Destinations are set to be directly and indirectly impacted by climate change (Agnew and Viner, 2001). However, the majority of the respondents in this study acknowledged that although climate change is a serious issue, the effects of it on the tourism sector in South Africa have not yet been felt. Respondent 4 indicated that South Africa currently has a very diverse tourism product offering, which outweighs any negative Influence of climate change across the country. However, the changing climate over the period 2005-2014 has resulted in positive or negative shifts in the climate suitability for tourism at each of the destinations (*Figure 6.11*). This further suggests that, although the tourism sector in South Africa, according to the tourism academics and researchers in this study, is not being explicitly impacted by climate change yet, the effects of climate change are noticeable and are having an influence on the climate suitability of destinations in South Africa. The majority of the locations in this study experienced an increase in their climate suitability in response to a change in climate conditions over the period 2005-2014 (*Figure 6.11*). Although only St Lucia, Port Nolloth and Knysna show statistically significant increases in climate attractiveness over the study period, there are still small and noticeable increase in most of the destinations. The remainder of the locations all demonstrate decreases in climate suitability for tourism over the study period, and this suggests that climate change is having a negative influence on the climate attractiveness of these destinations (*Figure 6.11*).

Fitchett *et al*. (2016) found that the coastal towns of Cape St Francis and St Francis Bay are experiencing negative impacts of climate change, which is demonstrated through a decrease in the climate suitability for tourism for the period 1978 to 2014. Furthermore, it was found that based on already worsening climate conditions, both towns are set to see a further decrease in their climate suitability for tourism in the future (Grant, 2015). Similarly, Port Elizabeth which is located relatively close to Cape St Francis and St Francis Bay, also demonstrated a decrease in climate attractiveness as a result of worsening climate conditions (Figure 6.10).Based on the findings in this study (*Figure 6.10*), and the results of the study in St Francis Bay and Cape St Francis (Fitchett *et al*., 2016), it could be suggested that the perceptions of most of the tourism stakeholders are partly inaccurate because climate change is already impacting the tourism sector by altering the climate suitability of destinations. However, this change is not yet being explicitly noticed by tourism stakeholders and tourists within the country. This was noted by respondent 6, who suggested that for climate change to become a threat to the tourism sector, the climate would have to change to an extent that exceeded the optimal levels of comfort for tourists. Furthermore, respondent 6 eluded to the fact that although there might be some noticeable impacts of climate change being experienced in the tourism sector in South Africa, they are not big enough to be a threat and that as a result "*the country and the tourism sector in particular is going to continue to follow business as usual patterns*".

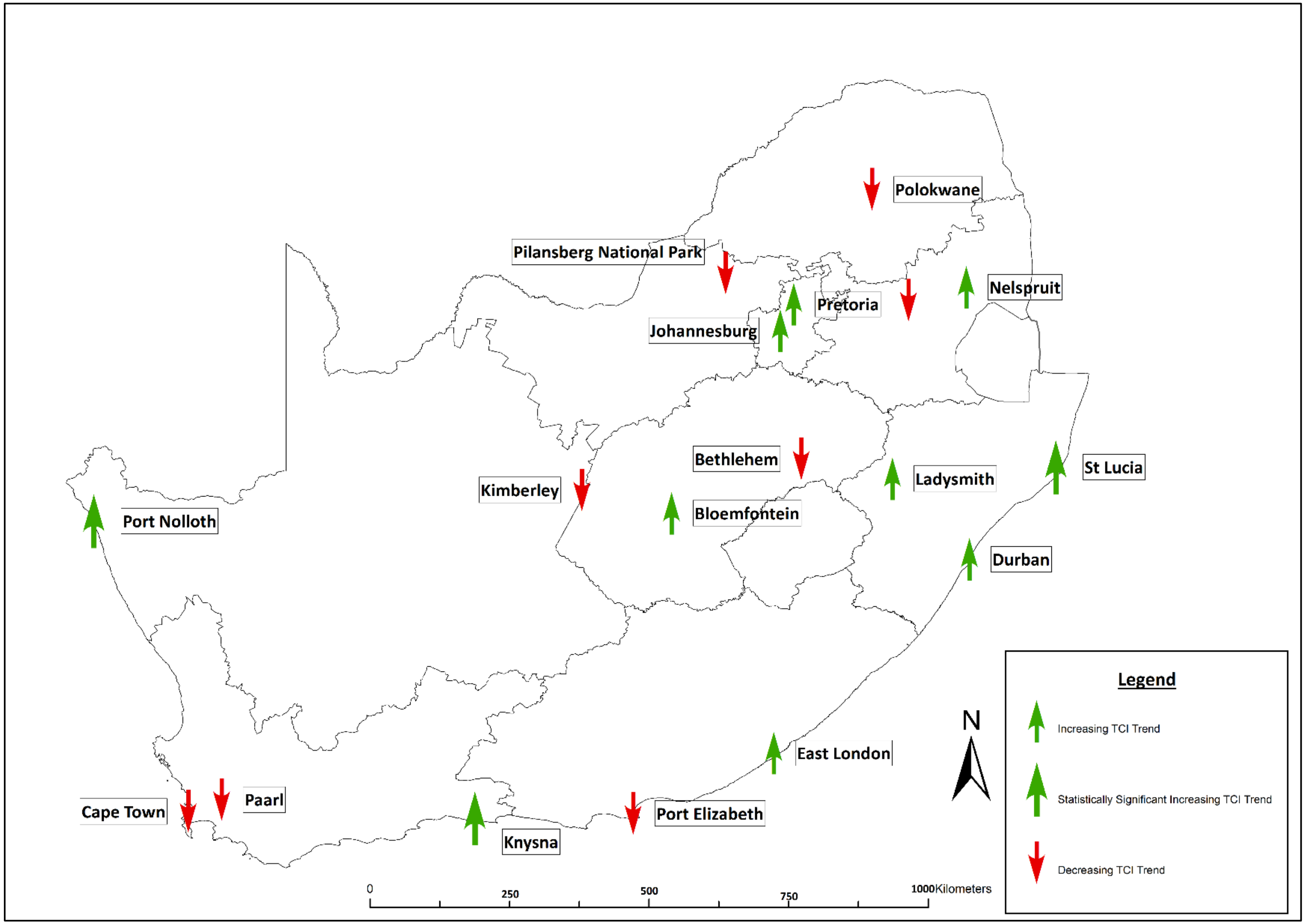


Figure 6.11: The change in the mean annual TCI scores in response to a change in the climate for the period 2005-2014.

Individuals in developed countries perceive climate change to be a distant issue that should only be of concern in the future (Ohe and Ikeda, 2005; Wolf and Moser, 2011; Spence *et al*., 2011). However, this study has demonstrated that it is not only individuals from developed countries who perceive climate change to be a threat that requires attention in the future, rather than immediately. It is clear that the majority of the respondents in this study, who are situated in a developing country, perceive climate change to be an issue, however they felt that it is not an imminent threat at the moment and will only affect the country in the future. These types of perceptions about climate change have resulted in many efforts to plan and implement adaptation strategies being seen as unnecessary and irrelevant (Weber, 2010). On this basis, it is clear why some studies have argued that the perceptions of tourism stakeholders regarding climate change can play a major role when it comes to formulating and implementing plans to reduce the impacts of climate change (Bord *et al*., 1998; O' Connor et al., 1999; Ungar, 2000; Leiserowitz, 2005). The literature suggests that how individuals understand climate change and its impacts is vital in determining their understanding of, and support for, mitigation and adaption policies, and their willingness to adjust their behaviour accordingly (Wolf and Moser, 2011). That said, it could be suggested that respondent 3, who perceived the current climate and future climate change to be a threat to the tourism sector, would be more predisposed to effectively adapt to climate change.

It is therefore important that tourism researchers and academics are made aware of the current threat that climate change poses to the tourism sector, by having access to information such as that which is represented in *Figure 6.10*. This will allow them to develop a better informed perception of the current threat that climate change poses to the tourism sector in South Africa, and will simultaneously enable them to act accordingly (Wolf and Moser, 2011).

The distributional impacts of climate change are clearly not evenly spread across South Africa based on the change in the TCI scores (*Figure 6.10*). Destinations are being impacted by climate change at different magnitudes, and some places are experiencing positive impacts while other places are dealing with negative impacts on their climate suitability for tourism. This supports other studies that have found that climate change and its impacts are not uniformly spread across the globe (Mendelsohn *et al*., 2006). To monitor the impacts of climate change and its spatial distribution, it is important that it is continually reassessed over time to provide tourism stakeholders with relevant and up-to-date information so that they can adapt to the change accordingly at a destination specific scale by developing and implementing strategies specific to conditions at each location.

Although the majority of the respondents indicated that climate change will have an impact on South Africa and the South African tourism industry in the future, none of them could provide a definite time at which it would start impacting the country. Under current climate conditions during the period 2005-2014, some destinations are already being negatively impacted (*Figure 6.10*). However, because climate change projections are always depicting worsening conditions, these current conditions are the best case scenario conditions that can be used to determine the extent to which the TCI scores will change by 2100. Using the linear regression for the mean annual TCI scores, the future TCI scores based on climate conditions during 2004-2014 were calculated for the years 2050, 2075 and 2100 (*Figure 6.11*).

It is obvious that even under the best case scenario climate conditions for future projections, the TCI scores across the country are becoming progressively worse as time goes by (Figure 6.11). By 2050 many of the locations will witness a drop in climate suitability for tourism from excellent to very good, with some of the destinations maintaining excellent climate conditions for tourism. At this stage, the climate conditions at most of the destinations in South Africa will still be considered favourable for tourism (*Figure 6.11A*). By 2075, South Africa would see a decrease in climate conditions that are considered comfortable for tourism for most of the destinations. Most destinations would still have only moved down one category in terms of climate suitability classifications, from excellent to very good. However other places such as St Lucia, Bethlem and Port Elizabeth would have shifted down two categories from excellent to acceptable by 2075 (*Figure 6.11B*). By 2100, there is a completely different country in terms of climate suitability for tourism. Four places (Port Nolloth, Belfast, Port Elizabeth and Bethlehem) will have climate conditions that are unfavourable for tourism, while the rest of the country will have acceptable to very good climate conditions (*Figure 6.11C*).

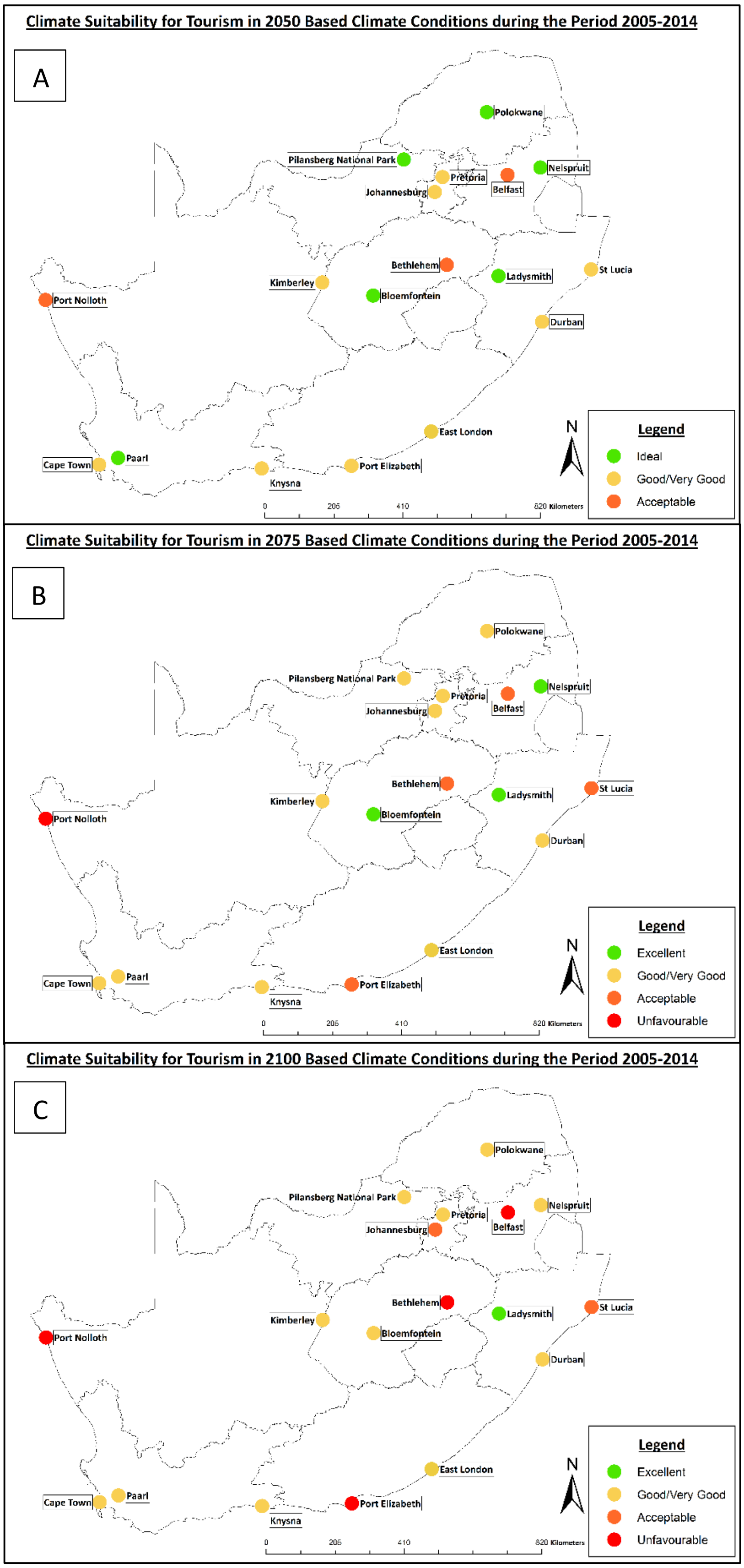


Figure 6.12: Future TCI scores for A) 2050, B) 2075 and C) 2100, based on climate conditions during 2005-2014.

This is a considerable decrease in climate suitability based on what the scores are for the period 2005-2014. More concerning is the fact that these projections are based on the best case scenario future climate conditions. It is hoped that this data raises alarms with both the tourism and climate change academics and researchers, who currently, based on the very limited nature of literature in South Africa, do not perceive the threat of climate change on the tourism sector to be significant enough to warrant that much attention.

Respondent 6 spoke to the fact that for climate change to be considered a threat, the climate conditions need to reach a threshold that exceeds the optimal range of what is considered comfortable. By 2100 that threshold would be surpassed at some destinations, and with some destinations climate conditions moving further away from optimal conditions of comfort. However, it is important to consider the rate at which this threshold would be reached and surpassed (*Figure 6.12*). It is clear that the rate of change varies from each destination, however it is concerning that some destinations (Port Nolloth, Bethlehem, Port Elizabeth and Belfast) are decreasing at a considerably faster rate than the rest of the country (Figure 6.12).

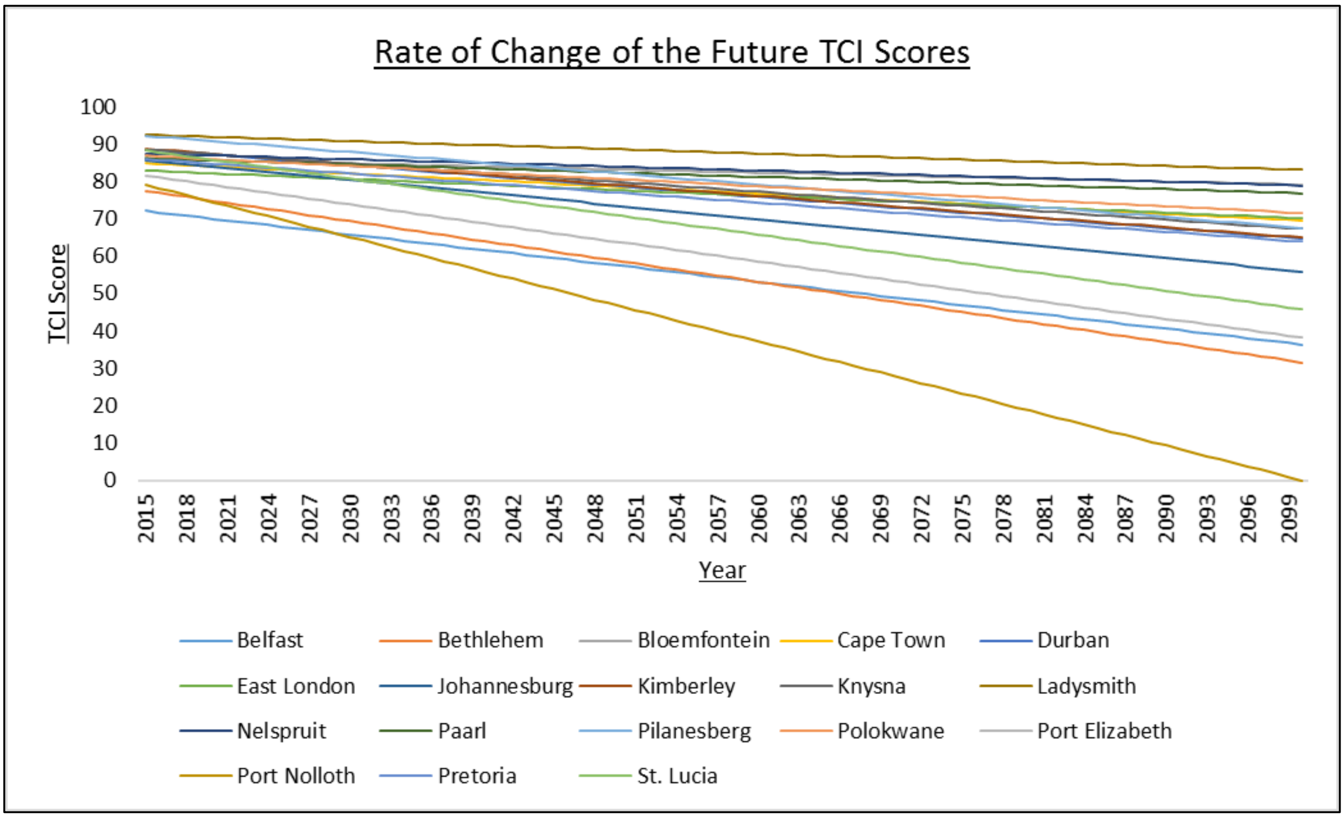


Figure 6.13: Rate at which the future TCI scores are changing, based on climate conditions during 2005-2014.

Some of the respondents in this study indicated that destinations that are set to experience an increase in extreme events should be more concerned about the impacts of climate change than other destinations, based on climate suitability. However, it could be more beneficial for the TCI scores of individual destinations to be calculated using future climate projections, and then to determine the rate at which those destinations are set to experience a decrease in climate suitability for tourism. Therefore, destinations that indicate that they are going to experience rapid decreases in climate suitability should be more concerned about the impacts of climate change, than places that will experience a much slower decrease. One of the major limitations to effective and successful adaptation to climate change is the fact that many organisations and governments wait for better information to develop effective plans and strategies (de Bruin and Dellink, 2011). Thus, using future climate data to estimate the rate of change of the climate suitability for tourism at destinations would provide tourism stakeholders with quantified timelines based on scientific data, which will allow them to adapt to, and prepare for, the impacts of climate change more effectively and efficiently (Berkhout *et al.*, 2006).

6.6. Factors other than Climate Change that Influence Tourism in South Africa

All the respondents perceived the tourism sector in South Africa to have a variety of threats, such as, crime, safety and security and quality of infrastructure. Respondent 1 stated: "*at each location, there will be threats to the tourism product and the tourist will make trade-offs based on those threats*". Out of all the mentioned threats, crime was one which was emphasized by the respondents as being a major threat to tourism in South Africa. In more recent years, the crime rates in South Africa for specific crimes have been decreasing and stabilizing, but there continues to be an increase in many types of crimes in South Africa (Perry and Potgieter, 2013). It has been argued that crime has a negative influence on tourism in South Africa, and that cases of crime can deter tourists from visiting the country (Ferreira and Harmse, 2000; Moyo and Ziramba, 2013). In addition, two of the respondents mentioned the importance of destination marketing as a factor that can greatly influence tourism in a region. However, due to high levels of crime throughout most of South Africa, destinations may not be able to market themselves effectively due to the manner in which tourists perceive the levels of safety of an area or due to the manner in which the media has portrayed a particular region or destination (Perry and Potgieter, 2013). Therefore, it is fundamentally important that tourism stakeholders, police and government devise strategies to prevent crime to ensure that the tourism industry is not significantly negatively impacted further by the effects of crime (Perry and Potgieter, 2013). Moyo and Ziramba (2013) stated:

> …ensuring the safety and comfort of visitors is not only important for encouraging more visitations but also for ensuring sustainable tourism growth, employment creation and poverty alleviation
>
> (Moyo and Ziramba, 2013: 14).

The negative influence of crime on tourism is only going to get worse with the increased prevalence of climate change in South Africa. Studies have found that higher temperatures lead to a considerable increase in crime (c.f. Cohn, 1990; Bushman *et al*., 2005; Brunsdon *et al*., 2009; Horrocks and Menclova, 2011). Although these studies have not been conducted in the South African context, it could be suggested that with the expected 4.3°C increase in temperature over South Africa in the future, crime could potentially increase as a result (Ranson, 2014). This highlights a secondary effect of climate change on tourism, and it cannot be modelled by the TCI.

Some respondents perceived the quality of transport and the ability to easily access tourism attractions as a factor that could influence tourism in South Africa. This issue is directly related to the issue of climate change and speaks to the bi-lateral relationship between climate change and tourism (Simpson *et al*., 2008; Colakoglu and Mil, 2011). It has been stipulated that transport accounts for more than 26% of the global CO_2 emissions, and there has been a call to reduce this figure to reduce the impacts of climate change (Chapman, 2007). It has been argued that the contribution of tourism to climate change is relatively large (Scott *et al*., 2012a). to stabilise the levels of greenhouse gases being released as a result of transport, there is a shift towards altering behaviours through policies to reduce the impact of the transport industry on contributing to climate change (Chapman, 2007). This could potentially negatively influence the ability of tourists to travel to South Africa, and travel cost-effectively in the country while on holiday. The majority of the respondents stated that the European Union's efforts to cut the amount of greenhouse gases being released during long haul flights may negatively influence the amount of European tourists that visit South Africa. Some respondents believe that the technological innovations by airline companies will dampen this effect of the above mentioned actions by the European Union.

It has been argued in the literature that technological innovation is considered to have most potential to reduce GHG emissions in the tourism sector. However, it alone will not be able to achieve the desired reductions in emissions (Simpson *et al*., 2008). Therefore, the European Union may potentially continue with their campaign to reduce the impacts of climate by discouraging long haul flights.

6.7. Validity of the TCI in the South African Context

6.7.1. The Need to Quantify Climate Change Threats to Tourism

The growing concern with regards to climate change has led to a large and rapidly growing body of research on the impacts of climate change on society (Kurukulasuriya *et al*., 2006). The last decade has seen a major shift towards being able to quantify the impacts of climate change on society (c.f. McCarthy *et al*., 2001; Tol, 2002; Mendelsohn and Williams, 2004). However, the literature surrounding climate change and tourism in South Africa is still relatively young, with respondent 6 stating "…*climate change and tourism research in South Africa is in its infancy*…". In addition, the need to quantify the impacts of climate change on the tourism sector in the country are only now being realised. All of the respondents in this study acknowledged the urgent need for research into the extent, timing and impact that climate change may have on tourism in South Africa, and respondent 2 stipulated that tourism is a major driver of social and economic development, and it is therefore important that further research be initiated to better understand the relationship between climate change and tourism in South Africa. The respondents believe there to be an urgent need to be able to quantify the impacts of climate change on the tourism sector, especially due to the fact that the majority of the tourism products in South Africa are heavily reliant on climate (Scott, 2003; Spenceley and Goodwin, 2007). Due to the fact that this study (*Figure 6.10*), and a similar study by Fitchett *et al*. (2016) found that the impacts of climate change are already having a negative influence on some destinations' climate suitability for tourism in South Africa, it is important that further work is undertaken to monitor and identify the extent and magnitude of further impacts on the tourism sector in the country.

The literature suggests that developing countries have a much lower adaptive capacity than developed regions, due to their decreased capital intensity and technological flexibility, and as a result, struggle to successfully implement effective strategies to deal with the impacts of climate change (Deressa *et al*., 2005; Kurukulasuriya *et al*., 2006; Fitchett *et al*., 2014). The same sentiment was shared by respondent 6 who indicated that the South African tourism sector has always been more reactive than proactive in terms of adaptation, particularly due to the cost of implementing the necessary infrastructure to deal with a potential negative event. Consequently, it is very important to develop the adaptive capacity of South Africa, and more specifically in this case, the tourism sector. In order to achieve this, it is imperative that further research into the impacts of climate change at the national and local scale of developing countries, such as this one, be pursued to enhance the certainty of what to expect by further quantifying the impacts of climate change in the country, which will allow for better planning and strategic proactive responses to be put in place. In light of this respondent 3 indicated that the tourism sector in South Africa is going to have to adapt more effectively to climate change, because the impacts of climate change are only likely to worsen. To achieve a more effective stance towards dealing with, and reducing the impacts of, climate change on the South African tourism sector, all of the respondents agreed that being able to quantify the impacts of future climate change more effectively will enhance the ability of tourism stakeholders to adapt to climate change, whether it is before the impacts occur or in response to an already present impact. In addition, having an improved idea of the potential impacts of climate change on the tourism sector in the country, and when they could occur, will allow tourism stakeholders to better estimate the costs associated with adaptation plans. This could greatly reduce the restrictions that financial resources have on influencing the ability of tourism stakeholders to adapt to climate change.

6.7.2. The Perceived use of TCIs to Quantify the Effects of Climate Change on Tourism

The tourism climate index is one of the most widely used tools to quantify the effect of climate change on the tourism sector (Mieczkowski, 1985; Amelung *et al*., 2007; Moreno and Amelung, 2008; de Freitas *et al*., 2008; Perch-Nielsen *et al.,* 2010; Kovács and Unger, 2014). However, the tourism academics and researchers interviewed in this study had not come across the TCI until it was explained to them during the interviews, despite their extensive coverage of the tourism literature. The fact that the respondents were not aware of the TCI prior to their involvement in this study could suggest two things. First, it suggests and also reinforces the point that the literature surrounding climate change and tourism in South Africa is relatively young with most of the research occurring in developed countries (c.f. Agnew and Viner, 2001; Madison, 2001; Elsasser an Burki, 2002; Hamilton *et al*., 2005a; March *et al*., 2014; Kubokawa *et al*., 2014), otherwise these academics and researchers, who are at the forefront of tourism knowledge and expertise in the country, would have had prior knowledge about the TCI due to its extensive use globally. Alternatively, this may also indicate that there is a lack of interest amongst tourism academics and researchers in researching the relationship between tourism in South Africa and climate change, due to the fact that it is not perceived to be a serious threat at the moment, according to the respondents of this study. Second, the lack of prior knowledge about the TCI or similar such methods, may suggest that the academics and researchers in the tourism sector may be biased towards qualitative methods.

That said, the respondents were reluctant to indicate that the use of the TCI model would be the best and only method that could be used to quantify the impacts of climate change on the tourism sector. However, there was no direct objection by the majority of the respondents to the use of the TCI model in future research. In light of this though, all the respondents made it clear that the use of the TCI model or similar such methods cannot be used in isolation, and should be used to supplement the already existing and future climate change and tourism research in South Africa. Respondent 5 reinforced this sentiment by indicating that there needs to be a multi-dimensional approach to tourism and climate research in South Africa. This statement by respondent 5, eludes to two factors that reinforce what was mentioned previously. First, that there is a perceived need for the impacts of climate change on the tourism industry to be quantified through the use of the TCI or similar methods. Second, it eludes to the fact that there is a willingness amongst the tourism researchers and academics to move away from only using predominantly qualitative methods, but to also incorporate quantitative methods into their research.

The respondents all had one uniform objection to the TCI model. This lay within the fact that the TCI model did not have the ability to account for tourist's numbers. Many of the respondents indicated that it would be useful if the model could identify the change in tourist's numbers at specific destinations in response to a change in the climate suitability for tourism. Respondent 4 expressed this sentiment by saying "*it would be interesting to see how* *the TCI results relate to the actual tourist numbers at each location*". Such research in itself is very limited and only one study could be found that demonstrated the relationship between TCI scores and actual tourist numbers (Kubokawa *et al*., 2014). This study in Japan found a generally positive correlation between TCI scores and tourist numbers, which suggests that when the climate suitability of an area went up in Japan, so did the tourists numbers during the same time period and vice versa (Kubokawa *et al*., 2014). Therefore, the results from this study in South Africa can be added to, and future work can look to explore the relationship between the change in climate suitability for tourism as a result of climate change at destinations across the country with tourist numbers.

6.7.3. The Appropriateness of the TCI model in the South African Context

The TCI model has been widely used in the international tourism and climate change literature to explore the impacts of climate change on tourism in developed countries (Figure 6.13). However, there are a very limited number of studies that use the TCI in the South African context. In an attempt to quantify the influence of climate change on the tourism sector in South Africa the TCI model was used. However, the ability to use the TCI model in the South African context was continually hindered by the availability and quality of meteorological data from the South African Weather Service (This is discussed in more detail in *section 6.8.1*). However, it is important to note that during the initial development of the TCI, Mieczkowski (1985) encountered data limitations and therefore adapted his initial model to fit the data that he had available to him. The main issue resulting from the data limitations meant that this study could not explore the impacts of climate change on a much larger scale across the country and, as such the study could only quantify the impacts of climate change on the climate suitability for tourism at a low resolution.

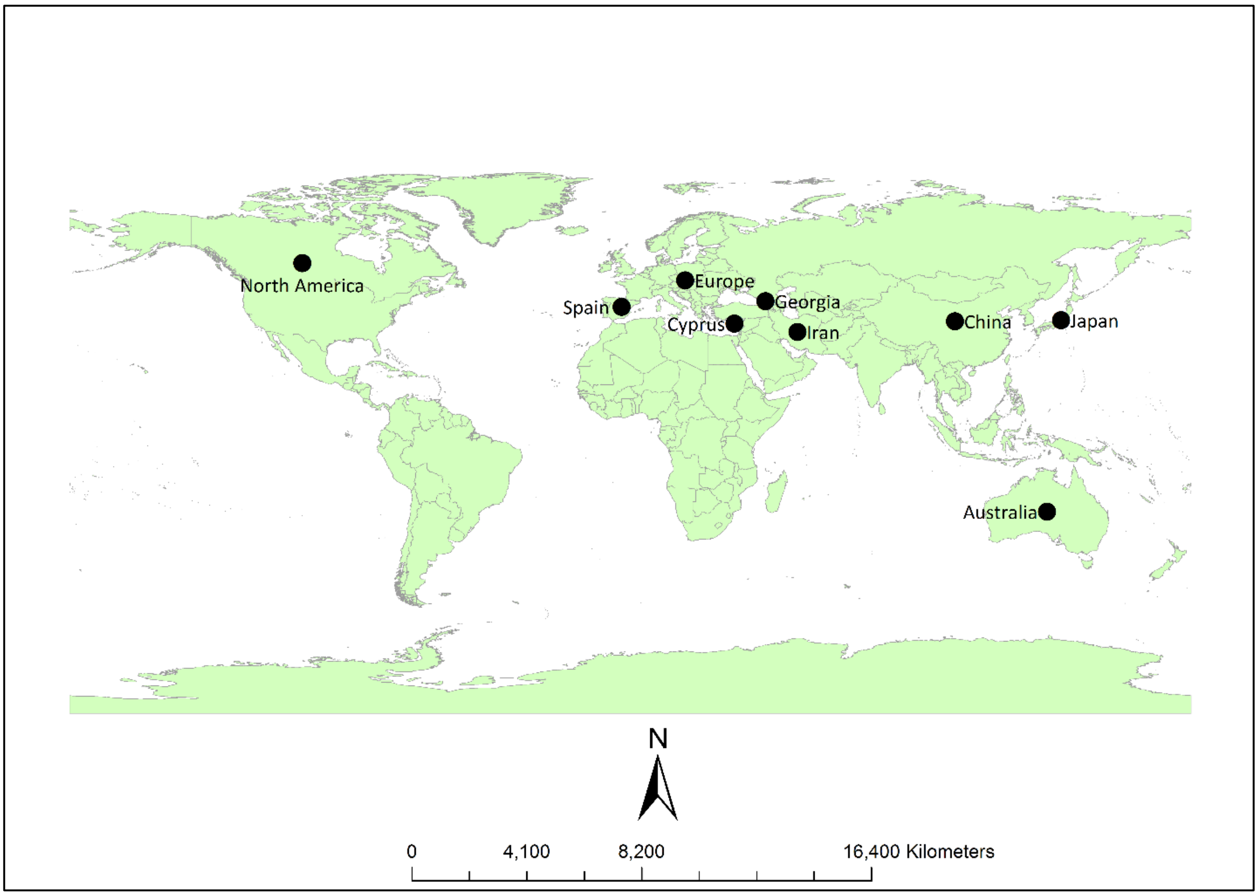


Figure 6.14: Locations of some of the TCI Studies that have been conducted around the world.

Where data were available across the country, many of the destinations had meteorological data that was either incomplete or some of the meteorological variables could not be accounted for, and as a result could not be used to calculate the TCI using the traditional model. This resulted in the use of the mathematically adapted TCI model for locations that did not have all the necessary data, primarily sunshine or cloud cover data. Subsequently, the results of the model were not as accurate as the traditional model and lead to results that were not 100% representative of the climate suitability for tourism in some of the locations.

That said, it is important to note that, despite all of the setbacks in trying to implement the traditional TCI model formulated by Mieczkowski (1985) and adapted by Perch-Nielsen *et al. (*2010) and the mathematically adapted TCI in the South African context during this study, it was achieved and the model produced results that could be compared to other international studies that used the TCI model (Figure 6.13). The results of the TCI allowed for patterns and changes in these patterns to be identified at each location across the country, which can be used as an important tourism planning and management tool. Consequently, it can be said that this model can be used as an effective measure that can be used to bridge the gap between the predominantly qualitatively orientated tourism literature and the predominantly quantitatively orientated climate science literature in South Africa.

One aspect of the TCI model that could potentially be improved on for the South African context in particular, is the manner in which the TCI scores are classified. This study found that the majority of the mean annual and mean monthly scores for the period 2005-2014 were classified as having an excellent climate suitability. Although this is positive news for the tourism sector in South Africa, it reduces the ability to make effective spatial and seasonal comparisons across the country. It is important to identify which places are better than others from a tourist's perspective and from a tourism management perspective. Therefore, there should be an attempt to improve the classification of places with excellent climate conditions for tourism, so as to provide a higher resolution look at the spatial and seasonal distribution of climate resources in response to a changing climate across the country. This could be achieved by increasing the intervals at which scores within the excellent category are classified as (*Table 6.6*). However, in doing so, the ability of the results to be compared to other similar studies may be compromised, based on the fact that the results will not be uniform.

Table 6.6: An alternative method of classifying the climate suitability of places that are considered to have excellent climate conditions for tourism.

Original Classification	Proposed Revision to Classification
Excellent (80-89)	Extremely Good (80-82)
	Superb (83-85)
	Outstanding (86-89)

6.8. Limitations

6.8.1. Limitations in Data Collection

Meteorological data for this study were collected from weather stations across the country that are registered with the South African Weather Service. SAWS is the leading authority for weather and climate forecasting in South Africa and is a member of the World Meteorological Organisation, and complies with international meteorological standards and regulations (Department of Environmental Affairs, 2016). There are various limitations that made the data collection process difficult and to a point restricted the ability of the study to explore the link between climate change and tourism in various locations across South Africa. The fundamental limitation that was encountered during the data collection process was the fact that the study was restricted to exploring the impacts of climate change on tourism for a limited range of destinations across the country. The inability to explore the impacts of climate change on all major tourism destinations in South Africa highlights the spatial limitation of the meteorological data that is made available by the South African Weather Service (SAWS).

From a tourism perspective, this in itself is a severe and fundamental problem as it inhibits the ability of tourism stakeholders and government from being able to explore the potential impacts of climate change at major tourism destinations across the country. Destinations such as, the Drakensberg Region, Kruger National Park, Namaqua National Park, Richtersveld World Heritage in the Northern Cape, and the Karoo Kubusi Indigenous Forest and Hogsback forest in the Eastern Cape, which hold significant roles within the tourism sector as a means of enabling social and economic development in each particular region, could not be explored in this study. *Table 6.2*, represents the study sites that were originally considered for this study, and further highlights the fact that the impacts of climate change at many other destinations throughout the country cannot be explored because of the limited reach that the SAWS has in terms of providing meteorological data. Consequently, the future impacts of climate change at these destinations will not be identified and will ultimately result in these locations not being able to employ destination specific adaptation measures, which are particularly important in the tourism industry. This is due to the unique nature of the tourism product on offer and because the environment on which tourism product offerings are based differ from each destination (UNWTO and UNEP, 2008). It is argued that for a destination to be more likely to effectively adapt to the impacts of climate change, major stakeholders and every level of government need to have a proactive attitude (Amelung and Nicholls, 2014). However, the spatial limitation of the SAWS perpetuates the inability of many tourism stakeholders from having access to the necessary information that is needed to adopt a proactive attitude in the face of imminent climatic changes.

To overcome the spatial restrictions imposed on this study through the lack of available meteorological data, alternative locations were chosen. These alternative locations had the necessary meteorological data needed to calculate the TCI, and where possible were situated near locations that represented a significant tourist destination. These alternative locations, were then used to gain an idea of the relative impacts that could be expected at the tourist destination (*Table 6.7*). An example of this is through the use of Belfast, which is situated relatively close to Dullstroom, and therefore because of this geographical proximity and similar climate, the impacts of climate change on the climate suitability of Belfast could potentially be inferred onto Dullstroom or immediate area around Belfast. Although it is understood that this is not ideal, under the circumstances it is the best alternative.

Table 6.7: Alternative locations that had to be used as alternatives to other nearby tourist locations due to data limitations.

Original Proposed Study Site	**Alternative Study Site Used**
Dullstroom	Belfast
Richtersveld World Heritage Site	Port Nolloth
Stellenbosch	Paarl
Clarens	Bethlehem

The next major limitation that was encountered during the data collection process related to the availability of the necessary meteorological factors needed to calculate the TCI at each study site. This limitation is not only restricted to the South African context, and was originally highlighted by Mieczkowski (1985). His original TCI model intended to include 12 meteorological variables, but due to the lack of available data, he adapted the original model to include seven variables, namely: the 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 (Mieczkowski, 1985; Perch-Nielsen *et al.,* 2010). *Table 6.2*, highlights the availability of each of the meteorological factors needed to calculate the TCI at each location. These data restrictions are not likely to be limited to South Africa, and could potentially be greatly exacerbated in other developing countries where infrastructure quality is low. It is therefore important to be able to overcome this particular data restriction, so that places that rely on tourism as a means of generating social and economic development can use the data they have available to them to quantify the effects of climate change on the climate suitability of the region. Within this context, this study developed two adapted forms of the traditional TCI model formulated by Mieczkowski (1985) and adapted by Perch-Nielsen *et al.* (2010) to overcome this form of data restriction. To calculate the TCI scores for the locations that did not have all the necessary data available, a mathematically adapted TCI formula and a rainfall proxy TCI formula were developed. The detailed methods surrounding the two adapted TCI models can be found under *section 4.2.4* and *section 4.2.5*. In addition, the results of the accuracy of each model is detailed in *section 5.3.1* and *section 5.3.2*. Nevertheless, the development of these adapted TCI models demonstrates that regions that do not have access to all the necessary meteorological variables needed to calculate the TCI can develop an adapted model to fit their available data.

The final major limitation that was encountered during the data collection process was pertaining to the temporal scale at which data was collected at the various weather stations across the country. The majority of the study sites that have weather stations that recorded all the necessary variables needed in this study, do not have data for periods longer than 30 years. This is a fundamental restriction of a climate change study, as the World Meteorological Organisation (WMO) states that it is required to have datasets that are 30 years or longer when looking at the impacts of climate change (WMO, 2013). Unfortunately, the nature of this limitation makes it inherently impossible to overcome and needs to be resolved by SAWS. However, the study did make use of the longest continuous data period across all the study sites, to make effective comparisons across destinations, and also calculated results for the longest continuous period at each location.

Table 6.8: The data availability of meteorological factors from the South African Weather Service.

Location	T_{max}	T_{min}	Wind Speed	Rainfall	Humidity	Cloud Cover	Sunshine Hours
Belfast	✓	✓	✓	✓	✓	X	X
Bethlehem	✓	✓	✓	✓	✓	✓	✓
Bloem	✓	✓	✓	✓	✓	✓	✓
Cape Town	✓	✓	✓	✓	✓	✓	✓
Carletonville	✓	✓	X	✓	X	X	X
Cederberg	X	X	X	X	X	X	X
Clarens	✓	✓	X	✓	X	X	X
Dullstroom	X	X	X	X	X	X	X
Durban	✓	✓	✓	✓	✓	✓	X
East London	✓	✓	✓	✓	✓	✓	✓
George	X	X	X	X	X	X	X
Graaff-Reinet	X	X	X	X	X	X	X
Grahamstown	X	X	X	X	X	X	X
Hazy View	X	X	X	X	X	X	X
Hermanus	X	X	X	X	X	X	X
Hluhluwe	X	X	X	X	X	X	X
Hoedspruit	✓	✓	X	✓	✓	X	X
Johannesburg	✓	✓	✓	✓	✓	✓	✓
Kimberley	✓	✓	✓	✓	✓	✓	✓
Knysna	✓	✓	✓	✓	✓	X	X
Kruger National Park	X	X	X	X	X	X	X
Ladysmith	✓	✓	✓	✓	✓	X	X
Langebaan	X	X	X	X	X	X	X
Margate	X	X	X	X	X	X	X
Mooi River	✓	✓	✓	✓	X	X	X

Location	T_{max}	Min Temp	Wind Speed	Rainfall	Humidity	Cloud Cover	Sunshine Hours
Nelspruit	✓	✓	✓	✓	✓	X	X
Newcastle	X	X	X	X	X	X	X
Nottingham Road	X	X	X	X	X	X	X
Paarl	✓	✓	✓	✓	✓	X	X
Parys	X	X	X	X	X	X	X
Port Elizabeth	✓	✓	✓	✓	✓	✓	✓
Phalaborwa	X	X	X	X	X	X	X
Piet Retief	X	X	X	X	X	X	X
Pilanesberg	✓	✓	✓	✓	✓	X	X
Polokwane	✓	✓	✓	✓	✓	✓	✓
Port Nolloth	✓	✓	✓	✓	✓	✓	✓
Potch	✓	✓	✓	✓	✓	X	X
Pretoria	✓	✓	✓	✓	✓	X	X
Queens Town	X	X	X	X	X	X	X
Robertson	X	X	X	X	X	X	X
Rustenburg	X	X	X	X	X	X	X
St Lucia	✓	✓	✓	✓	✓	✓	X
Stellenbosch	X	X	X	✓	X	X	X
Still Bay	X	X	X	X	X	X	X
Tzaneen	X	X	X	X	X	X	X
Vanderbijlpark	X	X	X	X	X	X	X
Vereeniging	X	X	X	X	X	X	X
Vryburg	X	X	X	X	X	X	X
Welkom	X	X	X	X	X	X	X
Worcester	X	X	X	X	X	X	X

Smaller, less significant limitations that were encountered during the data collection process involved making sense of the supplied data from SAWS. Due to the data spanning over long time periods in some cases, some weather stations underwent name changes. This made the collation of data from these weather stations particularly difficult, especially with no indication from SAWS that these stations represent the same data, but are just named differently. The daily data that was sourced from SAWS contained many blank entries across all variables for which data was requested. As a result, these blank entries were removed from the dataset, due to the fact that it is not possible to determine exactly what the missing value should have been. It has been stipulated that it is less harmful to the dataset to remove superficially incorrect values than reducing the n-value of the data set (Ledneva *et al*., 2004; Nordli *et al*., 2008; Underhill & Bradfield, 2009).

From a qualitative perspective, there were only two real limitations that were encountered during the interview process. First, some of the tourism academics that were approached to participate in the study were unresponsive to multiple attempts of communication and never indicate their willingness or lack thereof to participate in the study. This resulted in the study only obtaining a limited number of responses from tourism academics and researchers, whereas more participants would have allowed for a more in-depth and broader insight into the different perceptions held across the country. Second, a few tourism academics and researchers that were approached felt that they were not qualified to discuss matters pertaining to climate change, even though they were reassured that the questions and discussion thereafter was not based on climate change science but more broadly based on their own perceptions of the relationship between climate change and tourism in South Africa. This limitation may account for the limited nature of the tourism and climate change literature in South Africa and suggests that there might be a general reluctance to deal with aspects of climate change despite its importance within the tourism sector. It was positive to witness that some respondents, despite being reluctant about the climate change aspects of the process, were still willing to participate, because they understand that the impacts of climate change can be devastating to the tourism sector in South Africa. The hope is that, through this study, more tourism researchers and academics, and other tourism stakeholders see the value in participating in similar studies.

6.8.2. Statistical Limitations

The strength of any statistical analyses, and the ability of the statistical tool to accurately model and attribute patterns to the observed changes is limited to the quality of the dataset in terms of extent of missing data. Even if the missing data is averaged out, or modelled, there is no certainty that those values will be exactly the same to what the missing values would have been (Croitoru *et al*., 2012). Using interpolated values in place of what the original values would have been could also potentially skew the time trends between the TCI scores over time (Ledneva *et al*., 2004; Nordli *et al*., 2008). The datasets for all variables obtained from the SAWS often contained missing values throughout and therefore adding interpolated values would have been less beneficial than just merely omitting the missing values from the study. However, this presents itself as a major concern, regarding the fact that, had those missing data values been important relative to the available data, the relationship may have been different based on calculations had those missing values been available (Fitchett, 2013).

The concern that missing data values could have potentially changed the nature of the trends is nullified through the calculation of the statistical significance of each trend (Fitchett, 2013). The p value represents the statistical significance and determines the probability that the data trends would hold in a greater dataset (Manly, 2009). The detrimental effects of a lower *n value* due to the omission of the missing data values, guarantees that the subsequent lower level of statistical significance reported is an accurate probability that the results could not have occurred by chance (Fitchett, 2013).

6.9. Future Work

The research on climate change and tourism in South Africa is still relatively new, and because of the projected climate change expected in the future across the country, and the important social and economic role that the tourism sector plays in the country (Rogerson and Visser, 2011a; Visser and Hoogendoorn, 2011), it is important that there is continued research to gain an understanding of the relationship between climate change and tourism within South Africa and the broader context of Africa.

The first and probably the most important aspect that requires attention, before any major climate change studies can be conducted effectively at a finer resolution, is improving the meteorological data made available through SAWS. In this context it would be recommended that SAWS improve the spatial scale at which data is made available, and enhance the temporal scale of available data across all weather stations in the country. For the impacts of climate change at all tourist destinations across South Africa to be explored, there needs to be appropriate meteorological data at each location to do so. As such, it would be greatly beneficial if there could be a far greater spatial distribution of weather stations across all destinations or towns and cities in the country that have the ability to capture meteorological variables that are needed to calculate models such as the TCI. In addition to this, SAWS, through consistent and effective data capturing processes should work towards generating meteorological datasets for all variables, that extend to a minimum of 30 years, as the WMO defines this as the minimum time period needed to explore the impacts of climate change (WMO, 2013). By doing so, future climate change studies at all scales would be able to effectively explore the impacts of the resultant change in climate factors at each location or destination across the country.

That said, there is a need for the continued analysis of impacts of climate change on the climate suitability of destinations across South Africa. This study only fills one small gap by evaluating the impacts of climate change on 18 destinations in South Africa, however there are many more destinations that are likely to be impacted by climate change and therefore destination specific analysis of the impacts of climate change are imperative. Such analyses would provide tourism stakeholders, national and local governments with information that would allow them to make better informed planning and management decisions concerning the development and management of tourism infrastructure and tourism product offerings. According to SAWS they have 172 active weather stations around South Africa (Figure 6.15). If and when these weather stations can provide all the necessary meteorological variables, and at a scale long enough to effectively evaluate the impacts of climate change needed to calculate the TCI score, it would be ideal if the climate suitability for tourism at each location be explored. This would provide a great high resolution look at the role of climate change on the climate suitability for tourism of locations across South Africa.

To enhance the adaptive capacity of tourist destinations in general across South Africa, it would be ideal if TCI scores could be based on modelled climate data under different emission scenarios. This would allow tourism stakeholders to adapt their tourism product offerings and services based on scientifically quantified future climate conditions. Furthermore, tourism stakeholders and all levels of governments can formulate multiple plans based on different future climate conditions under different climate change scenarios and the resultant TCI scores based on those modelled climate conditions. The ability to adopt a proactive attitude to climate change enhances the ability of tourism stakeholders to effectively and successfully plan and implement adaptation strategies, rather than just merely reacting to the impacts of climatic change (Simpson *et al*., 2008; Scott *et al*., 2009; Amelung and Nicholls, 2014). Due to the fact that the adaptive capacity of developing countries, such as South Africa, is considered to be considerably low (Buob and Stephan, 2013). Future work similar to this, would create an environment and culture that allows for increased access to information that is relevant and specific to each individual destination and would therefore increase the adaptive capacity of the country.

Due to the fact that there was a general reluctance by some tourism researchers and academics to participate in this study because of the quantitative nature surrounding climate change, future work could be to encourage more interdisciplinary work between tourism and climate change academics that builds on both tourism and climate expertise, especially as the tourism sector has an important role to play in South Africa and because climate change has the potential to be greatly detrimental to the tourism sector. In addition, it would be beneficial to encourage tourism academics and researchers to engage more with quantitative research methods such as the TCI to develop a deeper understanding of the relationship between tourism and climate change. This too could be said for climate change researchers, particularly those concerned with the impact that climate change has on the tourism sector in South Africa. Future qualitative work could look to engage with tourism stakeholders, such as tourism businesses and government departments that have a role to play in the South African Tourism sector, undertaking similar interviews as were conducted in this study. Their perceptions and knowledge could provide a different perspective to the relationship between tourism and climate change and their perceptions regarding the ability to adapt to the impacts of climate change and could shed some light on the way forward in terms of policy and research priorities.

Finally, research that was called for by many of the respondents in this study, involves exploring the ability to match the results of the TCI model to the actual tourist numbers at each destination. Ideally, it would be useful if a model had to be designed that could account for the climate suitability of a destination while simultaneously indicating the actual tourist numbers of a particular location for the particular study period. In addition, it would be even more valuable to observe the resultant change in tourist numbers in response to a change in the climate suitability. This would provide a definite and quantifiable description of the extent and magnitude of the impact of climate change and tourism at a destination scale, while simultaneously allowing tourism stakeholders to quantify evidence that can be used to plan and implement subsequent adaptation strategies.

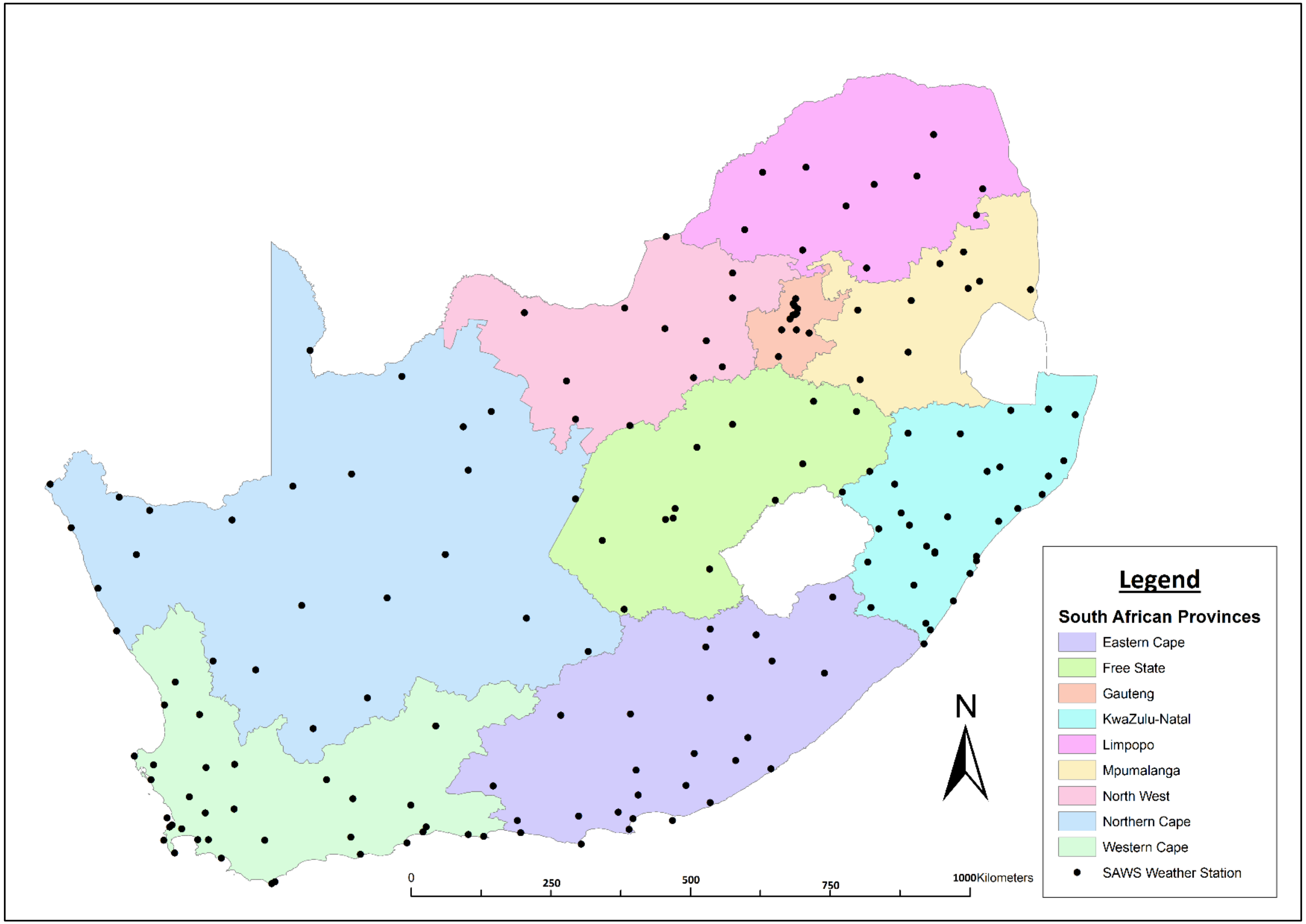


Figure 6.15: Map of all SAWS weather stations in South Africa.

Chapter 7: Conclusion

7.1. Introduction

Tourism is one of the fastest growing sectors globally, and plays a major role in national and local economies at destinations (Scott and Lemieux, 2010). Recently, climate change has been recognised as a major threat to the tourism sector, with wide and far reaching negative impacts (Hamilton *et al*., 2005b; Moreno, 2010; March *et al*., 2014). It has been argued that the direct and indirect impacts of climate change are already impacting destinations around the world (Simpson *et al*., 2008; Colakoglu and Mil, 2011). The natural environment is an important resource for the global tourism markets, therefore any changes to the natural conditions or environment as a result of climate change can have a significant impact on tourism destinations (Agnew and Viner, 2001).

Many African countries rely heavily on tourism as a means of generating income, and with unique natural and social capital, many countries use tourism as a tool for social and economic development (Nyaupane and Chhetri, 2009; Hambira and Saarinen, 2015). This is true for South Africa, with domestic and international tourism increasing since the fall of apartheid (Akinboade and Braimoh, 2010). In South Africa, tourism is an important sector for the country due to the fact that it is used as a strategy to promote social and economic development (Lee and Chang, 2008). However, weather and climate and any resultant change in these systems will have a considerable impact on the tourism sector in South Africa, particularly with the climate change projections that are expected to occur in the near future (c.f. Davis, 2010; Karmalkar *et al*., 2012; Jawtusch, 2014; Stevens *et al*., 2014; Ziervogel *et al*., 2014). The natural resources of the country form the foundation of many of the tourist product offerings, therefore, if climate change negatively influences these resources, the tourism sector will be severely impacted.

Within this context, the main aim of this study was to quantify the influence of climate change on the South African tourism sector, by calculating the climate suitability for tourism of various destinations across the country using the TCI. Through the analysis of the TCI results, using correlation and regression analysis, this study highlights changes in the annual, monthly and seasonal influence of climate change on the climate suitability for tourism at locations across South Africa over time. Additionally, it makes a contribution to an improved regional and global understanding of climate suitability shifts and the rate at which these shifts are taking place in response to a changing climate.

This chapter will examine the extent to which the aims of the study have been achieved and will highlight the primary results of the study. This will be followed by a discussion of the regional significance of the results and a brief summary of the application of the findings.

7.2. Achievement of Study Aims

The fundamental aim of this study was to provide the first quantitative evaluation of climate suitability for the tourism industry at a destination level across the country, by calculating the TCI for these respective locations. In addition, the study set out to provide the first in-depth spatial and temporal analysis of TCI scores in South Africa, by using the TCI results from the 18 study sites across the country. The extent to which each study aims has been achieved and the main results, will be discussed in the order in which the aims were presented in *section 1.3*.

1. *Explore the long-term Tourism Climate Indices (TCIs) for 18 locations across South Africa.*

This aim, required the tourism climate index to be calculated for the 18 study sites that were selected for this study. Due to data restrictions that resulted in inconsistent data availability across the study sites, two different TCI models were used to calculate TCI scores. In both instances the TCI score for each location was calculated for the period 2005-2014, to allow for a direct comparison to be made, and it was calculated for the longest continuous period for which meteorological data was available for each site. The study sites that had all the necessary meteorological data (maximum daily temperature; mean daily temperature; minimum daily relative humidity; daily relative humidity; precipitation; daily sunshine hours and wind speed) to calculate the TCI developed by Mieczkowski (1985) and later adapted by Perch-Nielsen (2010) were calculated using the methodology outlined in *section 4.2.3*. The traditional TCI was calculated for Bethlehem, Bloemfontein, Cape Town, East London, Johannesburg, Kimberley, Port Elizabeth, Polokwane and Port Nolloth.

The remaining study sites did not have all the necessary meteorological data needed to calculate the traditional TCI scores, with most notably an absence of cloud cover data. As a result, the study developed an alternative TCI that could best fit the data that these remaining nine study sites had. The study developed two adaptations of the original TCI model, the first being the mathematically adapted TCI and the second being the rainfall proxy TCI. Both of the adapted models were run against the two sets of data (complete and incomplete) for the locations used in *section 5.2*, to test the validity and accuracy of each model and determine which model was the best one to use as an alternative in this study. The methods and procedures that were used to develop the adapted models can be found under *section 4.2.4 and section 4.2.5.* Ultimately, the mathematically adapted TCI proved to be a more accurate adaptation of the original model, the results of which can be found under *section 5.3*. Consequently, the mathematically adapted TCI was used to calculate the TCI scores at the remaining nine study sites: Belfast, Durban, Knysna, Ladysmith, Nelspruit, Paarl, Pilanesberg, Pretoria and St Lucia.

In both instances, the mean annual TCI score was calculated for the period 2005-2014 and the longest continuous annual mean (based on the longest continuous set of data) for each study site. Furthermore, the mean monthly TCI scores were calculated for each month of the year at each study site for both periods of time. A detailed account of these results can be found under *section 5.2.1.1 and 5.4.1*.

The mean annual TCI scores for the period 2005 to 2014 reveal that the majority of the study sites demonstrate TCI scores between 80 and 89 and are considered to have excellent climate conditions for tourism. This suggests that the majority of the selected study sites across South Africa have ideal to excellent climatic conditions for tourism, and should attract the high levels of tourism numbers relative to the global mean. Based on these results, it could be suggested that different tourism markets in these regions may potentially thrive under favourable climate conditions at an annual scale. Conversely, Belfast, East London and Port Nolloth all demonstrate relatively lower TCI scores, although still classifies as having very good climate conditions for tourism. Although not terrible for tourists visiting those regions relative to global means, the TCI scores demonstrated at these three locations are relatively lower than those at the rest of the study sites. Port Nolloth and East London are the only coastal sites that are considered to have very good climate conditions for tourism, while all the other coastal study sites are considered to have excellent climate conditions for tourism. Comparing the mean annual TCI for the period 2005-2014 to the longest continuous mean for each of the locations, it can be seen that the climate suitability of each location has remained constant in terms of classification in the rating categories. However, there are slight, but noticeable increases or decreases in the annual average TCI scores across the different time scales. This suggests that despite any changes in the climate over different time scales, the climate suitability for tourism across South Africa has remained largely excellent.

The mean monthly TCI scores for Bethlehem, Bloemfontein, Johannesburg, Kimberley, Ladysmith, Nelspruit, Pilanesberg, Pretoria, Polokwane and Belfast all demonstrate a general pattern that suggests that the climate suitability in these regions is most favourable during spring and autumn (*Section 5.5*). This is as a result of large temperature differences between winter and summer due to the effects of continentality. These regions all experience summer rainfall, which reduces the climate suitability of these regions during summer. Durban and St Lucia demonstrate mean monthly TCI scores that suggest that the winter months are more climatically suitable for tourism. This is primarily due to the fact that the winter months experience a decrease in rainfall over these regions, and there is a slight decrease in temperatures, which are more comfortable than the extremely hot temperatures experienced in summer. Cape Town, Port Elizabeth, Port Nolloth, Knysna and Paarl all have the most favourable climate for tourism during the summer months. These regions see a decrease in mean monthly TCI scores during winter as a result of the compounding negative effects of multiple climatic conditions (decrease in temperatures and increase in rainfall) affecting the climate suitability of the two regions.

2. *Determining the direction and magnitude of change in the TCI scores over the study period*.

To identify the direction and strength of any trends in the annual mean TCI scores and the mean monthly TCI scores over the periods 2004-2014 and the longest continuous period at each location, linear univariate regression and Pearson's correlation analysis was used. *Section 4.2.5* outlines the methods used to establish a relationship between TCI scores and time. Once the trends in the TCI scores over time had been calculated, the linear regression equation was used to determine the rate at which the TCI scores were changing over the study period, the methods used to achieve this are detailed under *section 4.2.6.* For a detailed account of the results regarding the traditional TCI and mathematically adapted TCI trends, refer to *section 5.2.1.2 and 5.4.2*.

The annual mean TCI score trends over time varied across the country for the period 2005-2014. Bethlehem, Belfast, Cape Town, Kimberley, Port Elizabeth, Paarl and Pilanesberg all demonstrated statistically insignificant decreases in their TCI scores over the period 2005-2014. Despite this decrease in the TCI scores over the study period for these locations, the mean annual TCI scores remained classified as excellent at Bethlehem, Cape Town, Kimberley, Port Elizabeth, Paarl and Pilanesberg, while the annual mean TCI score remained classified as very good. This suggests that the slight decrease in TCI scores over the study period at these locations did not alter the climate suitability at a large enough extent for the climate suitability to be reclassified into a grouping that is considered less ideal. There were small changes to the TCI scores in their broader classifications, consistent with the statistically insignificant increases in TCI scores. For the period 2005-2014, St Lucia, Knysna and Port Nolloth all demonstrated statistically significant increases in their annual mean TCI scores. This suggests that tourists coming to these regions would be met with increasingly favourable climate conditions for tourism. The remaining locations of Bloemfontein, East London, Johannesburg, Durban, Ladysmith, Nelspruit and Pretoria all demonstrated statistically insignificant increases in their TCI scores for the period 2005-2014.

3. *Explore the perceptions of tourism academics and researchers in South Africa regarding the relationship between climate change and tourism, and the suitability of TCIs.*

In-depth interviews were carried out with a number of tourism academics and researchers from different universities, with the respondents occupying varying positions at each university, from PhD candidate to full professor. This was undertaken in order to obtain a wide ranging view of perceptions, relating to the suitability of TCIs in assessing the impacts of climate change to tourism in South Africa from the different respondents. The full details of the interview process can be found under *section 4.3.* The results of the interviews with the tourism academics and researchers can be found under *section 5.5.*

All of the respondents were aware of climate change and demonstrated a reasonably in-depth knowledge and understanding regarding the issue. Although the respondents acknowledged that climate change is a global issue, the majority of them perceived climate change to be an issue that will only start to impact the tourism sector in the future. It was perceived by most of the respondents that for climate change to become an issue that results in negative impacts, a threshold needs to be reached, at which point the climate would become too uncomfortable for tourism. In addition, some respondents cited future increases in extreme events and flooding as potentially having a negative impact on the tourism sector. However, none of the respondents could provide a time-frame for when they thought the impacts of climate change would be felt in South Africa. Despite this, respondents acknowledged the major role played by the tourism sector in South Africa, and therefore, all the respondents encouraged the need for more research that explores the relationship between climate change and tourism in the country.

Most of the tourism academics and researchers were not familiar with the TCI, however, the majority of them felt that there was a definite need for incorporating a quantitative tool into the current tourism and climate change research agenda. Most of them found value in being able to quantify the impacts of climate change on the tourism sector in South Africa and stated that it would be extremely valuable to utilise in future research. A few of the respondents called for the TCI results to be compared to actual tourism numbers. Although this was one of the original aims of the study, the respondents did not want to engage with whether or not they perceived the results to be accurate based on their perceptions, because of their limited knowledge of the TCI model and therefore this could not be achieved. This remains a primary aim for future research. Many respondents noted that all the study sites in this research are experiencing increases in tourism, however, some of the TCI trends indicate that the theoretical climate of some destinations are becoming increasingly unfavorable for tourism. This demonstrates that there are enough drivers attracting tourists to destinations around the country, despite a decrease in the climate suitability of some places.

7.3. Regional Significance of the Results

The fundamental aim of this study was to quantify the influence of climate change on the South African tourism sector, by calculating the climate suitability for tourism of various destinations across the country using the TCI. In doing so, this research has made a major contribution to filling the gap in the limited climate change and tourism literature in South

Africa. This study has made a considerable contribution to the African tourism and climate change literature. This study can be used as the foundation for further research in South Africa and at a larger scale within the African context. This study has demonstrated, that despite data limitations, that are not likely to be limited to South Africa, that adapted forms of the TCI can be developed and used as a reasonably accurate alternative. As a result, various countries, whose weather stations do not capture the full spectrum of meteorological data needed to calculate the traditional TCI, can still determine their climate suitability.

While some global studies that have calculated a TCI score for South Africa at a national scale (c.f. Amelung *et al*., 2007; Rosselló and Santana-Gallego, 2014), this study has taken this further and calculated the TCI at a much higher resolution by being able to quantify the climate suitability for tourism at a destination scale, rather than a national scale. As a result, this study, although largely academic in nature, can be used in a more practical manner as well, guiding tourism management to make more informed decisions during adaptation planning and implementation.

Despite many other factors that influence the tourism sector in South Africa, including crime, quality of infrastructure, cost and product offerings, climate change is a threat that is set to have wide and far reaching impacts on all destinations in the country and on the tourism sector. Due to the important role of the tourism sector in South Africa in terms of encouraging social and economic development, the results of this study provide destinations across South Africa, with improved knowledge and understanding of the potential impacts of climate change on tourism. It therefore provides tourism stakeholders an opportunity to make better informed decisions regarding adaptation processes, while simultaneously demonstrating the value of such research. It is through this perceived value by tourism stakeholders that this study can act as a catalyst for future research on the relationship between climate change and tourism in South Africa.

7.4. Application of Findings

With the increasing threat of climate change having a considerable impact on South Africa, and consequently on the South African tourism sector (Scott, 2003; Gomez-Martin, 2006; Spenceley and Goodwin, 2007; Stevens *et al*., 2014), it is important that current and future climate change and tourism research become more practical in terms of on-the-ground application at the destination level. The results of this research can be directly applied to each location that was used as a study site, and can be used as a planning and decision making tool during the adaptation process. Tourism stakeholders at each location can use the TCI results to adapt to the changing climate. In so doing, tourism stakeholders could adapt the type of tourism products that they offer, they could alter the timing at which they offer tourism products and they could implement certain processes and improvements to the product offerings so as to lessen the impacts of climate to the tourist's experience.

Many of the respondents acknowledged that coastal regions are particularly vulnerable to the impacts of climate change and consequently the tourism product offerings will be at threat to climate change. It has been stipulated that coastal areas may be impacted by sea level rise, which could result in coastal erosion and could be threatening to beach activities (Scott *et al*., 2007a; Nyaupane and Chhetri, 2009; Fitchett *et al*., 2016; Hoogendoorn *et al*., 2016). Changes in in the climate, such as increased temperatures and increased rainfall, can play a major role in negatively influencing the tourism at coastal locations. It is therefore imperative that coastal destinations such as Cape Town and Port Elizabeth, that demonstrated a decrease in climate suitability for tourism over the study site, make use of these results to understand the extent to which climate change may potentially influence climate. In so doing, these destinations will be able to make better informed decisions during the adaptation process, which will enhance the probability that correct and effective adaptation processes are implemented. As a result, this would reduce the impact of climate change on the climate suitability of the destinations for tourism and will ultimately benefit the local tourism market.

Adaptation measures have been implemented in the tourism sector, to reduce the impacts of climate change at destinations around the world, such as building bigger seas walls (to protect beaches and infrastructure from seas level rise) and improved air-conditioning, operating at off-peak season and diversifying the tourism product offering. Successful adaptation within the tourism industry is often very specific to the destinations' climate and tourism product offering (UNWTO and UNEP, 2008). Therefore, tourism stakeholders across South Africa can use these TCI results, which are based on destination specific climate data, to tailor their adaptation strategies to suit the individual characteristics of each destination.

7.5. Synthesis

The majority of the study sites were calculated to have TCI scores indicative of excellent climate suitability for tourism was excellent and ideal, while Belfast, East London and Port Nolloth all demonstrate relatively lower TCI scores indicative of only very good climate conditions for tourism. Due to the fact that the majority of the study sites have annual mean TCI scores that are considered excellent, it could be beneficial to scale the rating categories of the TCI scores in such a way so as to make it easier to differentiate between places that are considered to have excellent climate conditions for tourism.

Furthermore, to differentiate between the climate suitability of South African towns for tourism, it could be argued that more pertinent climate variables should be considered. Fluctuations between conditions of drought and flooding are a significant concern for tourism in South Africa. It would therefore be ideal for such variables to be considered in the index. Extreme events, which include but are not limited to floods and droughts, are particularly detrimental in South Africa due to the low adaptive capacity. The frequency and severity of extreme events should therefore also be included in the index.

For the period 2005-2014, the majority of the trends between the annual traditional TCI scores and time demonstrate statistically significant decreases in the TCI scores. These should be continually monitored. However, the remaining locations of Bloemfontein, East London, Johannesburg and Port Nolloth all demonstrate positive trends over the same time period, with only Port Nolloth demonstrating a statistically significant positive trend of 0.93units/year. The majority of the annual trends for the mathematically adapted TCI scores were increasing over the period 2005-2014, with Knysna and St Lucia both demonstrating statistically significant increases of 0.76units/yr and 0.50units/yr respectively. For the same period, Belfast, Paarl and Pilanesberg all demonstrate statistically insignificant decreases in their TCI scores for that period.

The majority of the respondents believe that there is a need to be able to quantify the impacts of climate change on the tourism sector in South African, and many perceived the TCI to be a valuable tool that can be used in current and future tourism and climate change research, to gain an understanding of the relationship between climate change and tourism in South Africa.

References

Adams, R.M., Rosenzweig, C., Peart, R.M., Ritchie, J.T., McCarl, B.A., Glyer, J.D., Curry, R.B., Jones, J.W., Boote, K.J. and Allen, L.H. (1990). Global Climate change and united-states agriculture. *Nature*, 345: 219-224.

Adger, W.N., Arnell, N.W. and Tompkins, E.L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, 15: 77-86.

Adger, W.N., Huq, S., Brown, K., Conway, D. and Hulme. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, 3: 179-195.

Agnew, M.D. and Viner, D. (2001). Potential impacts of climate change on international tourism. *International Journal of Tourism and Hospitality Research*, 3: 37-60.

Ahmed, M.T. and Hefny, M. (2007). Climate Change and tourism: An Egyptian perspective. *Cairo: Egyptian Biodiversity Cleaning House Mechanism*.

Akinboade, O.A. and Braimoh, L.A. (2010). International tourism and economic development in South Africa: A Granger causality test. *International Journal of Tourism Research*, 12: 149-163.

Amelung, B. and Nicholls, S. (2014). Implications of climate change for tourism in Australia. *Tourism Management*, 41: 228-244.

Amelung, B. and Viner, D. (2006). Mediterranean tourism: exploring the future with the tourism climate index. *Journal of Sustainable Tourism*, 14: 349-366.

Amelung, B., Nicholls, S. and Viner, D. (2007). Implications of global climate change for tourism flows and seasonality. *Journal of Travel Research*, 45: 285-296.

Amiranashvili, A.G., Chargazia, K.Z. and Matzarakis, A. (2014). Comparative characteristics of the tourism climate index in the south Caucasus Countries Capitals (Baku, Tbilisi, Yerevan). *Journal of Georgian Geophysical Society*, 17b: 14-25.

Araujo, J.A., Babatunde, J.A. and Crespo, O. (2014). Impacts of drought on grape yields in Western Cape, South Africa. *Theoretical and Applied Climatology*, 123: 117-130.

Bassey, E. (2006). The rise and fall of this This Day Newspaper: the significance of advertising to its demise. *Master of Arts Dissertation submitted to the University of Johannesburg*: Johannesburg.

Becken, S. (2013) A review of tourism and climate change as an evolving knowledge domain. *Tourism Management Perspectives*, 6: 53-62.

Becken, S. and Clapcott, R. (2011). National tourism policy for climate change, *Journal of Policy Research in Tourism. Leisure and Events*, 3: 1-17.

Becken, S., Hay, J. and Espiner, S. (2011). The risk of Climate change for tourism in the Maldives. In Carlsen J.C. and Butler, R. (Eds.) *Island Tourism: Sustainable Perspectives*. CABI: Oxfordshire.

Becker, S. (1998). Beach comfort index: a new approach to evaluate the thermal conditions of beach holiday resort using a South African example. *GeoJournal*, 44: 297-307.

Berkhout, F., Hertin, J. and Gann, D.M. (2006). Learning to adapt: organisational adaptation to climate change. *Climate Change*, 78: 135-156.

Binns, T. and Nel, E. (2002). Tourism as a local development strategy in South Africa. *The Geographical Journal*, 168: 235-247.

Booysen, I. (2010). Rethinking township tourism: towards responsible tourism development in South African townships. *Development Southern Africa*, 27: 273-287.

Bord, R.J., Fisher, A. and O'Connor, R.E. (1998). Public perceptions of global warming: United States and international perspectives. *Climate Research*, 11: 75-84.

Boykof, M.T. and Boykoff, J.M. (2004). Balance as bias: global warming and the US prestige press. *Global Environmental Change*, 14: 125-136.

Brand South Africa. (2015). Advice for travellers: South Africa's weather and climate. Retrieved on 25 February 2016 from:

http://www.southafrica.info/travel/advice/climate.htm#.VuVrz5x97Df

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3: 77-101.

Briedenhann, J. (2008). The role of the public sector in rural tourism: respondents' view. *Current Issues in Tourism*, 10: 584-607.

Brooks, S. (2005). Images of 'Wild Africa': nature tourism and the (re)creation of Hluhluwe Game Reserve, 1930-1945. *Journal of Historical Geography*, 31: 220-240.

Brunsdon, C., Corcoran, J., Higgs, G. and Ware, A. (2009). The influence of weather on local geographical patterns of police calls for service. *Environment and Planning B: Planning and Design*, 36: 902-926.

Bruwer, J. (2003). South African wine routes: some perspectives on the wine tourism industry's structural dimensions and wine tourism product. *Tourism Management*, 24: 423-435.

Buob, S. and Stephan, G. (2013). On the incentive compatibility of funding adaptation. *Climate Change Economics*, 4: 1-18.

Bushman, B., Wang, M. and Anderson, C. (2005). IS the curve relating temperature to aggression linear or curvilinear? *Journal of Personality and Social Psychology*, 89: 62-66.

Campbell, M. and Phago, K. (2008). The impact of major sporting events on the economy and the people of a developing region: The case of the 2010 FIFA World Cup tournament *Africa Insight*, 38: 26-34.

Cegnar, T. and Matzarakis, A. (2004). Trends of thermal bioclimate and their applications for tourism in Slovenia. In Matzarakis, A., de Freitas, C.R., Scott, D. (Eds). *Advances in tourism climatology.* Freiburg: Berichte des Meteorologischen Institutes der Universitat Freiburg, 158-165.

Chapman, L. (2007). Transport and climate change: a review. *Journal of Transport Geography*, 15: 354-367.

Charters, S. and Ali-Knight, J. (2002). Who is the wine tourist? *Tourism Management*, 23: 311-319.

Chase, B.M. and Meadows., M.E. (2007). Late Quaternary dynamics of Southern Africa's winter rainfall zone. *Earth Science Reviews*, 84: 103-138.

Christiansen, L., Ray, A.D., Smith, J.B. and Haites, E. (2012). Accessing international funding for climate change. Retrieved on 9 May 2015 from:

http://www.tech-action.org/Publications/TNA-Guidebooks.

Climate-data. (2014). Climate: South Africa. Retrieved on 12 January 2015 from http://en.climate-data.org/country/61/.

Cohn, E. (1990). Weather and crime. *British Journal of Criminology*, 30: 51-64.

Colakoglu, O.E. and Mil, Z. (2011). Effects of climate changes on tourism. *International Journal of Contemporary Economics and Administrative Sciences*, 1: 234-271.

Connell, J., (2006). Medical tourism: Seas, sun, sand and … surgery. *Tourism Management*, 27: 1093-1100.

Croitoru, A., Holobaca, I., Lazar, C., Moldovan, F. and Imbroane, A. (2012). Air temperature trend and the impact on winter wheat phenology in Romania. *Climate Change*, 111: 393-410.

Dangor, F., Hoogendoorn, G. and Moolla, R. (2015). Medical Tourism by Indian-South Africans to India: an exploratory investigation. *Bulletin of Geography: Socio Economic Series*, 29: 19-30.

Davis, C., (2010). Climate change handbook for North-Eastern South Africa. *Climate Change Research Group*, Council for Scientific and Industrial Research, Pretoria.

Davis, N.E. (1968). An optimum weather index. *Weather*, 23: 305-317.

Day, J., Chin, N., Syndor, S. and Cherkauer, K. (2013). Weather, climate, and tourism performance: a quantitative analysis. *Tourism Management Perspectives*, 5: 51-56.

de Bruin, K.C. and Dellink, R.B. (2011). How harmful are restrictions on adapting to climate change? *Global Environmental Change*, 21: 34-45.

de Freitas, C.R. (1990). Recreation climate assessment. *International Journal of Climatology*, 10:89-103.

De Freitas, C.R., Scott, D. and McBoyle, G. (2008) A second generation climate index for tourism (CIT): specification and verification. *International Journal of Biometeorology*, 52: 399-407.

Department of Environmental Affairs. (2016). South African Weather Service (SAWS). Retrieved on 29 February 2016 from: https://www.environment.gov.za/statutorybodies/saws#services

Deressa, T., Hassan, R and Poonyth, D. (2005) Measuring the Impact of Climate Change on South African Agriculture: The Case of Sugarcane Growing Regions. *Agrekon*, 44: 524-542.

Deser, C., Phillips, A., Bourdette, V. and Teng, H. (2012). Uncertainty in climate change projections: the role of internal variability. *Climate Dynamics*, 38: 527-546.

Dieke, P.U.C. (1994). Cross-national comparison of tourism development: lessons from Kenya and Gambia. *Journal of Tourism Studies*, 4: 558-561.

Dieke, P.U.C. (2010). From Apartheid to 'managed revolution': tourism development and transition in South Africa. In R. Butler and W. Suntikul (Eds.), *Tourism and Political Change*. Oxford: Goodfellow Publishers, 120-132.

Donaldson, R. and Ferreira, S., (2009). (Re)creating urban destination impact: Opinions of foreign visitors to South Africa on safety and security? *Urban Forum*, 20: 1-18.

Doorenbos, J. and Pruit, W.O. (1977). Guidelines for predicting crop water requirements. *Food and Agriculture Organisation of the United Nations: Irrigation and Drainage Paper*, 24: Rome.

Dubois, G., Ceron, J., Gössling, S. and Hall, M. (2016). Weather preferences of French tourists: lessons for climate change impact assessment. *Climate Change*, DOI 10.1007/s10584-016-1620-6.

Dyson, L.L. (2015). A heavy rainfall sounding climatology over Gauteng, South Africa, using self-organising maps. *Climate Dynamics*, 45: 3051-3065.

Ehmer, P. and Heymann, E. (2008). Climate change and tourism: Where will the journey lead? *Current Issues: Energy and Climate Change*, 1-28.

Elsasser, H. and Bürki, R. (2002). Climate change as a threat to tourism in the Alps. *Climate Research*, 20: 253-257.

Falk, M. (2014). Impact of weather conditions on tourism demand in peak summer seasons over the last 50 years. *Tourism Management Perspectives*, 9: 24-35.

Fang, Y. and Yin, J. (2015). National assessment of climate resources for tourism seasonality in China using the tourism climate index. *Atmosphere*, 6: 183-194.

Fergusson, P. (1964). Summer weather at the English seaside. *Weather*, 19: 144-146.

Ferreira, S. (2011). Cape Town and Table Mountain National Park: Neighbours living in symbiosis with nature. *Current Issues in Tourism*, 14: 275-293.

Ferreira, S.L.A. and Harmse, A.C. (2000). Crime and tourism in South Africa: International tourist perception and risk. *South African Geographical Journal*, 82: 80-85.

Feser, F., Rockel, B., von Storch, H., Winterfeldt, J. and Zahn, M. (2011). Regional climate models add value to global model data. *American Meteorological Society*, 92: 1181-1192.

Fitchett, J., Grab, S.W. and Thompson, D.I. (2014). Temperature and tree age interact to increase mango yields in the Lowveld, South Africa. *South African Geographical Journal*, 98: 105-117.

Fitchett, J.M. (2013). Phenological responses of citrus flowering to climate variability and change in Iran. *Master of Science Dissertation submitted to the University of the Witwatersrand: Johannesburg.*

Fitchett, J.M., Grant, B. and Hoogendoorn, G. (2016). Climate Change threats to two low-lying South African coastal towns: risks versus perceptions. *South African Journal of Science* (in press).

Füssel, H.M. (2007). Adaptation planning for climate change: concepts, assessment approaches, and key lessons. *Sustainable Science*, 2: 265-275.

Gammon, S. and Robinson, T. (1997). Sport and tourism: a conceptual framework. *Journal of Sports Tourism*, 4: 8-24.

George, R. (2003). Tourists' perceptions of safety and security while visiting Cape Town, *Tourism Management*, 24: 575-585.

George, R. and Booysens, I. (2014). Township tourism demand: tourists' perceptions of safety and security. *Urban Forum*, 25: 449-467.

George, R. and Frey, N. (2010). Creating change in responsible tourism management through social marketing. *South African Journal of Business*, 41: 11-23.

Gibson, H.J. (2003). Sport tourism: an introduction to the special issue. *Journal of Sport Management*, 17: 205-213.

Gomez-Martin, B. (2006). Climate potential and tourist demand in Catalonia (Spain) during the summer season. *Climate Research*, 32: 75-87.

Gomez-Martin, M.B. (2005). Weather, climate and tourism- a geographical perspective. *Annual Tourism Research*, 32: 571-591.

Grant, G.C. (2015). Investigating tourism and climate change: the case of St Francis Bay and Cape St Francis. Master of Science Dissertation submitted to the University of the Witwatersrand: Johannesburg.

Hall, C.M. (2001) Trends in ocean and coastal tourism: the end of the last frontier? *Ocean and Coastal Management*, 44: 601-618.

Hambira, W.L. and Saarinen, J. (2015). Policy-maker's perceptions of the tourism-climate change nexus: policy needs and constraints in Botswana. *Development Southern Africa*, 32: 350-362.

Hambira, W.L., Saaeinen, J., Manwa, H. and Atlhopheng, J.R. (2013). Climate change adaptation practices in nature-based tourism in Maun in the Okavango Delta area, Botswana: how prepared are the tourism businesses? *Tourism Review International*, 17: 19-29.

Hamilton, J.M., Maddison, D. and Tol, R.S.J. (2005b). Effects of climate change on international tourism. *Climate Research*, 20: 245-254.

Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2005a). Climate change and international tourism: A simulation study. *Global Environmental Change*, 15: 253-266.

Hammett, D., (2011). British media representations of South Africa and the 2010 FIFA World Cup. *South African Geographical Journal*, 93: 63-74.

Harlfinger, O. (1991). Holiday bioclimatology: A study of Palma de Majorca, Spain. *GeoJournal*, 25: 377-381.

Harper, D. and Thompson, A.R. (2011). Qualitative Research Methods in Mental Health and Psychotherapy: A Guide for Students and Practitioners. Wiley and Sons: Chichester, UK. DOI: 10.1002/9781119973249

Harrison, S.J., Winterbottom, S.J. and Johnson, R.C. (2001). A preliminary assessment of the socio-economic and environmental impacts of recent changes in winter snow cover in Scotland. *Scottish Geographical Journal*, 117: 297-312.

Hawkins, E. and Sutton, R. (2009). The potential to narrow uncertainty in regional climate predictions. *American Meteorological Society*, 90: 1095-1107.

Hein, L., Metzger, M.J. and Moreno, A. (2009). Potential impacts of climate change on tourism: a case study of Spain. *Current Opinion in Environmental Sustainability*, 1: 170-178.

Hill, E., Knox, S., Thompson, B., Nutt, W.E., Hess, S. and Ladnay, N. (2005). Consensual qualitative research: an update. *Journal of Counselling Psychology*, 52: 1-25.

Hoogendoorn, G. (2014). Mapping fly-fishing tourism in South Africa. *South African Journal of Hospitality, Tourism and Leisure*, 3: 1-13.

Hoogendoorn, G. and Fitchett, J.M. (2016). Tourism and climate change: a review of threats and adaptation strategies for Africa. *Current Issues in Tourism*, DOI: http://dx.doi.org/10.1080/13683500.2016.1188893.

Hoogendoorn, G. and Rogerson, C.M. (2015). Tourism geography in the global South: new South African perspectives. *South African Geographical Journal*, 97: 101-110.

Hoogendoorn, G. and Visser, G. (2015). Focusing on the 'blessing' and not the 'curse' of second homes: notes from South Africa. *Area*, 1-6.

Hoogendoorn, G., Grant, B. and Fitchett, J. (2015). Towards green guest houses in South Africa: the case of Gauteng and KwaZulu-Natal. *South African Geographical Journal*, 97: 123-138.

Hoogendoorn, G., Grant, B. and Fitchett, J. (2016). Disjunct perceptions? Climate change threats in two low-lying South African coastal towns. *Bulletin of Geography. Socio-Economic Series*, 31: 59-71.

Hoogendoorn, G., Marais, L. and Visser, G. (2009). Changing countryside's, changing villages: Second homes in Rhodes, South Africa. *South African Geographical Journal*, 91: 75-83.

Horrocks, J. and Menclova, A. (2011). The effects of weather on crime. *New Zealand Economic Papers*, 45: 231-254.

Hughes, T.P., Baird, A.H., Bellwood, D.R., Connolly, S.R., Folke, C. and Roughgarden, J. (2003). Climate change, human impacts and the resilience of coral reefs. *Science*, 301: 929-933.

Hulme, M., Conway, D, Jones, P.D., Jiang, T., Barrow, M. and Turney, C. (1995). Construction of a 1961-1990 European climatology for climate change modelling and impact applications. *International Journal of Climatology*, 15: 1333-1363.

Ingle, M. (2008). The Sabaru Fauresmith 200km challenge: looking a gift-horse in the mouth? *Africa Insight*, 38: 86-99.

Intergovernmental Panel on Climate Change (IPCC). (2007). Parry M, Canziani OF, Palutikof J, van der Linden PJ, Hanson C (Eds). In *Climate change 2007: impacts, adaptation and vulnerability*, contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge.

Jawtusch, J. (2014). Climate change and disaster risk guide: Which climate and disaster risks affect South African and how do they affect South Africa? Retrieved on 16 January 2015 from: http://www.brotfueralle.ch/fileadmin/deutsch/2_Entwicklungpolitik_allgemein/B-Klima/Klimaguides/2014_Guide_CC_and_DRR_SA_2014-04-27.pdf. (WEB)

Jeuring, J. and Becken, S. (2013). Tourists and severe weather- An exploration of the role of 'Locus of responsibility' in protective behaviour decisions. *Tourism Management*, 37: 193-202.

Jones, B. and Scott, D. (2006). Climate change, seasonality and visitation to Canada's National Parks. *Journal of Parks and Recreation Administration*, 24: 42-62.

Jones, G.V., White, M.A., Cooper, O.R. and Storchmann, K. (2005). Climate change and global wine quality. *Climatic Change*, 73: 319-343.

Kaján, E. and Saarinen, J. (2013). Tourism, climate change and adaptations: a review. *Current Issues in Tourism*, 16: 167-195.

Kalabokidis, K., Palaiologou, P., Gerasopoulos, E., Giannakopolous., Kostopoulou, E. and Zerefos, C. (2015). Effect of climate change projections on forest fire behaviour and values-at-risk in southwestern Greece. *Forests*, 6: 2214-2240.

Karmalkar, A., McSweeney, C., New, A. and Lizcano, G. (2012). UNDP climate change country profiles: South Africa. Retrieved on 15 January 2015 from: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/?country=South_Africa&d1=Reports.

Kavita, E. and Saarinen, J. (2016). Tourism and rural community development in Namibia: policy issues review. *Fennia*, 193: 1-10.

Kiambo, W. (2005). The emerging role of tourism in Mozambique's post-war reconstruction. *Africa Insight*, 35: 142-148.

Kirsten, M. and Rogerson, C.M. (2002) Tourism, business linkages and small enterprise development in South Africa. *Development Southern Africa*, 19: 29-59.

Kotze, N. (2006). Cape Town and the Two Oceans Marathon: The impact of sports tourism. *Urban Forum*, 17: 282-293.

Kovács, A. and Unger, J. (2014). Modification of the Tourism Climate Index to Central European climatic conditions- examples. *Quarterly Journal of Hungarian Meteorological Services*, 118: 147-166.

Kubokawa, H., Inoue, T. and Satoh, M. (2014). Evaluation of the Tourism Climate Index over Japan in a future climate using a statistical downscaling method. *Journal of the Meteorological Society of Japan*, 92: 37-54.

Kulendran, N. and Witt, S.F. (2003) Forecasting the demand for international business tourism. *Journal of Travel Research*, 41: 265-271.

Kurtzman, J. and Zauhar, J. (1995). Research: sport as a touristic endeavour. *Journal of Tourism Sport*, 3: 30-54.

Kurukulasuriya, P., Mendelsohn, R., Hassan, R., Benhin, J., Deressa, T., Diop, M., Eid, H.M., Fosu, K.Y., Gbetibouo, G., Jain, S., Mahamadou, A., Mano, R., Kabubo-Mariara, J., El-Marsafawy, S., Molua, E., Ouda, S., Ouedraogo, M., Sene, I., Maddison, D., Seo, S.N. and Dinar, A. (2006) Will African agriculture survive climate change? *The World Bank Economic Review*, 20: 367-388.

Lamont, T., van den Berg, M.A. and Barlow, R.G. (2016). Agulhas current influence on the shelf dynamics of the KwaZulu-Natal Bight. DOI: 10.1175/JPO-D-15-0152.1

Lapeyre, R., (2011). The Gootberg lodge partnership in Namibia: Towards poverty alleviation and empowerment for long-term sustainability? *Current Issues in Tourism*, 14: 221-234.

Ledneva, A., Miller-Rushing, A., Primack, R. and Imbres, C. (2004). Climate change as reflected in a naturalist's diary, Middleborough, Massachusetts. *The Wilson Bulletin* 116: 224-231.

Lee, C. and Chang, C. (2008). Tourism development and economic growth: A closer look at panels. *Tourism Management*, 29: 180-192.

Leiserowitz, A. (2005). American risk perceptions: is climate change dangerous? *Risk Analysis*, 25: 1433-1442.

Lin, T. and Matzarakis, A. (2011). Tourism climate information based on human thermal perception in Taiwan and Eastern China. *Tourism Management*, 32: 492-500

Lin, T. and Matzarakis, A. (2011). Tourism climate information based on human thermal perception in Taiwan and Eastern China. *Tourism Management*, 32: 492-500.

Lindsay, P., Alexander, R., du Toit, J. and Mills, M. (2005). The potential contribution of ecotourism to African wild dog *Lycaon pictus* conservation in South Africa. *Biological Conservation, 123: 339-348.*

Lobell, D.B., Field, C.B., Cahill, K.N. and Bonfils, C. (2006). Impacts of future climate change in California perennial crop yields: Model projections with climate and crop uncertainties. *Agricultural and Forest Meteorology*, 141: 208-218.

Long, D. and Hoogendoorn, G. (2014). Second home owner perceptions of their environmental impacts: the case of Hartbeespoort. *Urban Forum*, 25: 517-530.

Lorenzoni, I. and Pidgeon, N.F. (2006). Public views on climate change: European and USA perspectives. *Climate Change*, 77: 73-95.

Lorenzoni, I., Nicholson-Col, S. and Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change*, 17: 445-459.

Lourens, M. (2007). Route Tourism: A roadmap for successful destinations and local economic development. *Development Southern Africa*, 24: 475-489.

Maddison, D. (2001). In search of warmer climates? The impact of climate change on flows of British tourists'. *Climatic Change*, 49: 193-208.

Maharaj, S. and Balkaran, R. (2014). A comparative analysis of the South African and global tourism competitiveness models with the aim of enhancing a sustainable model for South Africa. *Journal of Economics and Behavioral Studies*, 6: 273-278.

Mahoney, K. and Van Zyl, I. (2002). The impacts of tourism investment on rural communities: Three case studies in South Africa. *Development Southern Africa*, 19: 83-103.

Manly, B. (2009). Statistics for environmental science and management. *Chapman & Hall:* Florida, 68-74, 113, 182-184.

March, H., Sauri, D. and Llurdes, J.C. (2014). Perception of the effects of climate change in winter and summer tourist areas: The Pyrenees and the Catalan and Balearic coasts, Spain. *Regional Environmental Change*, 14: 1189-1201.

Marshall, N.A., Marshall, P.A., Abdulla, A., Rouphael, T. and Ali, A. (2011). Preparing for climate change: recognising its early impacts through the perceptions of dive tourists and dive operators in the Egyptian Red Sea. *Current Issues in Tourism*, 14: 507-518.

McCarthy, J., Canziani, O., Leary, N., Dokken, D. and White, K. (2001). *Climate Change 2001: Impacts, Adaptations, and Vulnerability*. Cambridge University Press: Cambridge. (BOOK)

Mendelsohn, R. and Williams, L. (2004). Comparing Forecasts of the Global Impacts of Climate Change. *Mitigation and Adaptation Strategies for Global Change*, 9: 315-333.

Mendelsohn, R., Dinar, A. and Williams, L. (2006). The distributional impacts of climate change on rich and poor countries. *Environment and Development Economies*, 11: 159-178.

Mertz, O., Halsnaes, K., Olesen, J.E. and Rasmussen, K. (2009). Adaptation to climate change in developing countries. *Environmental Management*, 43: 743-752.

Mieczkowski, Z. (1985). The tourism climate index: A method of evaluating world climates for tourism. *The Canadian Geographer* 29: 220-233.

Mitchell, M. and Jolley, J. (2013). *Research Design Explained* (8th Edition). Wadsworth Publishing: United States.

Montgomery, D.C., Peck, E.A. and Vining, G.G. (2012). *Introduction to linear regression analysis (5th Edition)*, John Wiley & Sons Inc.: New Jersey.

Moreno, A. and Amelung, B. (2009). Climate change and tourist comfort on Europe's beaches in summer: A reassessment. *Coastal Management*, 37: 550-568.

Moreno, A., (2010). *Climate Change and Tourism: Impacts and Vulnerability in Coastal Europe*, Universitaire Pers Maastricht: Maastricht.

Morgan, R., Gatell, E., Junyent, R., Micallef, A., Özhan, E. and Williams, A.T. (2000). An improved user-based beach climate index. *Journal of Coastal Conservation*, 6: 41-50.

Morrison, C. and Pickering, C.M. (2013). Perceptions of climate change impacts, adaptation and limits to adaptation in the Australian Alps: the ski-tourism industry and key stakeholders. *Journal of sustainable Tourism*, 21: 173-191.

Moswete, N.N. and Dube, P.O. (2014). Wildlife-based tourism and climate: Potential opportunities and challenges for Botswana. In L. D'Amore and P. Kalifungwa (Eds.), *Meeting the challenges of climate change to tourism: Case studies of best practice*. Cambridge: Cambridge Scholars Publishing, 395-416.3

Moyo, B. and Ziramba, E. (2013). The impact of crime on inbound tourism to South Africa: an application of the bounds test. *African Security Review*, 22.1: 4-18.

Murray, R. (1972). A simple summer index with an illustration for summer 1971. *Weather*, 27: 161-169.

Ndlovu, N. and Rogerson, C.M. (2003). Rural local economic development through community-based tourism: The Mehloding hiking and horse trail, Eastern Cape, South Africa. *Africa Insight*, 33: 124-129.

Neuman, W. (1997). *Social research methods: qualitative and quantitative approaches*. Allyn and Bacon: Needham Heights.

New Partnerships for Africa's Development (NEPAD). (2004). *Tourism Action Plan*. Midrand: NEPAD.

Nhemachena, C., Hassan, R. and Chakwizira, J. (2014). Analysis of determinants of farm-level adaptation measures to climate change in southern Africa. *Journal of Development and Agriculture Economics*, 6: 232-241.

Nhemachena, C., Hassan, R. and Kurukulasuriya, P. (2010). Measuring the economic impact of climate change on African agricultural production systems. *Climate Change Economics*, 1: 33-35.

Nieman, G., Visser, G. and Van Wyk, R. (2008). Constraints facing tourism entrepreneurs in South Africa: a study in Gauteng and Mpumalanga provinces, South Africa. *Development Southern Africa*. 25: 283-296.

Nordli, Ø., Wielgolaski, F., Bakken, A., Hjeltnes, S., Måge. F., Sivle, A. and Skre, O. (2008). Regional trends for bud burst and flowering of woody plants in Norway as related to climate change. *International Journal of Biometeorology* 52: 625-639.

Nyaupane, G.P. and Chhetri, N. (2009). Vulnerability to climate change of nature-based tourism in the Nepalese Himalayas. *Tourism Geographies*, 11: 95-119.

O'Connor, R.E, Bord, R.J. and Fisher, A. (1999). Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Analysis*, 19: 461-471.

Ohe, M. and Ikeda, S. (2005). Global warming: risk perception and risk-mitigating behaviour in Japan. *Mitigation and Adaptation Strategies for Global Change*, 10: 221-236.

Olya, G.T. and Alipour, H. (2015). Risk assessment of precipitation and the tourism climate index. *Tourism Management*, 50: 73-80.

Palaniswamy, U. and Palaniswamy, K. (2006). Handbook of statistics for teaching and research in plant and crop science. *Haworth Reference Press:* New York, 59, 207-265.

Parry, M.L., Rosenzweig, C., Iglesias, A., Livemore, M. and Fischer, G. (2004). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change*, 14: 53-67.

Peeters, P. and Dubois, G. (2010). Tourism travel under climate change mitigation constraints. *Journal of Transport Geography*, 18: 447-457.

Perch-Nielsen, S.L. (2010b). The vulnerability of beach tourism climate change- an index approach. *Climatic Change*, 100: 579-606.

Perch-Nielsen, S.L., Amelung, B, and Knutti, R. (2010a). Future climate resources for tourism in Europe based on the daily Tourism Climate Index. *Climate Change*, 103: 363-381.

Perry, A. (2006) Will predicted climate change comprise the sustainability of Mediterranean tourism? *Journal of Sustainable Tourism*, 14: 367-375.

Perry, E.C. and Potgieter, C. (2013). Crime and Tourism in South Africa. *Journal of Human Ecology*, 43: 101-111.

Pickens, J. (2005). Attitudes and perceptions. In *Organisational behaviour in health care*, 43-76 (Ed. N. Borkowski), Jones and Bartlettt Publishers: Massachusetts.

Pienaar, J.J. and Visser, G. (2009). The throny issue of identifying second homes in South Africa. *Urban Forum*, 20: 455-469.

Preston-White, R.A. and Watson, H.K. (2005). Nature tourism and climate change in Southern Africa. In Hall, C.M. and Higham, J (Eds). *Tourism, recreation and climate change*. Cromwell Press: Clevedon.

Prudhomme, C., Reynard, N. and Crooks, S. (2002) Downscaling of global climate models for flood frequency analysis: where are we now? *Hydrological Processes*, 16: 1137-1150.

Quiggin, J. (2008). Uncertainty and climate change policy. *Economic Analysis and Policy*, 38: 203-210.

Ranson, M. (2014). Crime, weather, and climate change. *Journal of Environmental Economics and Management*, 67: 274-302.

Rathzel, N. and Uzzell, D. (2009). Changing relations in global environmental change. *Global Environmental Change*, 19: 326-335.

Reddy, M., 2011: Tourism and climate change risks: opportunities and constraints in South Africa (Doctoral Dissertation). Retrieved on 15 April 2015 from http://mobile.wiredspace.wits.ac.za/handle/10539/11392.

Reid, H., Sahlen, L., Stage, J. and MacGregor, J. (2007). The economic impact of climate change in Namibia: how climate change will affect the contribution of Nambia's natural resources to its economy. *Environmental Economic Programme Discussion Paper, 07-02*. International Institute for Environmental and Development: London.

Reja, U., Manfreda, K.L., Hlebec, V. and Vehovar, V. (2003). Open-ended vs. close-ended questions in web questionnaires. *Developments in Applied Statistics*, 19: 159-177.

Rogerson, C.M. (2002a). Tourism- a new economic driver for South Africa. In A. Lemon and C.M. Rogerson (Eds.) *Geography and economy in Southern Africa and its neighbours*, Ashgate: Aldershot.

Rogerson, C.M. (2002b). Driving developmental tourism in South Africa. *Africa Insight*, 32: 33-42.

Rogerson, C.M. (2004). The impact of the South African government's SMME programmes: a ten-year review (1994-2003). *Development Southern Africa*, 21: 765-784.

Rogerson, C.M. (2005). Unpacking tourism SMMEs in South Africa: structure, support needs and policy response. *Development Southern Africa*, 22: 623-642.

Rogerson, C.M. (2007). Tourism routes as vehicles for Local Economic Development in South Africa: the example of the Magaliesberg Meander. *Urban Forum*, 18: 49-68.

Rogerson, C.M. (2008). Shared growth in urban tourism: Evidence from Soweto, South Africa. *Urban Forum*, 19: 395-411.

Rogerson, C.M. (2012). The tourism-development nexus in sub-Saharan Africa: Progress and Prospects. *Africa Insights*, 42: 28-45.

Rogerson, C.M. (2014a). Reframing place-based economic development in South Africa: the example of local economic development. *Bulletin of Geography. Socio-economic Series,* 24: 203-218.

Rogerson, C.M. (2014b). The uneven geography of tourism in South Africa. *African Journal of Hospitality, Tourism and Leisure*, 3: 1-15

Rogerson, C.M. (2014c). Informal sector business tourism and pro-poor tourism: Africa's migrant entrepreneurs. *Mediterranean Journal of Social Sciences*, 5: 153-161.

Rogerson, C.M. (2016). Climate change, tourism and local economic development in South Africa. *Local Economy*, 31: 322-331.

Rogerson, C.M. and Lisa, Z. (2005). 'Sho't Left': Changing domestic tourism in South Africa. *Urban Forum*, 16: 88-111.

Rogerson, C.M. and Rogerson, J.M. (2011). Tourism Research within the Southern African Development Community: Production and consumption in academic journals, 2000-2010. *Tourism Review International*, 15: 213-222.

Rogerson, C.M. and Visser, G. (2004). Tourism and development in post-apartheid South Africa: A ten-year review. *Urban Forum*, 18: 49-68.

Rogerson, C.M. and Visser, G. (2007). *Urban tourism in the developing world: The South African experience*. New Brunswick, NJ: Transaction Press.

Rogerson, C.M. and Visser, G. (2011a). African tourism geographies: existing paths and new directions. *Tijdschrift voor Economische en Sociale Geografie*, 102: 251-259.

Rogerson, C.M. and Visser, G. (2011b). Current themes in tourism and development in South Africa. *Tourism Review International*, 15: 1-3.

Rogerson, C.M. and Visser, G. (2011c). Rethinking South African urban tourism research. *Tourism Review International*, 15: 77-90.

Rogerson, C.M., Simango, S. and Rogerson, J.M. (2013). From recreation to niche tourism: the transformations of birdwatching in South Africa. *African Journal for Physical, Health Education, Recreation and Dance*, 19: 122-137.

Rogerson, J.M. (2014d). Hotel locations in Africa's world class city: the case of Johannesburg, South Africa. *Bulletin of Geography: Socio-Economic Series*, 25: 181-196.

Rogerson, J.M. (2014e). Unpacking the growth of hotel chains in Africa: Enterprise and patterns. *Mediterranean Journal of Sciences*, 5: 135-146.

Rogerson, J.M. (2014f). Changing hotel location patterns in Ekurhuleni, South Africa's industrial workshop. *Urbani Izziv*, 25: S81-S95.

Rogerson. J.M. and Slater, D. (2014). Urban volunteer tourism: orphanages in Johannesburg. *Urban Forum*, 25: 483-499.

Root, T.L., Price, J.T., Hall, K.R., Schneider, S.H., Rosenzweig, C. and Pounds, J.A. (2003). Fingerprints of global warming on wild animals and plants. *Nature,* 421: 57-60.

Rosenzweig, C. and Parry, M.L. (1994). Potential impact of climate change on wood food-supply. *Nature*, 367: 133-138.

Roshan, G., Yousefi, R. and Fitchett, J.M. (2016). Long-term trends in tourism climate index scores for 40 stations across Iran: the role of climate change and influence on tourism sustainability. *International Journal of Biometeorology*, 60: 33-52.

Rosselló, J. and Santana-Gallego, M. (2014). Recent trends in international tourist climate preferences: a revised picture for climatic change scenarios. *Climatic Change*, 124: 119-132.

Rosselló-Nadal, J. (2014). How to evaluate the effects of climate change on tourism. *Tourism Management*, 42: 334-340.

Rübbelke, D.T.G. (2011). International support of climate change policies in developing countries: Strategic, moral and fairness aspects. *Ecological Economies*, 70: 1470-1480.

Rummukainen, M. (2010). State-of-the-art with regional climate models. *Wiley Interdisciplinary Reviews: Climate Change*, 1: 82-96.

Saarinen, J. (2014). Tourism geographies: connections with human geography and emerging responsible geographies. Geographica Polonica, 87: 343–352.

Saarinen, J. (2014). Traditions of sustainability in tourism studies. *Annals of Tourism Research*, 33: 1121-1140.

Saarinen, J. and Rogerson C.M. (2013). Tourism and the millennium development goals: perspectives beyond 2015. *Tourism Geographies*, 16: 23-30

Saarinen, J. and Tervo, K. (2006) Perceptions and adaptation strategies of the tourism industry to climate change: the case of Finnish nature-based tourism entrepreneurs. *International Journal of Innovation and Sustainable Development*, 1: 214-228.

Saarinen, J., Hamibra, W.L., Atlhopheng, J. and Manwa, H. (2012). Tourism industry reaction to climate change in Kgalagadi South District, Botswana. *Development Southern Africa*, 29: 273-285.

Saarinen, J., Moswete, N. abd Monare, M.J. (2014). Cultural tourism: new opportunities for diversifying the tourism industry in Botswana. *Bulletin of Geography: Socio-economic Series*, 26: 7-18.

saexplorer, 2014: South Africa. Retrieved on 12 January 2015 from: http://www.saexplorer.co.za/south-africa/search/search.asp?zoom_query=climate&zoom_per_page=100&zoom_and=1&zoom_sort=0.

Sagar, A.D., Oliver, H.H. and Chikkatur, A.P. (2006). Climate change, energy, and developing countires. *Vermont Journal of Environmental Law*, 7: 1-25.

Scott, D. and Lemieux, C. (2010). Weather and climate information for tourism. *Procedia Environmental Sciences*, 1: 146-183.

Scott, D. and McBoyle, G. (2001). Using a modified 'tourism climate index' to examine the implications of climate change for climate as a natural resource for tourism. Proceedings of the First International Workshop on Climate, Tourism and Recreation. Greece, 69-88.

Scott, D., (2003). Climate change and tourism in the mountain regions of North America, *1st International Conference on Climate Change and Tourism*, Tunisia.

Scott, D., de Freitas, C. and Matzarakis, A. (2009). Chapter 8: Adaptation in the tourism and recreation sector. In K.L, Ebi, I, Burton and G, McGregor (Eds). *Biometeorology for adaptation to climate variability and change*. Springer, Netherlands, 171-194.

Scott, D., Gössling, S. and de Freitas, C.R. (2008). Preferred climate for tourism: case studies from Canada, New Zealand and Sweden. *Climate Research*, 38: 61-73.

Scott, D., Gössling, S. and Hall, C.M. (2012b). International tourism and climate change. *WIRES Climate Change*, 3: 213-32.

Scott, D., Hall, C.M. and Gössling, S. (2012a). *Tourism and climate change: Impacts, adaptation and mitigation*. Routledge: New York.

Scott, D., Jones, B. and Konopek, J. (2007a). Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: A case study of Waterton Lakes National Park, 28: 570-579.

Scott, D., McBoyle, G. and Mills, G. (2003). Climate change and the skiing industry in Southern Ontario (Canada): exploring the importance of snowmaking as a technical adaptation. *Climatic Research*, 23: 171-181.

Scott, D., McBoyle, G. and Minogue, A. (2007b). Climate change and Quebec's ski industry. *Global Environmental Change*, 17: 181-190.

Scott, D., McBoyle, G. and Schwartzentruber, M. (2004). Climate change and the distribution of climatic resources for tourism in North America. *Climate Research*, 27: 105-117.

Shaaban, I. and Ramzy, Y. (2010). The impact of climate change on tourism in Egypt as perceived by both policymakers and tourism managers. *WIT Transactions on Ecology and the Environment*, 139: 241-251.

Shakeela, A. and Becken, S. (2013). *Perceptions of climate change vulnerability and risk*. Christchurch: Council of Australian University Hospitality and Tourism Education.

Simpson, M.C., Gössling, S., Scott, D., Hall, C.M. and Gladin, E. (2008). *Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices*. University of Oxford: Paris.

Slovic, P. (1993). Perceived risk, trust and democracy. *Risk Analysis*, 13: 675-682.

South African Government. (2015a). Geography and climate. Retrieved on 27 January 2016 from: www.gov.za/about-sa/geography-and-climate.

South African Government. (2015b). Tourism. Retrieved on 27 January 2016 from: www.gov.za/about-sa/tourism.

Spence, A., Poortinga, W. and Pidgeon, N. (2012). The psychological distance of climate change. *Risk Analysis*, 32: 957-972.

Spence, A., Poortinga, W., Butler, C. and Pidgeon, N.F. (2011). Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change*, 1: 46-49.

Spenceley, A. and Goodwin, H. (2007). Nature-based tourism and poverty alleviation: impacts of private sector and parastatal enterprises in and around Kruger National Park, South Africa. *Current Issues in Tourism*, 10: 255-277.

Spierenburg, M. and Wels, H. (2010). Conservation philanthropists, royalty and business elites in nature conservation in southern Africa. *Antipode*, 42: 647-670.

Stebbins, R. (1997). Identity and cultural tourism. *Annals of Tourism Research*, 24: 450-452.

Steinbrink, M., Haferburg, C. and Ley, A. (2011). Festivalisation and urban renewal in the global south: Socio-spatial consequences of the 2010 FIFA World Cup. *South African Geographical Journal*, 93: 15-28.

Stevens, L., Van Nierop, M. and Clarke, J. (2014). Climate change framework and operational change plan strategy. Retrieved on 23 December 2014 from: http://www.mogalecity.gov.za/content/pdfs/draft_climate_change_framework.pdf.

Steyn, J.N. (2012). Managing climate change impacts on tourism: mitigating and adaptive strategies with special reference to the Western Cape Province of South Africa. *African Journal for Physical, Health Education, Recreation and Dance*, 18: 552-564.

Stoddart, H. and Rogerson, C.M. (2004). Volunteer tourism: the case of Habitat for Humanity South Africa. *Geojournal*, 60: 311-318.

Stoll-Kleemann, S., O'Riordan, T. and Jaeger, C.C. (2001). The psychology of denial concerning climate mitigation measures: evidence from the Swiss focus groups. *Global Environmental Change*, 11: 107-118.

Swart, R., Bernstein, L., Ha-Duong, M. and Petersen, A. (2009). Agreeing to disagree: uncertainty management in assessing climate change, impacts and responses by the IPCC. *Climate Change*, 92: 1-29.

Tassiopoulos, D. and Haydam, N. (2008). Golf tourists in South Africa: a demand-side study of a niche market in sports tourism. *Tourism Management*, 29: 870-882.

Tol, R. (2002). Estimates of the damage costs of climate change: Part 1: Benchmark estimates. *Environmental and Resource Economics*, 21: 47-73.

Tol, R.S.J. (2005). Emission abetment versus development as strategies to reduce vulnerability to climate change: an adaptation of FUND. *Environment and Development Economics*, 10: 615-629.

Tompkins, E.L. and Eakin, H. (2012). Managing private and public adaptation to climate change. *Global Environmental Change*, 22: 3-11.

Tompkins, E.L., Adger, W.N., Boyd, E., Nicholson-Cole, S., Weatherhead, K. and Arnell, N. (2010). Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global Environmental Change*, 20: 627-635.

Tuckett, A.G. (2005). Applying thematic analysis theory to practice: a researcher's experience. *Contemporary Nurse*, 19: 75-87.

Unbehaun, U., Probstl, U. and Haider, W. (2008). Trends in winter sports tourism: challenges for the future. *Tourism Review*, 63: 36-47.

Underhill, L. and Bradfield., 2009: *Introstat*, Juta and Co. Ltd, Cape Town.

UNEP and UNWTO, 2008: *Climate Change and Tourism- Responding to Global Challenges*. Retrieved on 14 April 2015 from http://sdt.unwto.org/news/2011-08-16/climate-change-and-tourism-responding-global-challenges.

Ungar, S. (2000). Knowledge, ignorance and popular culture: climate change versus the ozone hole. *Public Understand Science*, 9: 297-312.

United Nations Children's Emergency Fund (UNICEF). (2011). *Exploring the impact of climate change on children in South Africa*. Retrieved from 13 January 2015 from: http://www.unicef.org/southafrica/resources_9983.html.

United Nations Environment Programme (UNEP). (2015). *Climate Change*. Retrieved on 22 April 2015 from: http://sdt.unwto.org/en/content/climate-change-tourism

United Nations World Tourism Organisation (UNWTO). (2009). *From Davos to Copenhagen and beyond: advancing tourism's response to climate change (UNWTO background paper)*. Retrieved on 28 September 2015 from: http://www.unep.org/resourceefficiency/Business/SectoralActivities/Tourism/Activities/WorkThematicAreas/ClimateChange/tabid/78787/Default.aspx

United Nations World Tourism Organisation (UNWTO). (2014). *Annual Report 2013*. Retrieved on 29 December 2015 from: http://www2.unwto.org/annual-reports.

United Nations World Tourism Organisation (UNWTO). (2015a) *Tourism Highlights: 2015 Edition*. Retrieved on 26 November 2015 from: http://www.e-unwto.org/doi/book/10.18111/9789284416899.

United Nations World Tourism Organisation (UNWTO). (2015b). *Annual Report 2014*. Retrieved on 6 January 2016 from: http://www2.unwto.org/annualreport2014.

Uyarra, M.C., Côté, I.M., Gill, J., Ticnh, Viner, D. and Watkinson, A.R. (2005). Island-specific preferences of tourists for environmental features: implications of climate change for tourism- dependent states. *Environmental Conservation*, 32: 11-19.

Uzzell, D. (2000). The psycho-spatial dimension to global environmental problems. *Journal of Environmental Psychology*, 20: 307-318.

Valentine, P. (1992). Review: Nature-based tourism. In B, Weiler and C.M., Hall (Eds.). *Special interest tourism*. Belhaven Press, London, 105-127.

Valls, J.F. and Sarda, R. (2009). Tourism expert perceptions for evaluating climate change impacts on the Euro-Mediterranean tourism industry. *Tourism Review*, 64: 44-51.

Van der Merwe, M. and Wocke, A. (2007). An investigation into responsible tourism practices in the South African tourism industry. *Journal of Business Management*, 38: 1-15.

Visser, G. and Hoogendoorn, G. (2011). Current paths in South Africa tourism research. *Tourism Review International*, 15: 5-20.

Visser, G. and Hoogendoorn, G. (2015). A decade of second home tourism research in South Africa: research prospects for the developing world? *South African Geographical Journal*, 97: 111-122.

Visser, G. and Kotze, N. (2008) The state and new-build-gentrification in central Cape Town, South Africa, *Urban Studies*. 45: 2565-2593.

Visser, G. and Rogerson, C.M. (2004). Researching the South African tourism and development nexus. *GeoJournal*, 60: 201-215.

Vujovic, J.O.S. (2013). FET geography teachers' knowledge and perceptions of climate change and an evaluation of the textbooks used for climate change education. *Master of Arts Dissertation submitted to the University of the Witwatersrand*: Johannesburg.

Wardekker, J.A. (2011). *Climate Change impact assessment and adaptation under certainty*. PHD Dissertation, University of Utrecht.

Weber, E.U. (2010). What shapes perceptions of climate change? *Wiley Interdisciplinary Reviews: Climate Change*, 1: 332.342.

Weber, K. (2001). Outdoor adventure tourism: a review of research approaches. *Annals of Tourism Research*, 28: 360-377.

Whetton, P.H., Haylock, M.R. and Galloway, R. (1996). Climatic change and snow-cover duration in the Australian Alps. *Climatic Change*, 32: 447-479.

Whitmarsh, L. (2011). Scepticism and uncertainty about climate change: dimensions, determinants and change over time. *Global Environmental Change*, 21: 690-700.

Wolf, J. and Moser, S.C. (2011). Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world, *Wiley Interdisciplinary Reviews: Climate Change*, 2: 547-569.

World Meteorological Organisation. (2013). Retrieved on 18 October 2013 from: www.wmo.int.

World Tourism and Travel Council (WTTC). (2013). Economic impact of travel and tourism 2013 annual update: Summary. Available from:

<http://www.wttc.org/~/media/files/reports/monthly%20updates/wttc%20monthly%20update%20august%202013.ashx> (Accessed on 28 December 2014).

World Travel and Tourism Council (WTTC). (2014). Travel and tourism economic impact 2014: Africa. Retrieved on 27 December 2014 from: http://www.wttc.org/focus/research-for-action/economic-impact-analysis/regional-reports/.

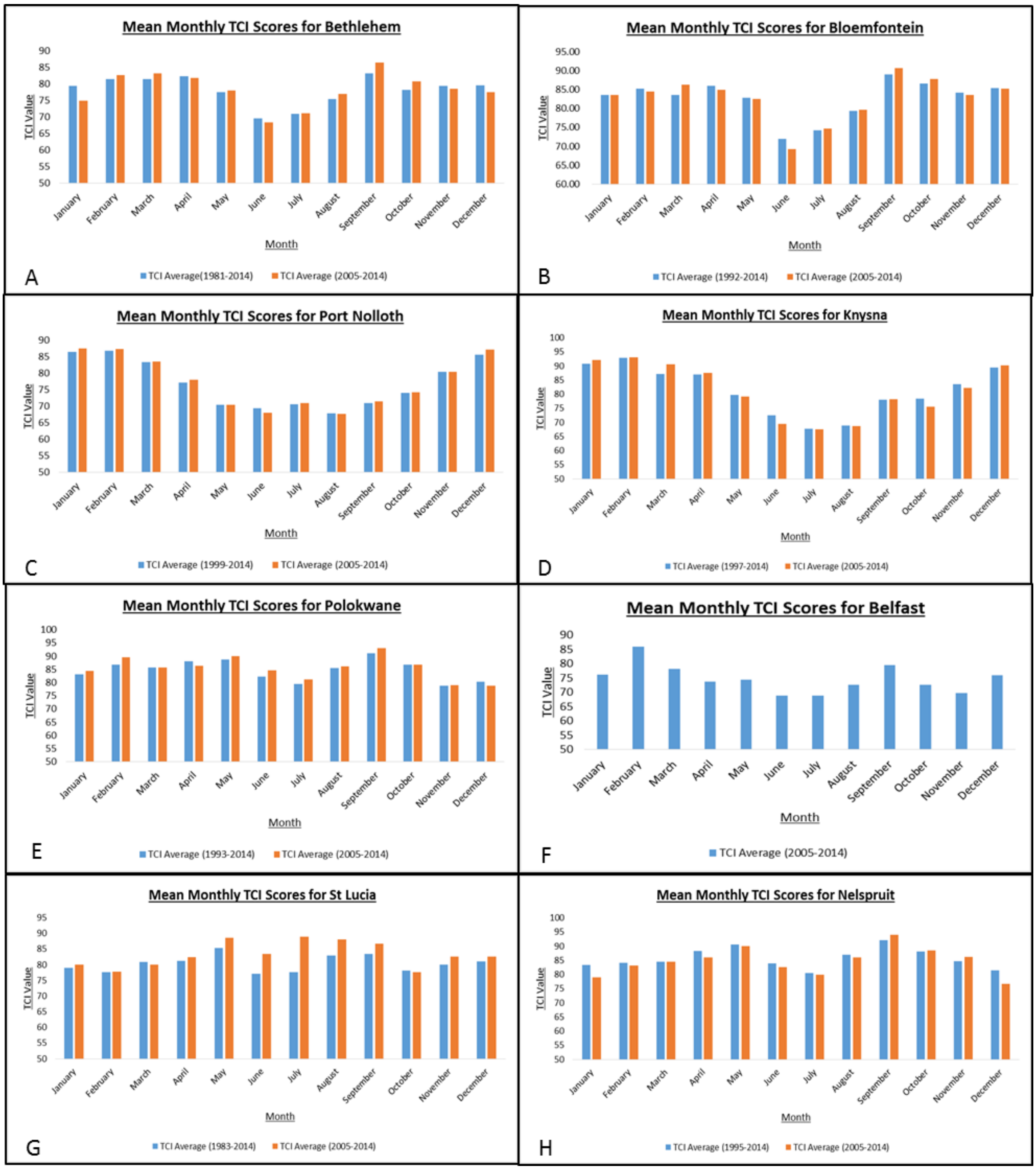
Ziervogel, G., New, M., van Garderen, E.A., Midgley, G., Taylor, A., Hamann, R., Stuart-Hill, S., Meyers, J. and Warburton, M. (2014). Climate change impacts and adaptation in South Africa. *WIREs Climate Change*, 5: 605-620.

Zinyengere, N., Crespo, O. and Hachigonta, S. (2013). Crop response to climate change in southern Africa: A comprehensive review. *Global and Planetary Change*, 11: 118-126.

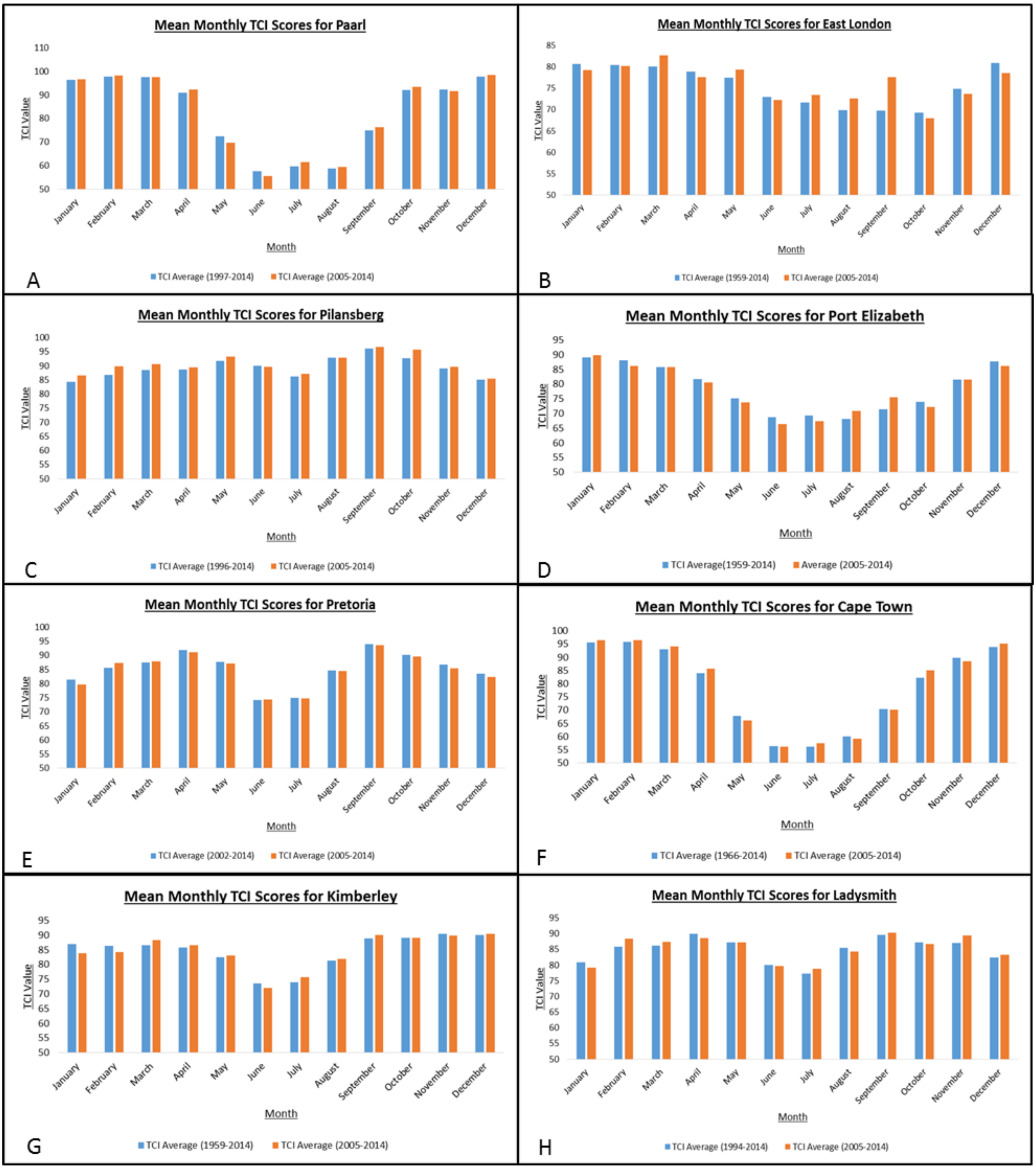
Appendices

Appendix A

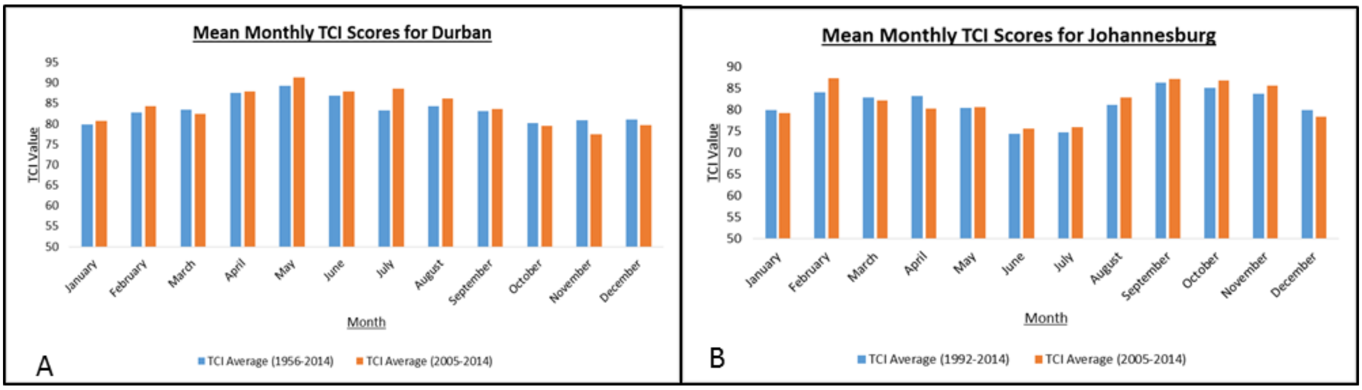
The mean monthly TCI scores for the period 2005-2014 and for the longest continuous period for each of the study sites.



Appendix A.1: The mean monthly TCI scores in: A) Bethlehem B) Bloemfontein C) Port Nolloth D) Knysna E) Polokwane F) Belfast G) St Lucia and H) Nelspruit for the period 2005-2014 and for the period 1981-2014.



Appendix A.2: The mean monthly TCI scores in: A) Paarl B) East London C) Pilanesberg D) Port Elizabeth E) Pretoria F) Cape Town G) Kimberley and H) Nelspruit for the period 2005-2014 and for the period 1981-2014.

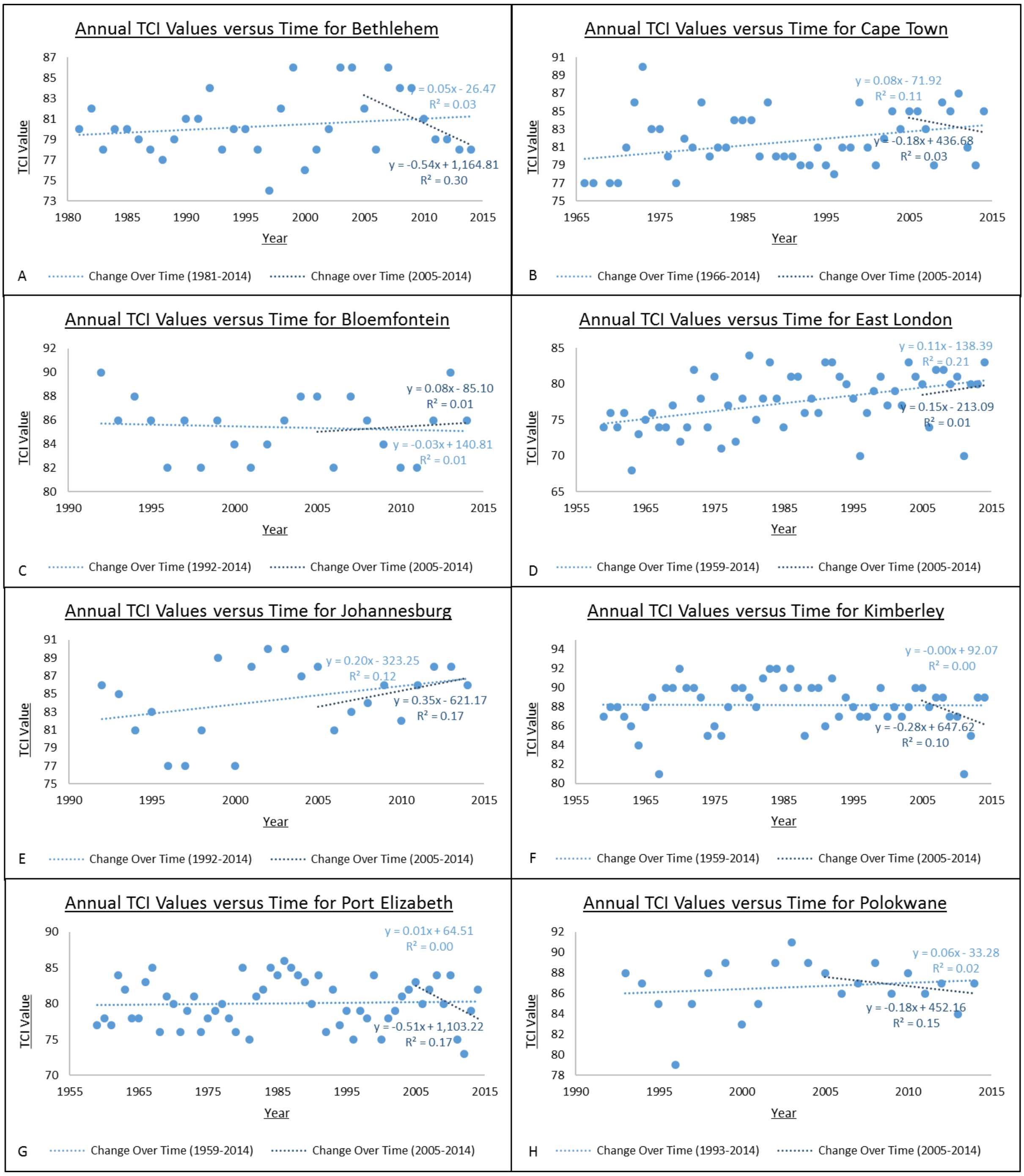


Appendix A.3: The mean monthly TCI scores in: A) Durban B) Johannesburg for the period 2005-2014 and for the period 1981-2014.

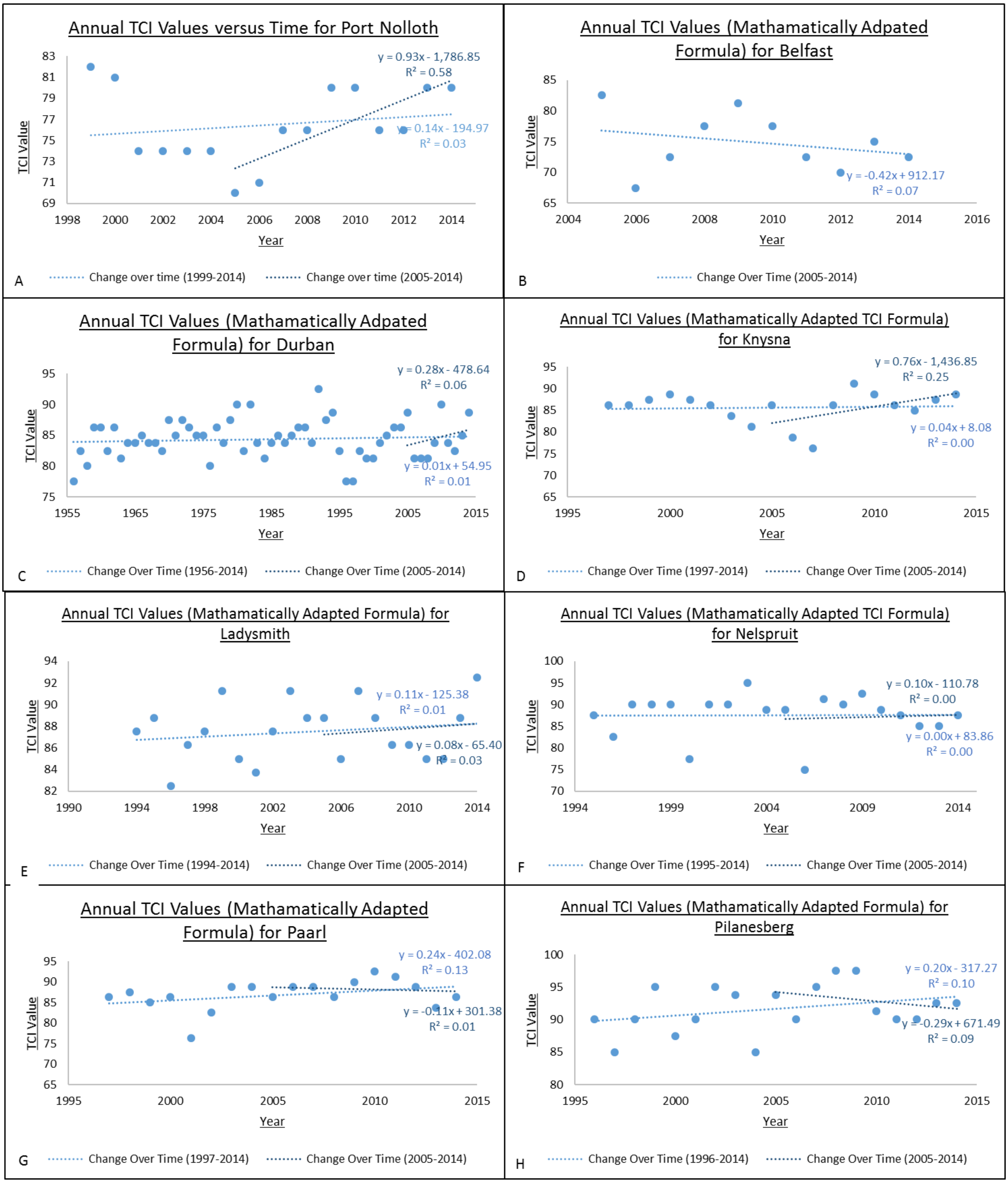
Appendix B

The correlation between annual mean TCI scores for the period 2005-2014 and the longest continuous period for each of the study sites.

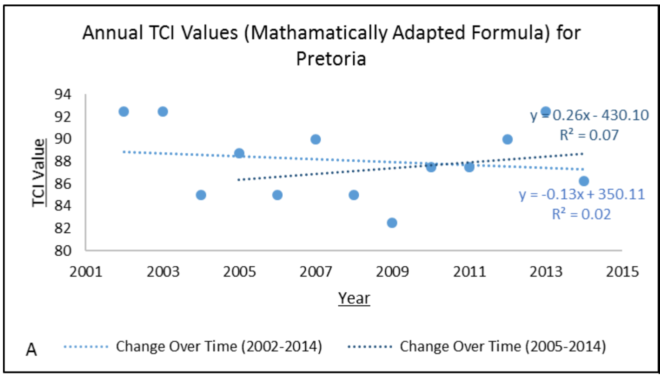
Appendix B.1: The correlation between annual mean traditional TCI scores in A) Bethlehem B)

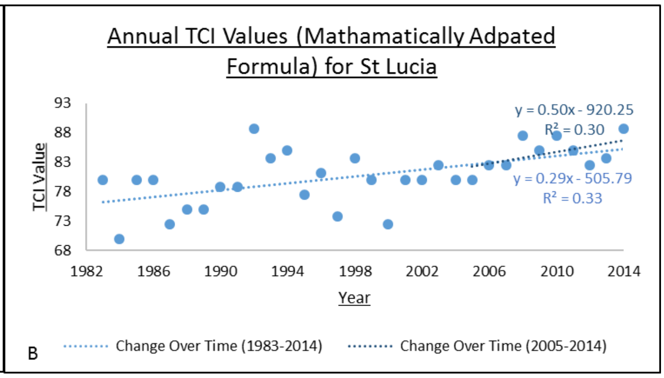


Cape Town C) Bloemfontein D) East London E) Johannesburg F) Kimberley G) Port Elizabeth and H) Polokwane.



Appendix B.2: The correlation between annual mean traditional TCI scores in A) Port Nolloth B) Belfast C) Durban D) Knysna E) Ladysmith F) Kimberley G) Paarl and H) Pilanesberg.

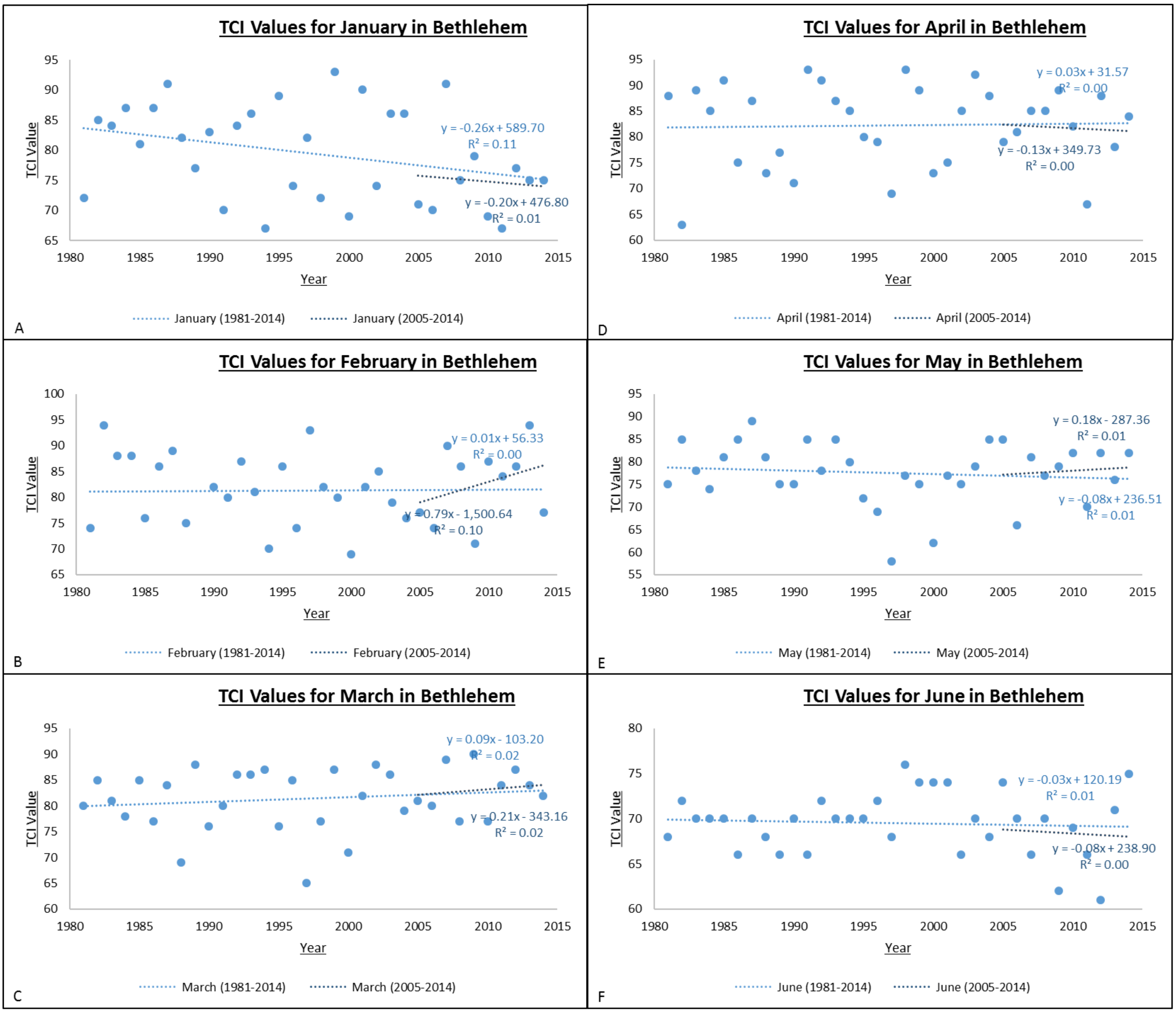




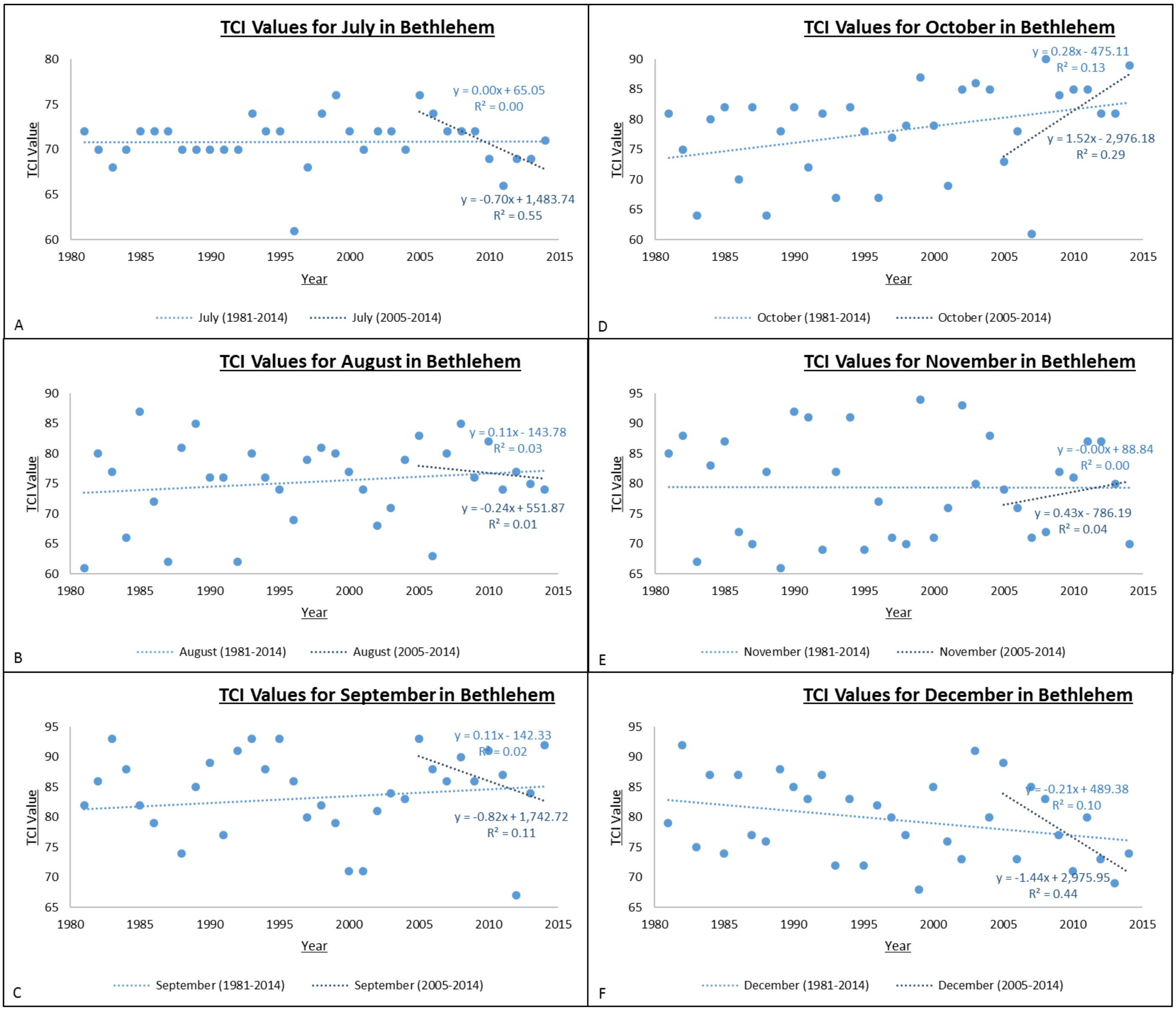
<u>Appendix B.3:</u> The correlation between annual mean traditional TCI scores in A) Pretoria B) St Lucia.

Appendix C

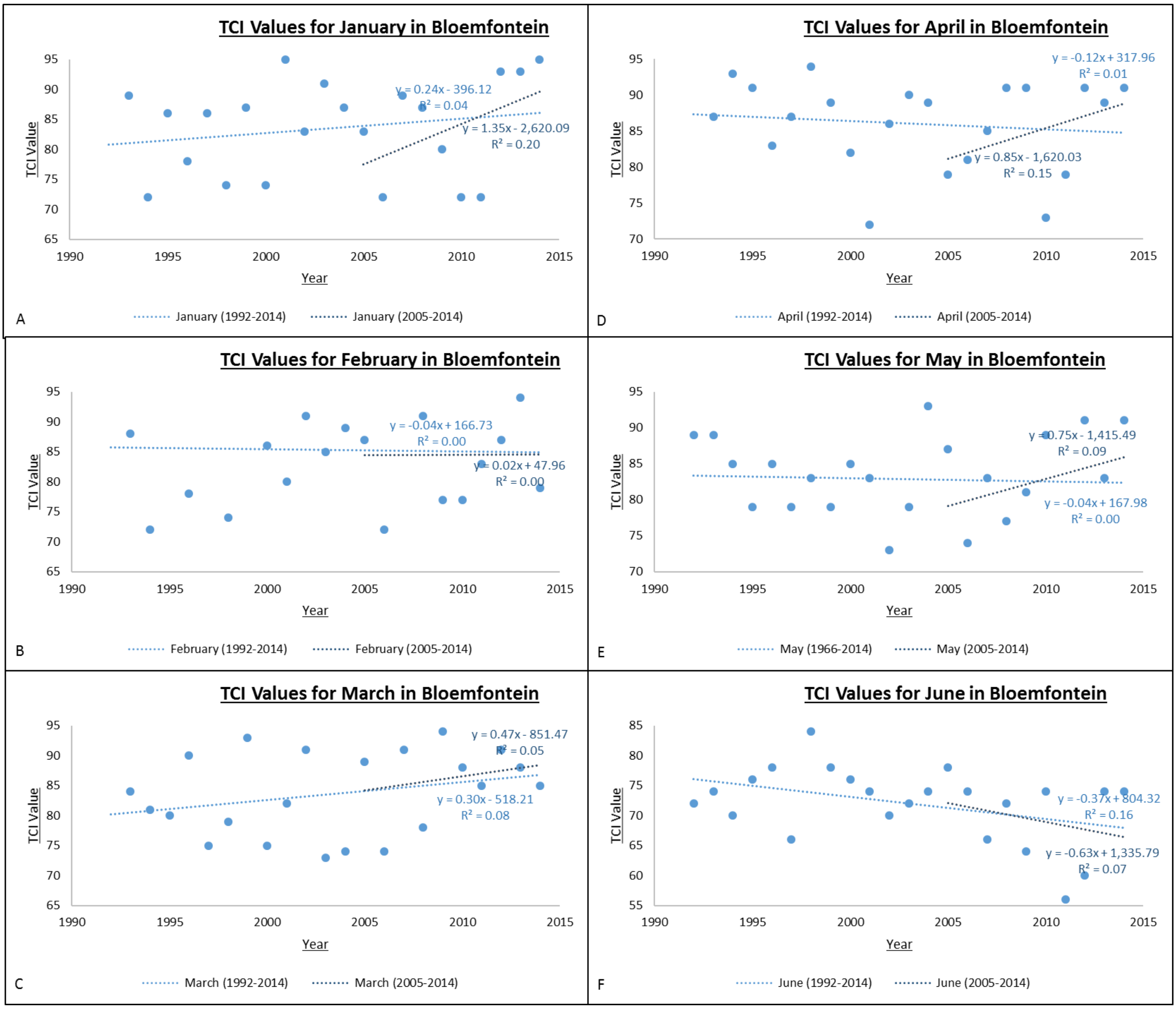
The correlation between the mean monthly TCI scores and time for each month of the year at each location.



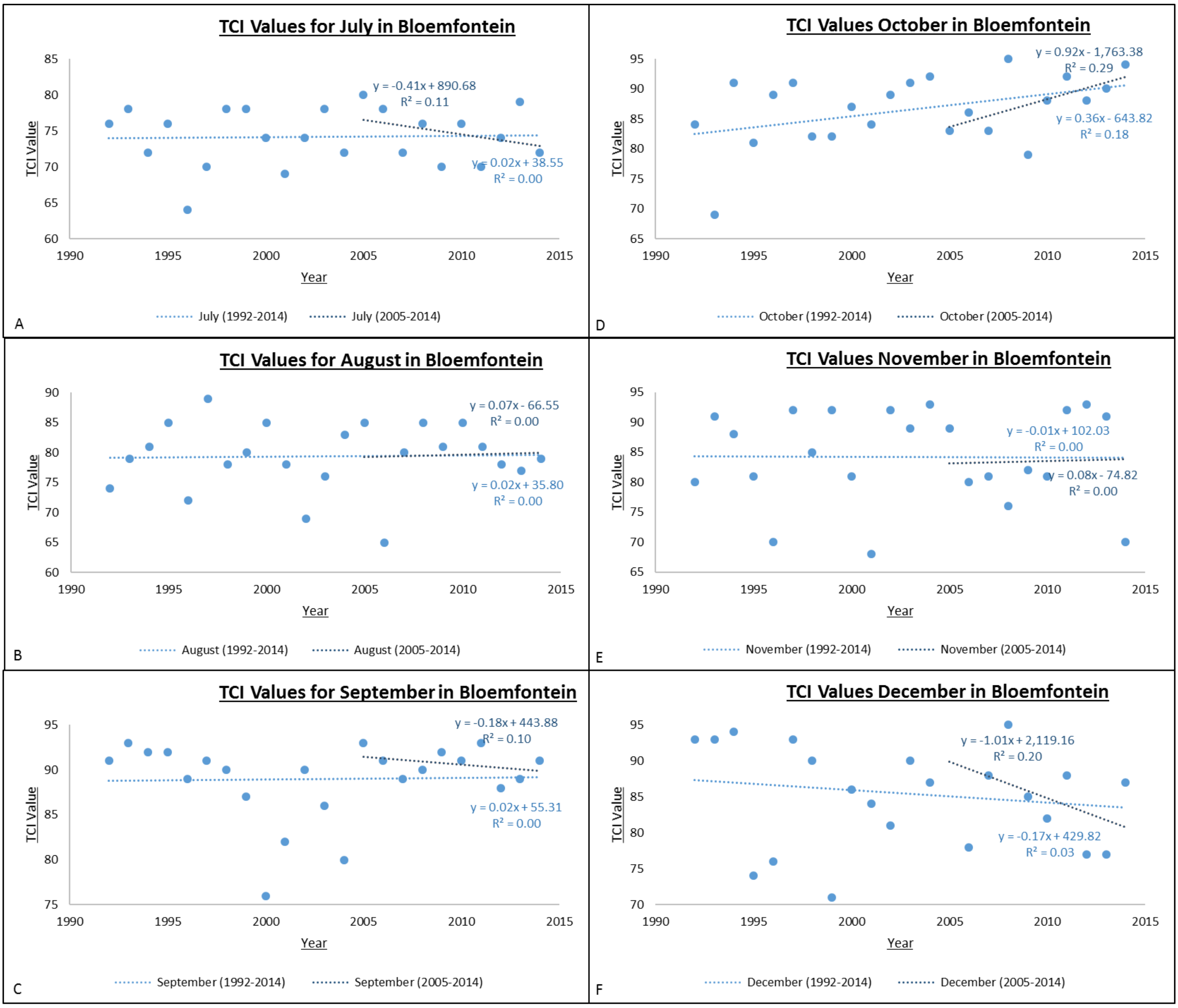
Appendix C.1: The correlation between the mean monthly TCI scores and time in Bethlehem for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1981-2014.



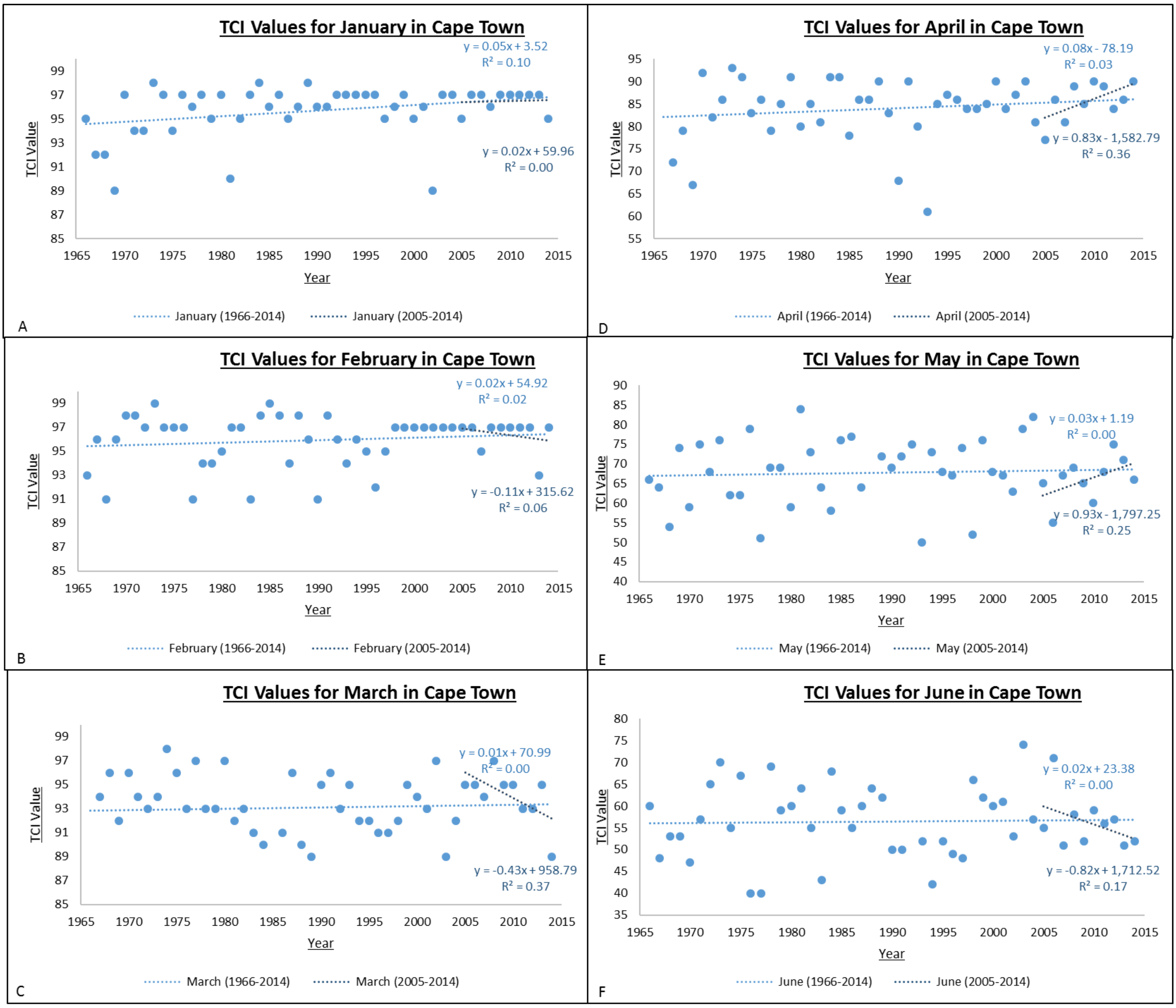
Appendix C.2: The correlation between the mean monthly TCI scores and time in Bethlehem for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1981-2014.



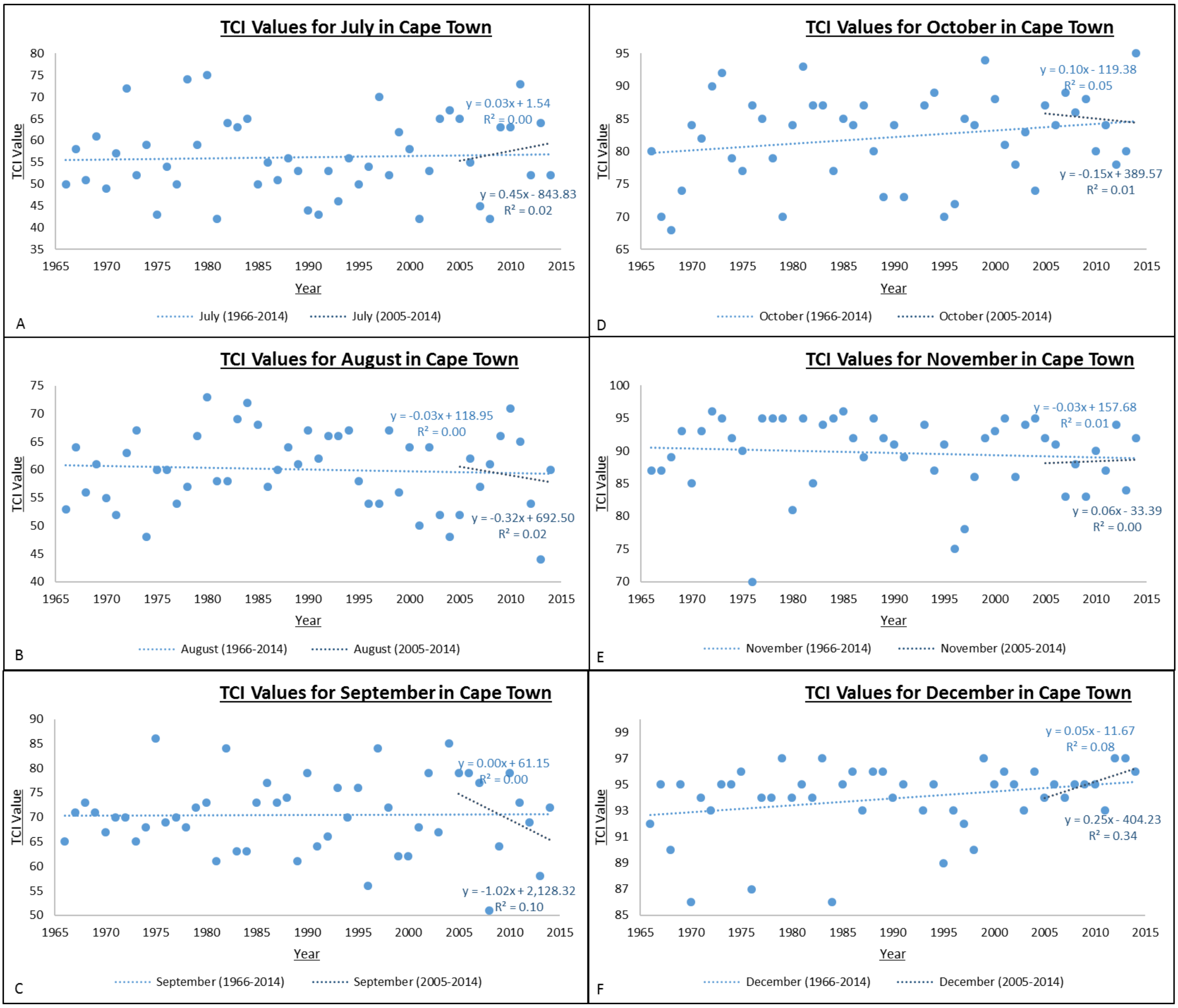
Appendix C.3: The correlation between the mean monthly TCI scores and time in Bloemfontein for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1992-2014.



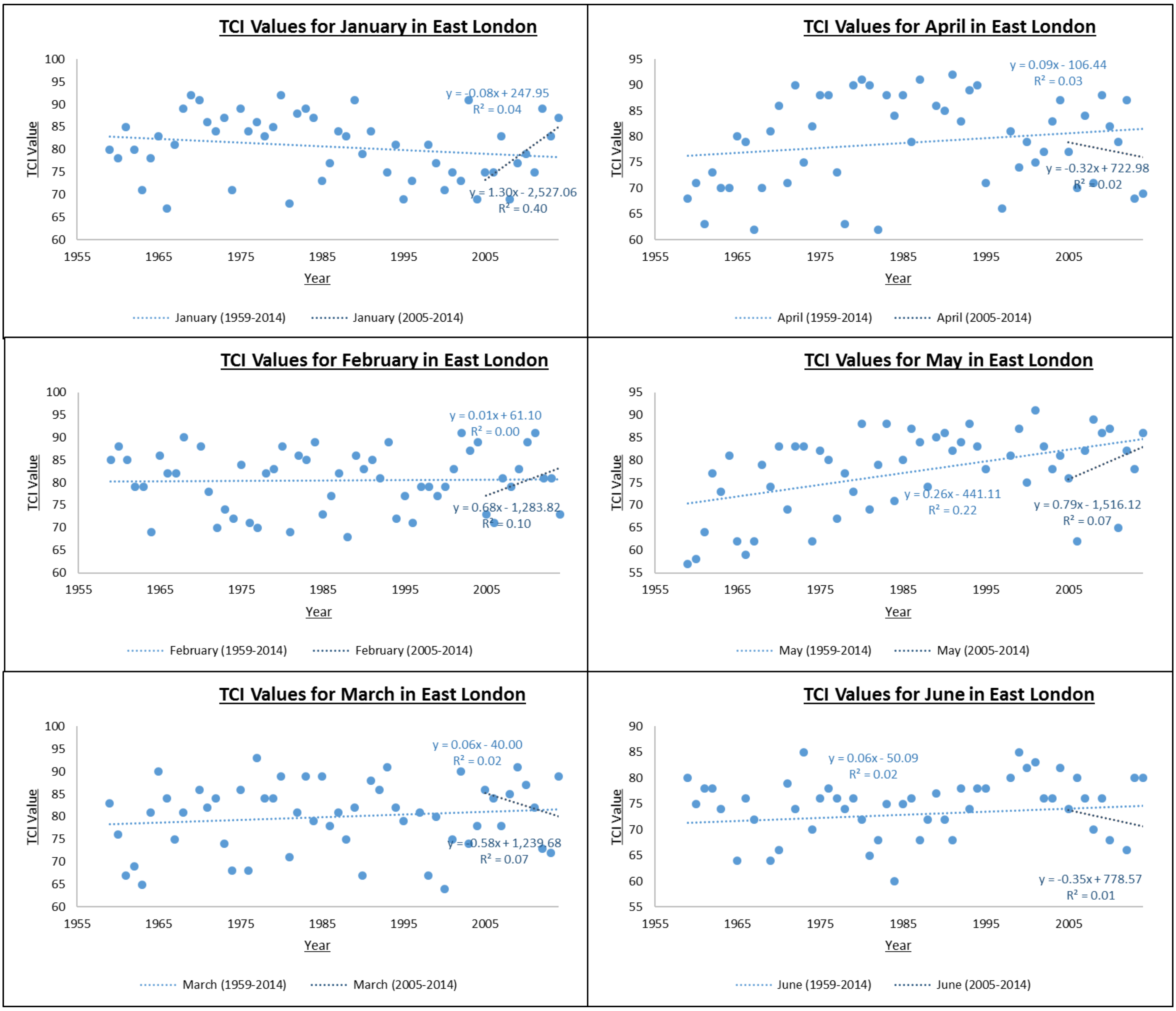
Appendix C.4: The correlation between the mean monthly TCI scores and time in Bloemfontein for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1992-2014.



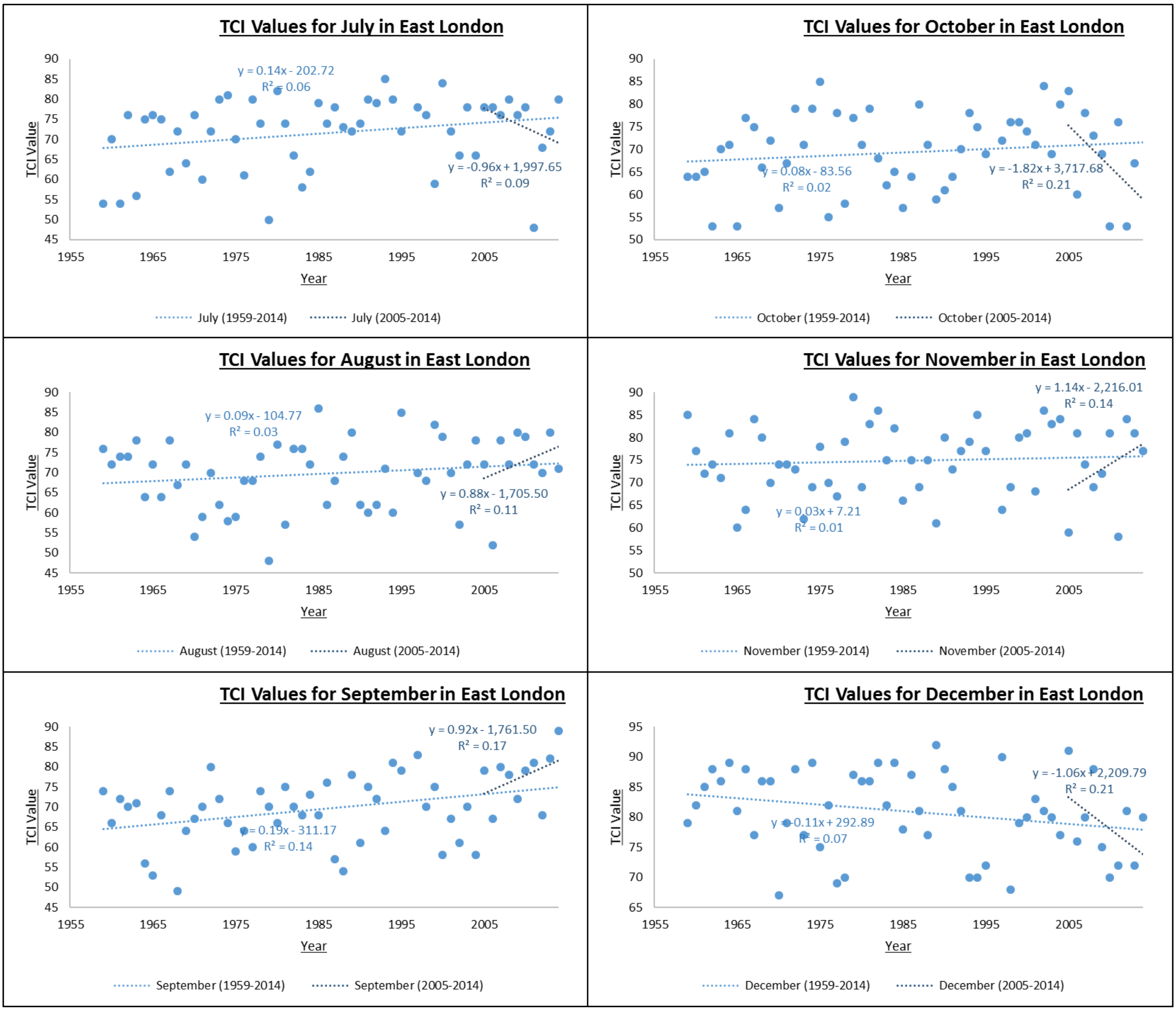
Appendix C.5: The correlation between the mean monthly TCI scores and time in Cape Town for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1966-2014.



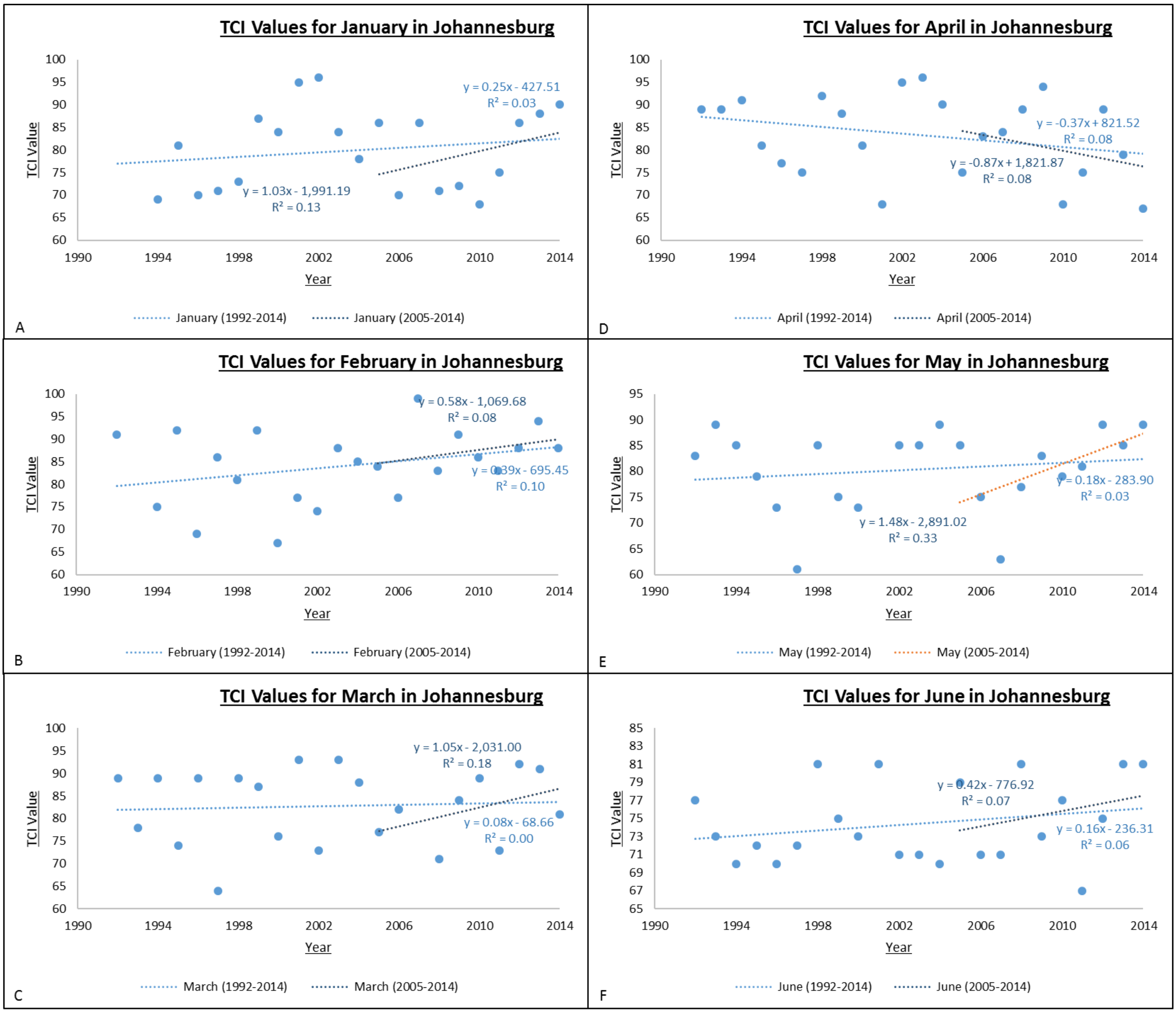
Appendix C.6: The correlation between the mean monthly TCI scores and time in Cape Town for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1966-2014.



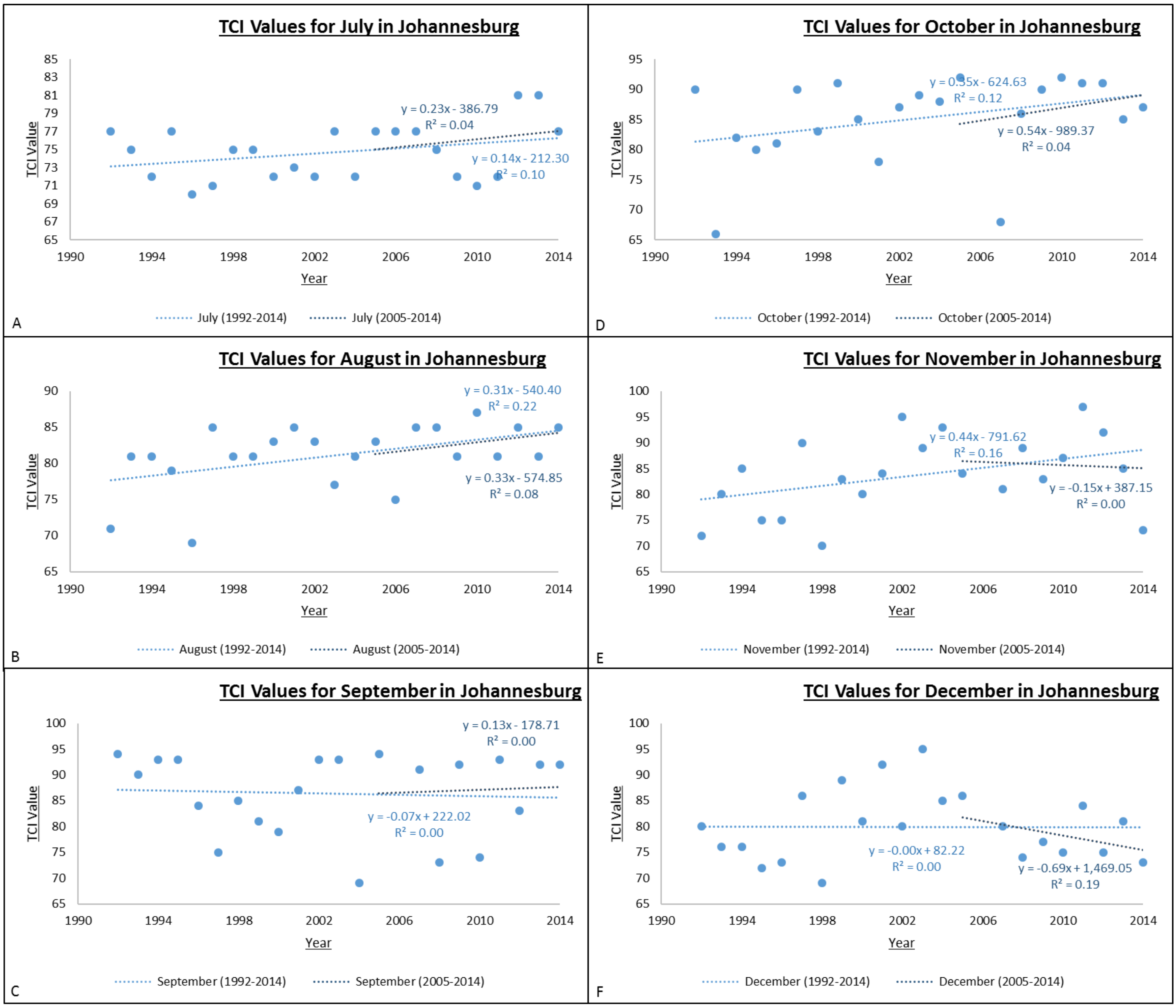
Appendix C.7: The correlation between the mean monthly TCI scores and time in East London for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1959-2014.



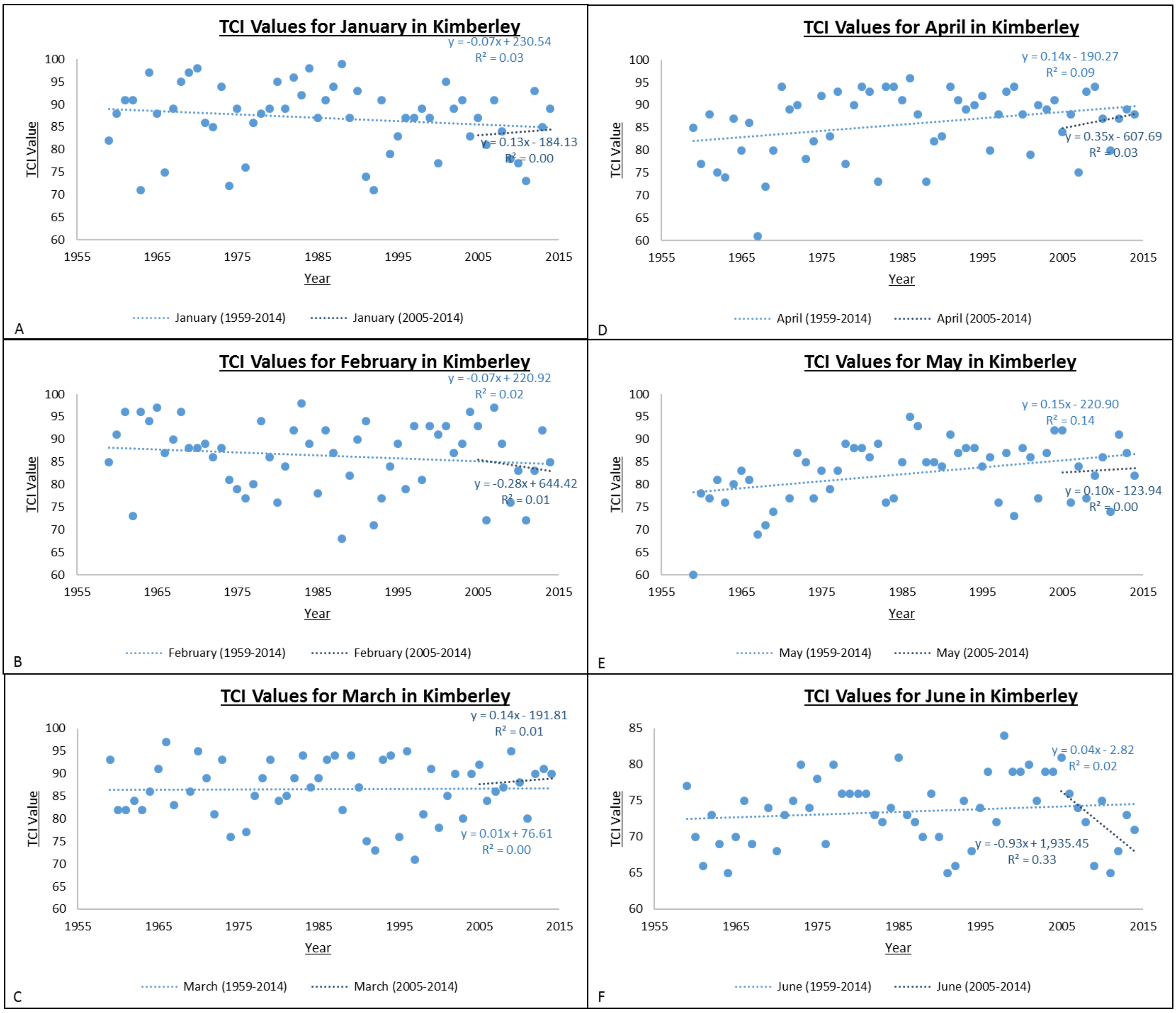
Appendix C.8: The correlation between the mean monthly TCI scores and time in East London for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1959-2014.



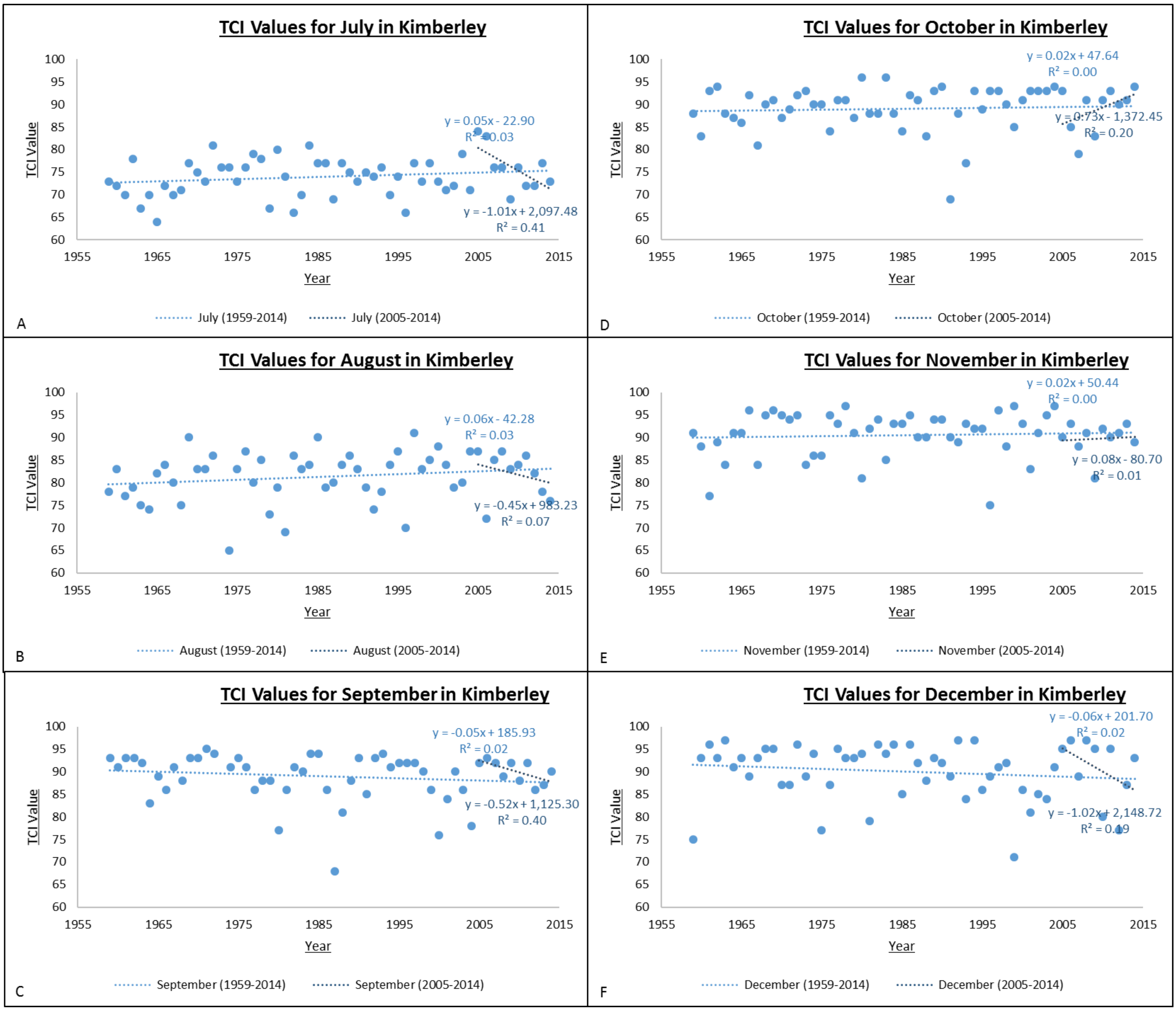
Appendix C.9: The correlation between the mean monthly TCI scores and time in Johannesburg for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1992-2014.



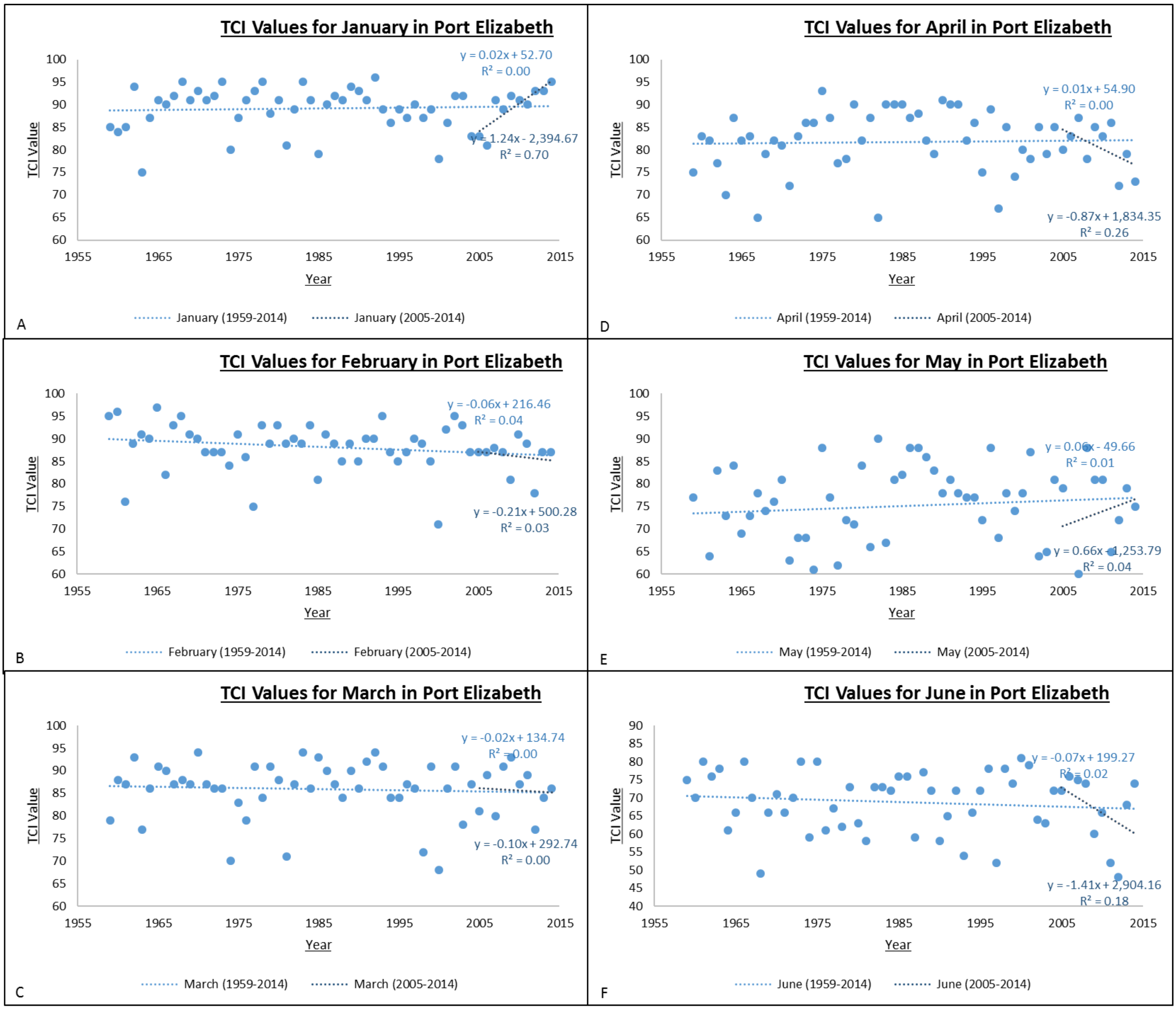
Appendix C.10: The correlation between the mean monthly TCI scores and time in Johannesburg for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1992-2014.



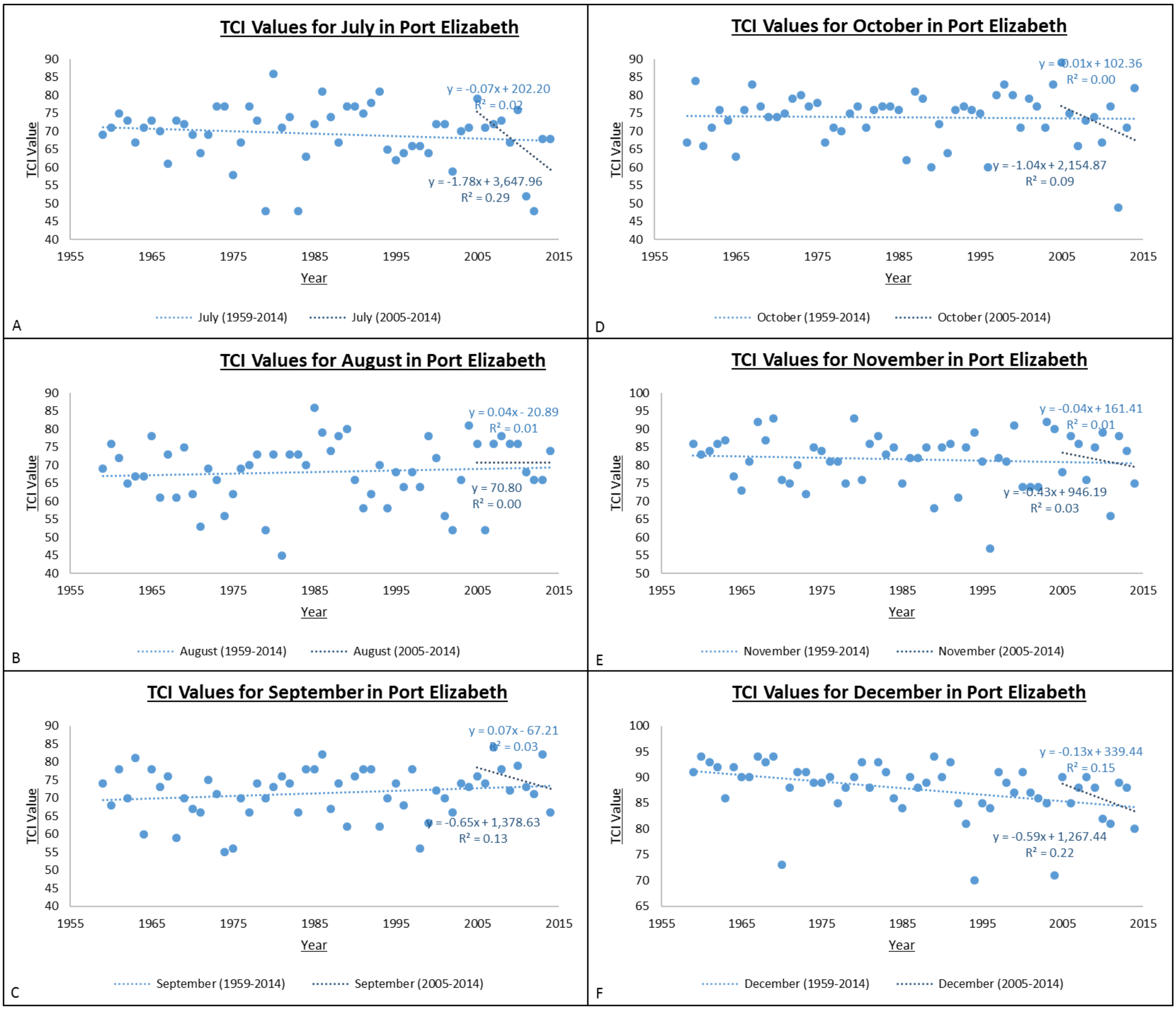
Appendix C.11: The correlation between the mean monthly TCI scores and time in Kimberley for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1959-2014.



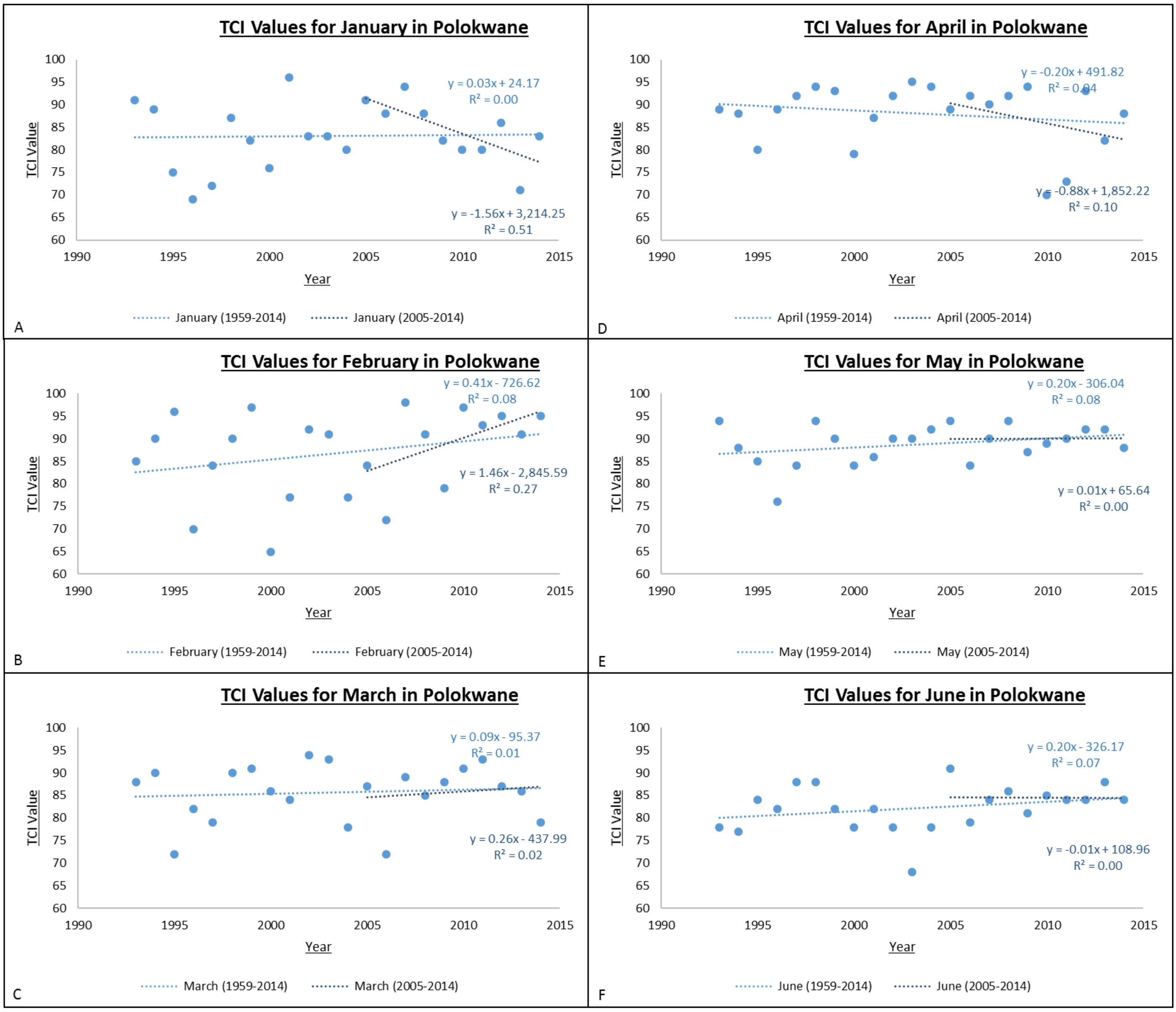
<u>Appendix C.12:</u> The correlation between the mean monthly TCI scores and time in Kimberley for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1959-2014



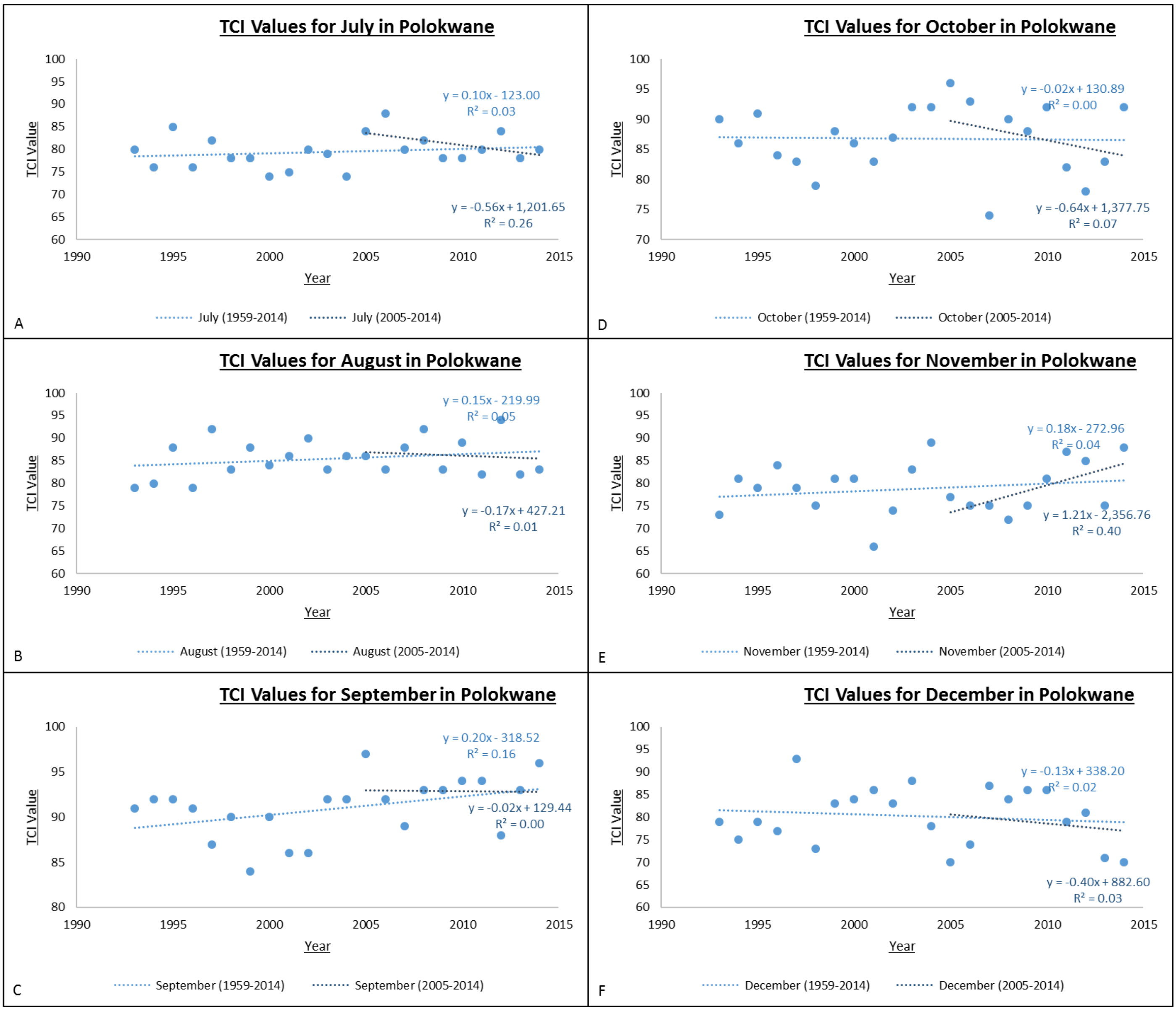
Appendix C.13: The correlation between the mean monthly TCI scores and time in Port Elizabeth for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1959-2014.



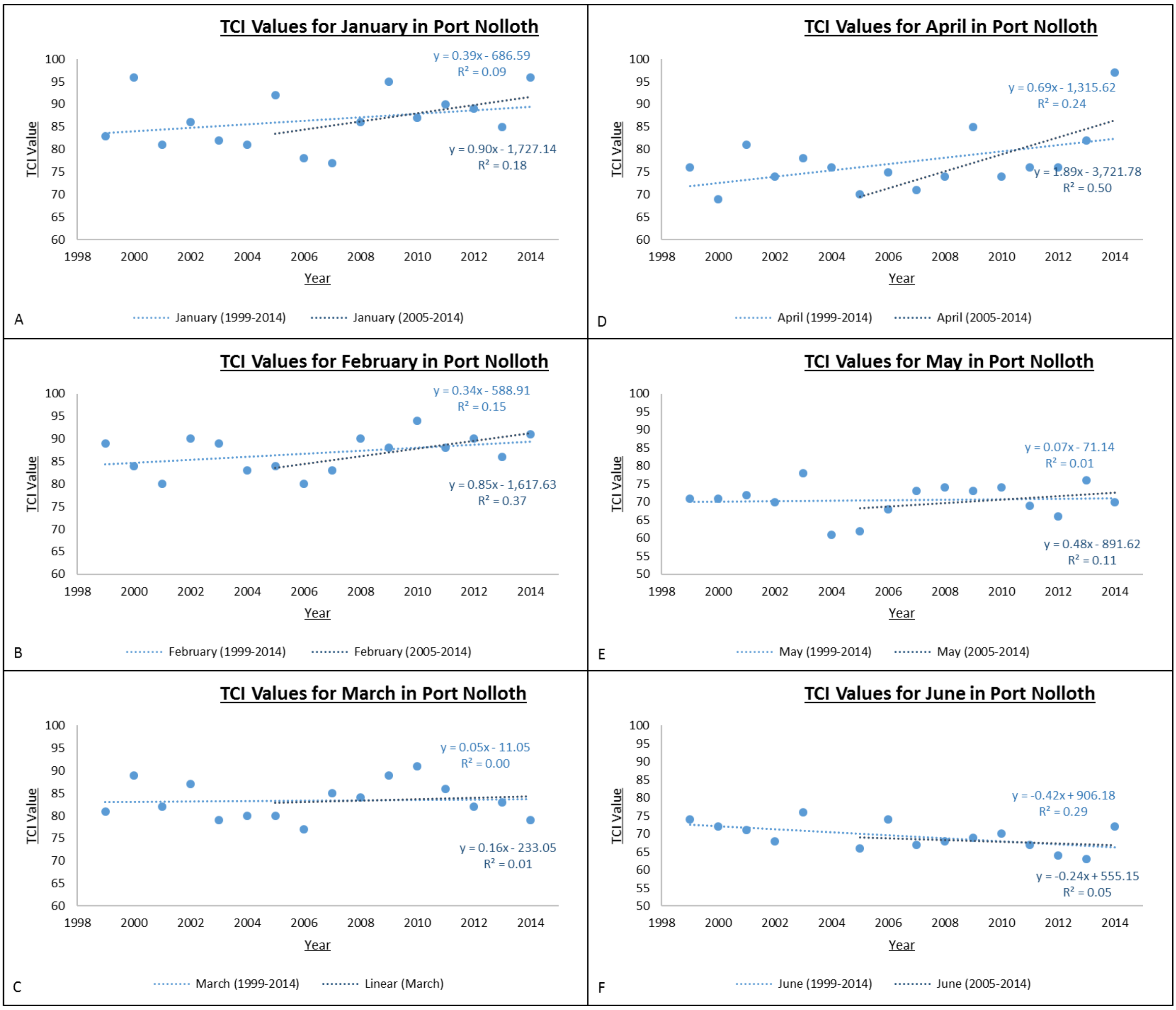
Appendix C.14: The correlation between the mean monthly TCI scores and time in Port Elizabeth for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1959-2014.



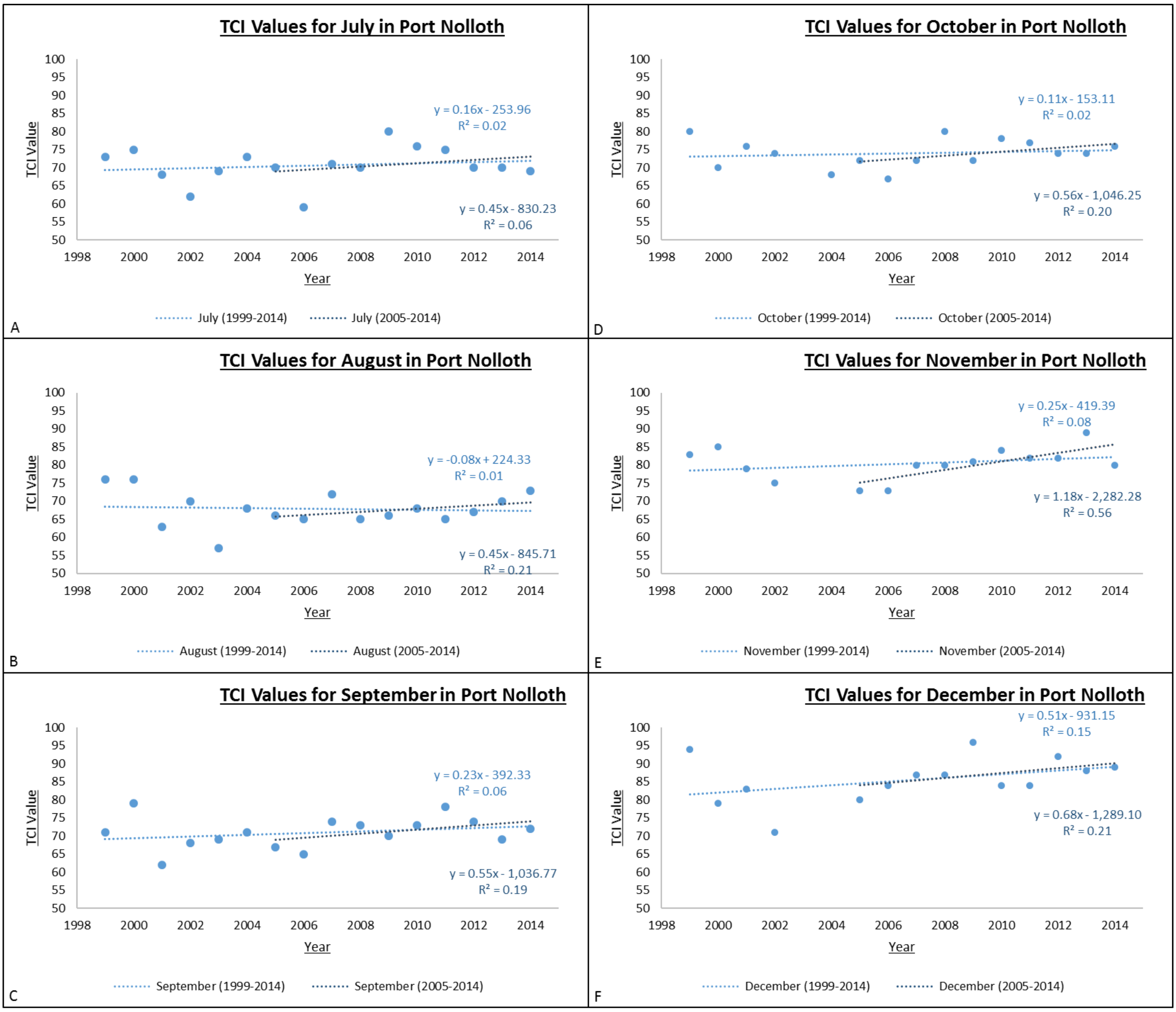
Appendix C.15: The correlation between the mean monthly TCI scores and time in Polokwane for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1993-2014.



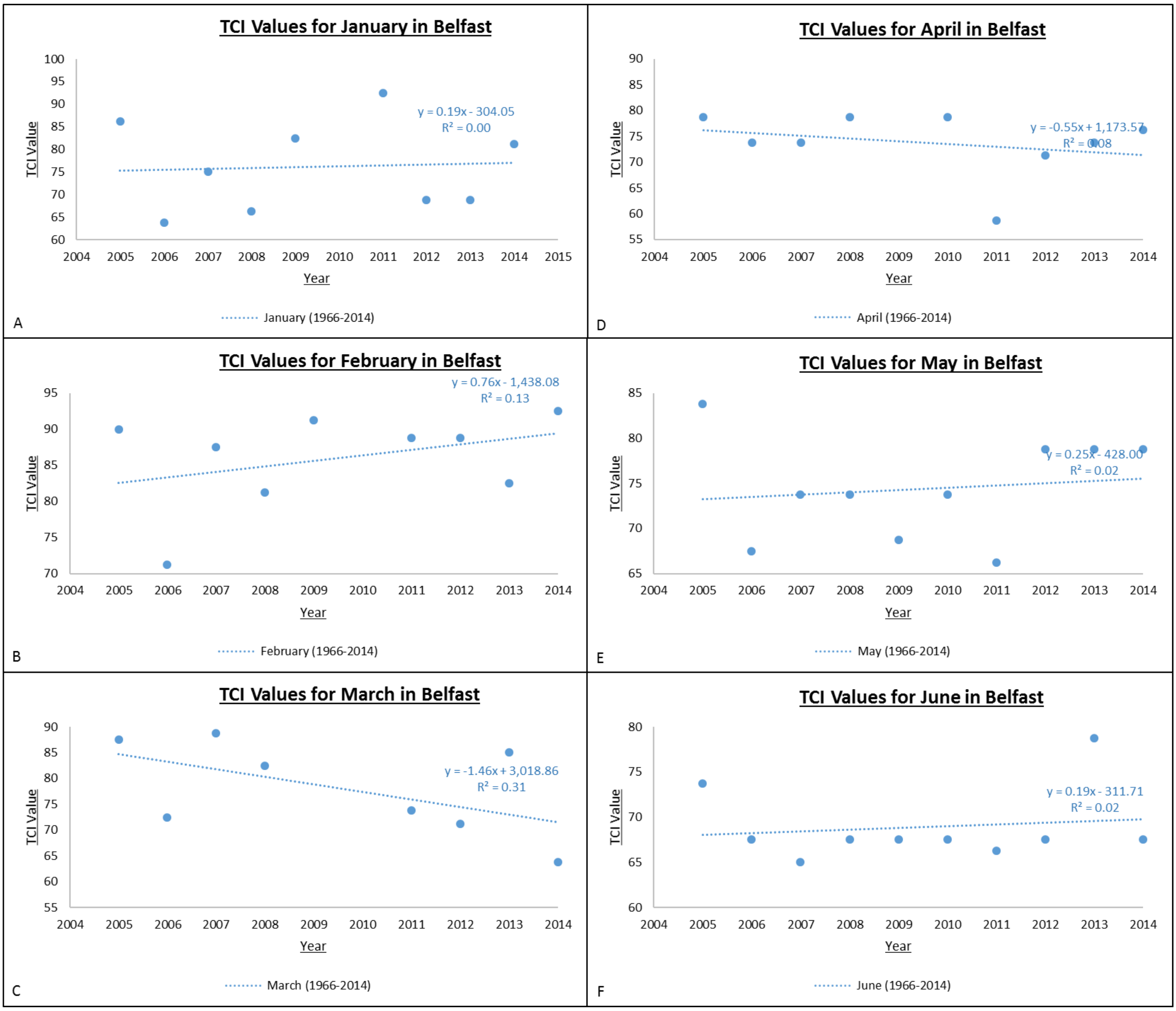
Appendix C.16: The correlation between the mean monthly TCI scores and time in Polokwane for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1999-2014.



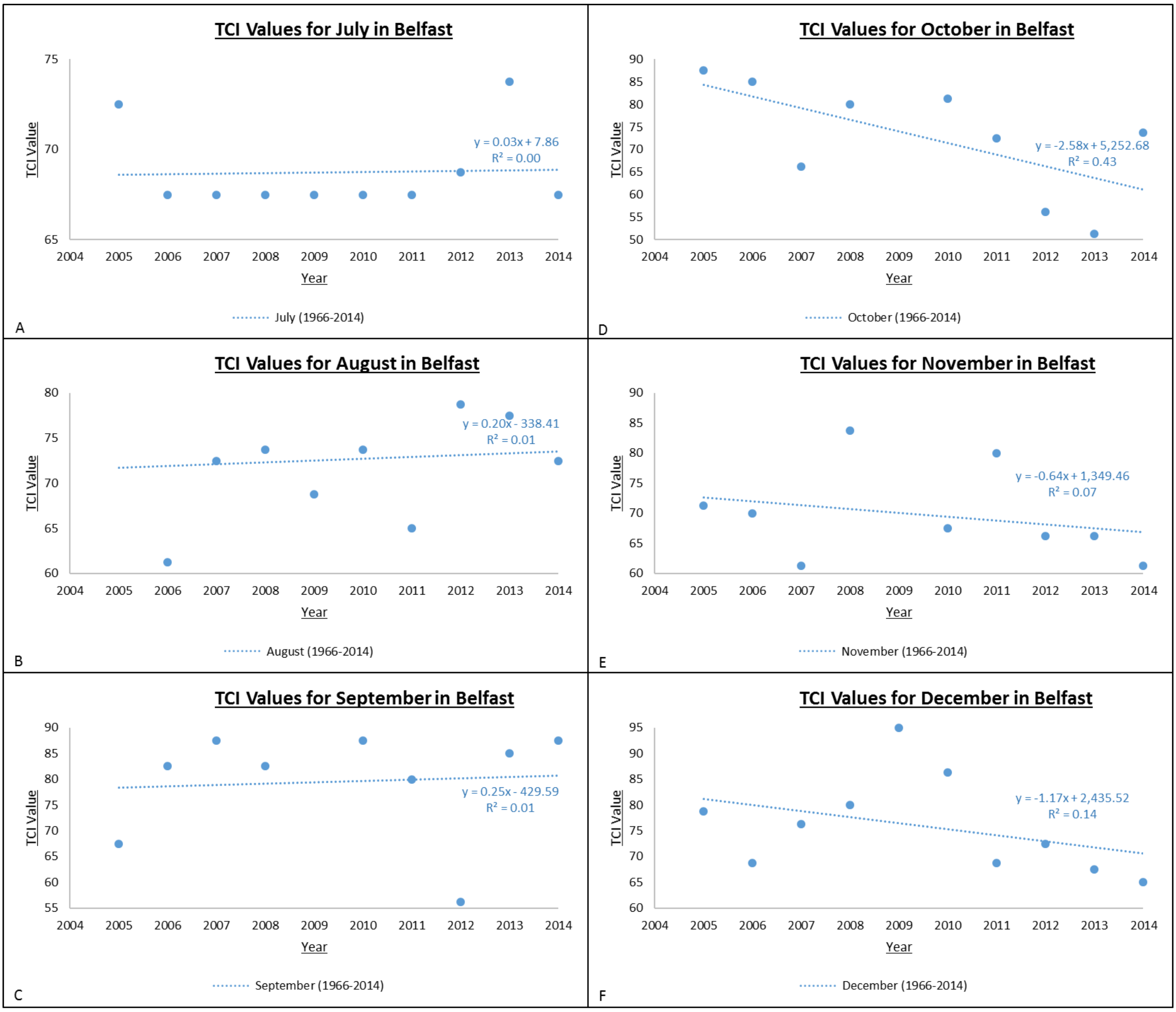
Appendix C.17: The correlation between the mean monthly TCI scores and time in Port Nolloth for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1999-2014.



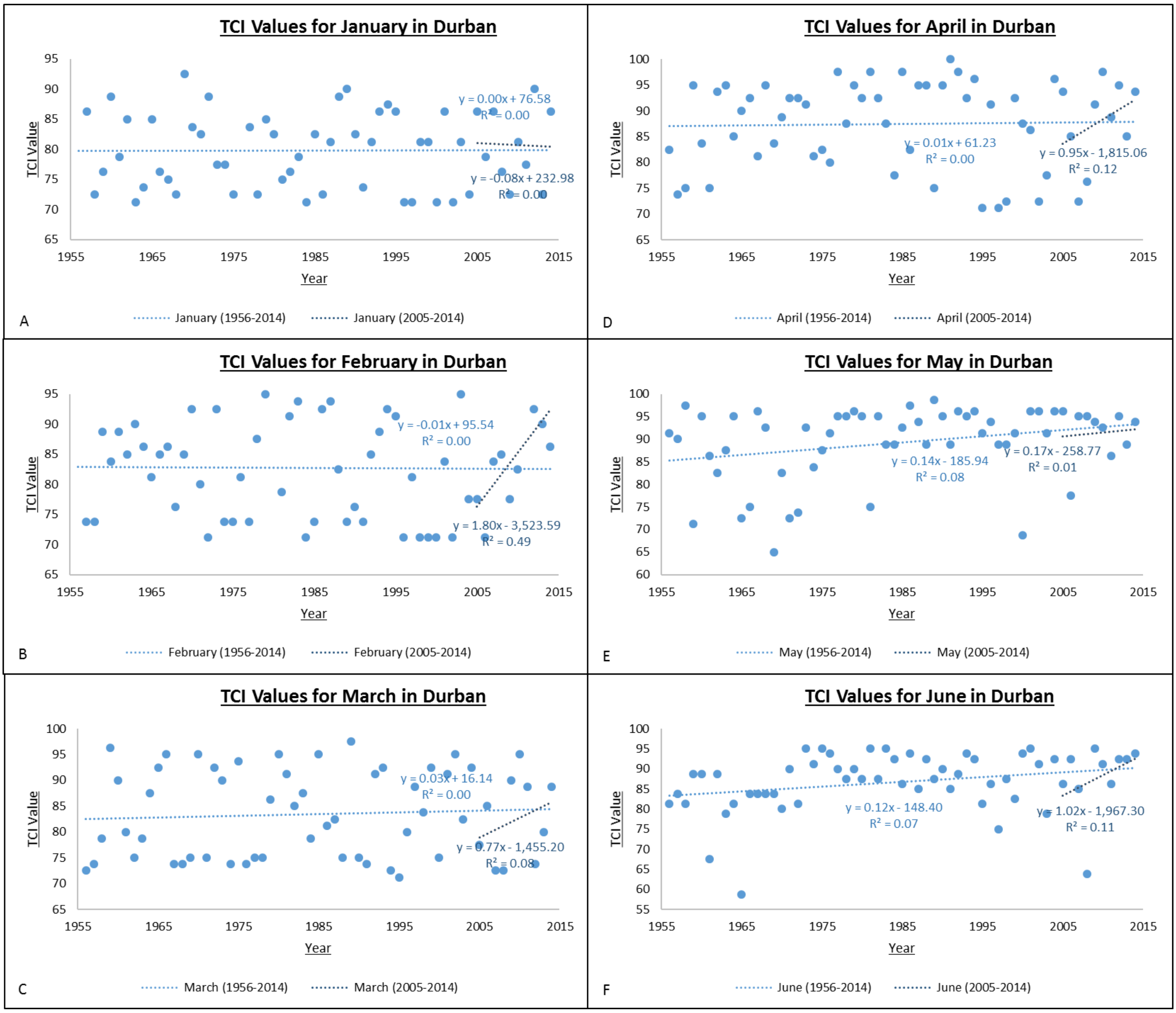
Appendix C.18: The correlation between the mean monthly TCI scores and time in Port Nolloth for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1993-2014.



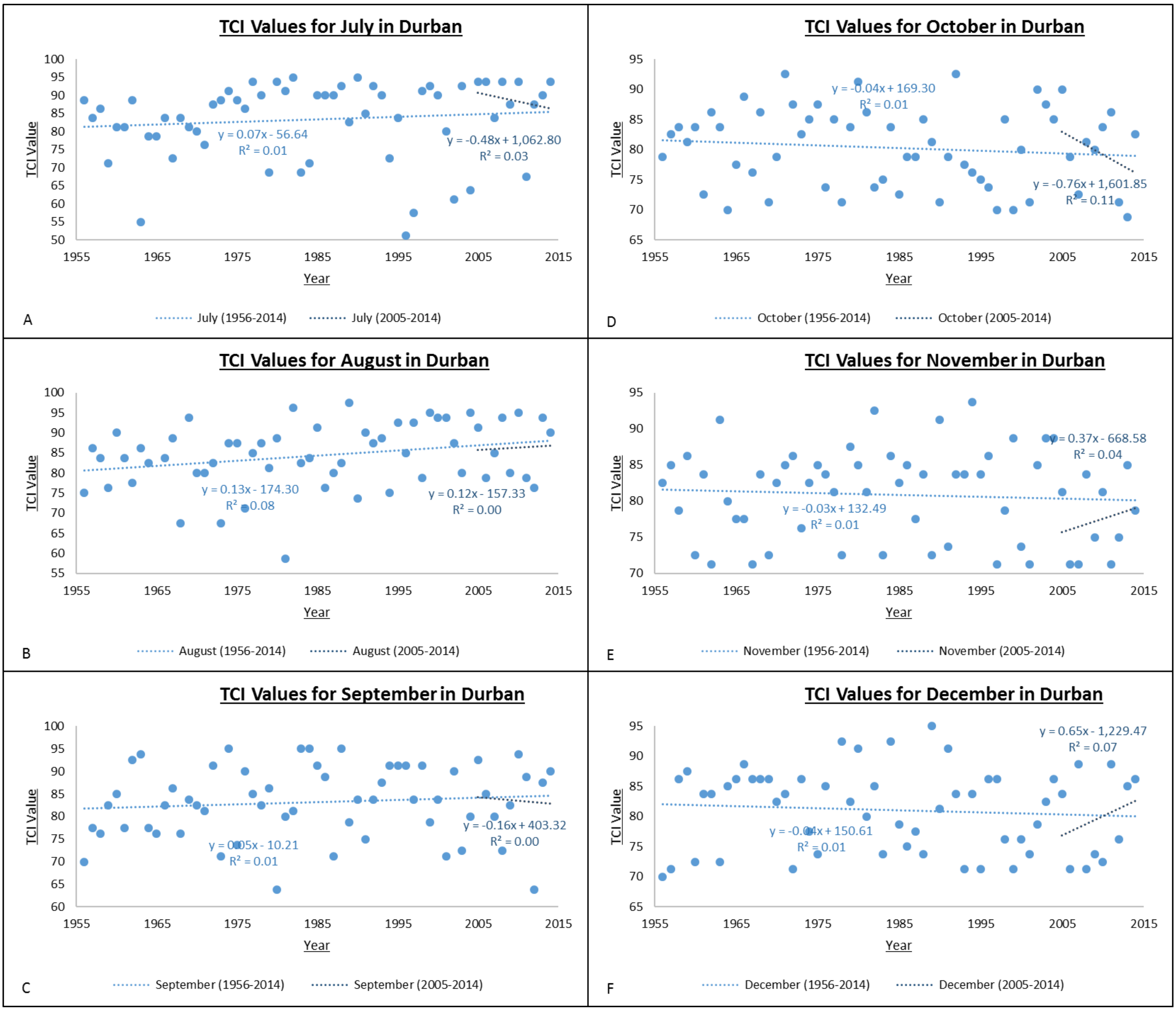
Appendix C.19: The correlation between the mean monthly TCI scores and time in Belfast for A) January B) February C) March D) April E) May F) June, for the period 2005-2014.



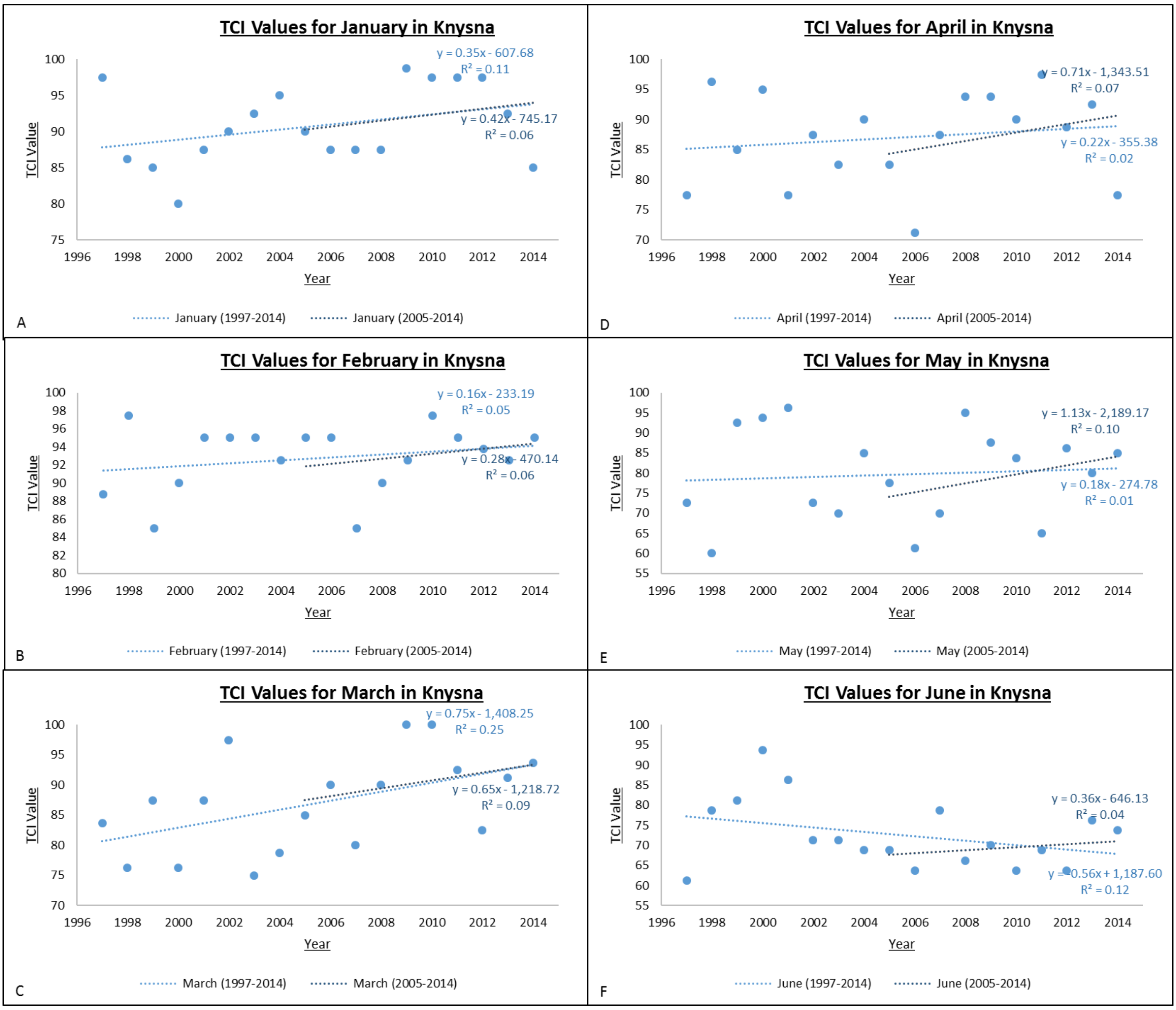
Appendix C.20: The correlation between the mean monthly TCI scores and time in Belfast for A) July B) August C) September D) October E) November F) December, for the period 2005-2014.



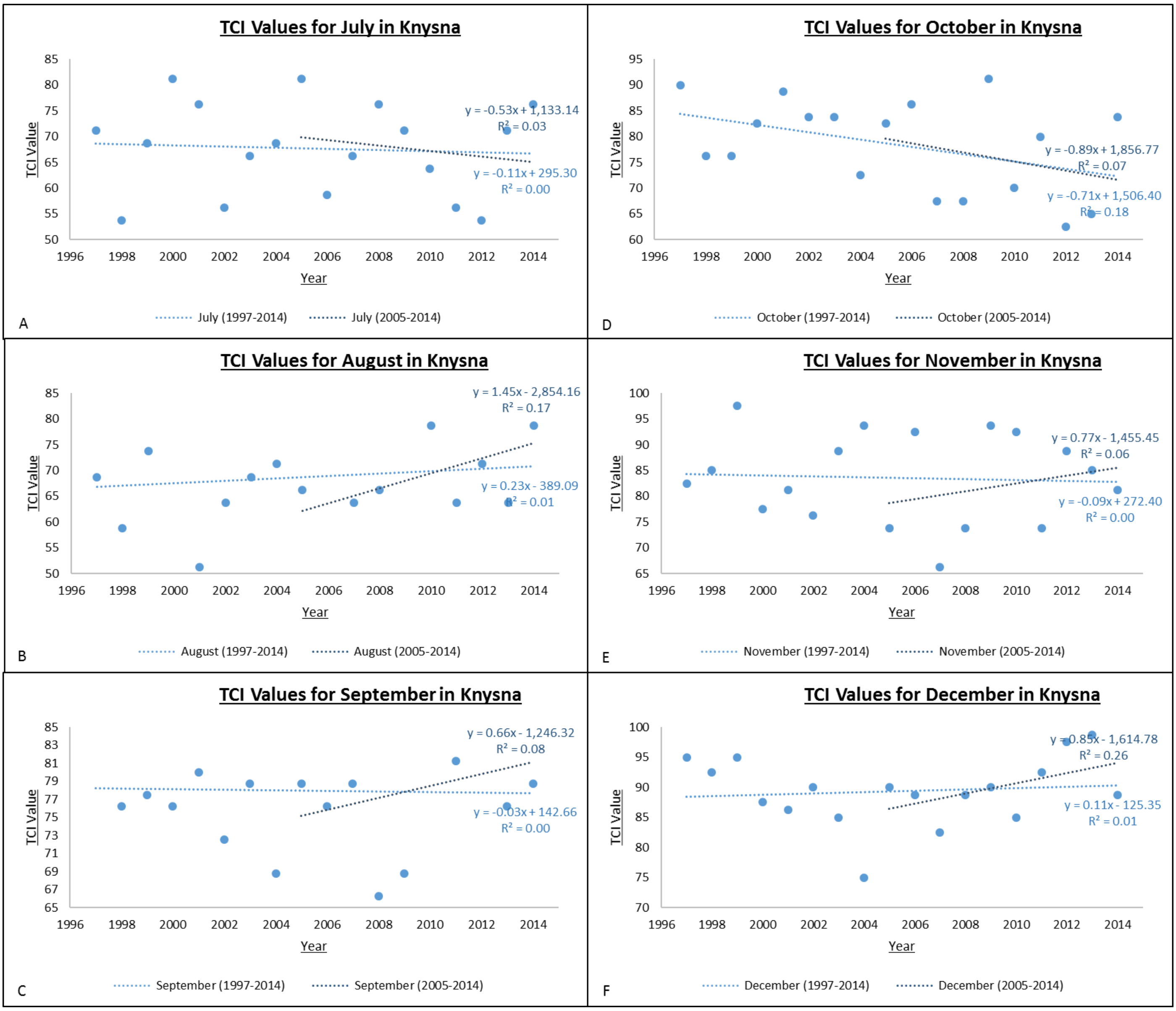
Appendix C.21: The correlation between the mean monthly TCI scores and time in Durban for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1956-2014.



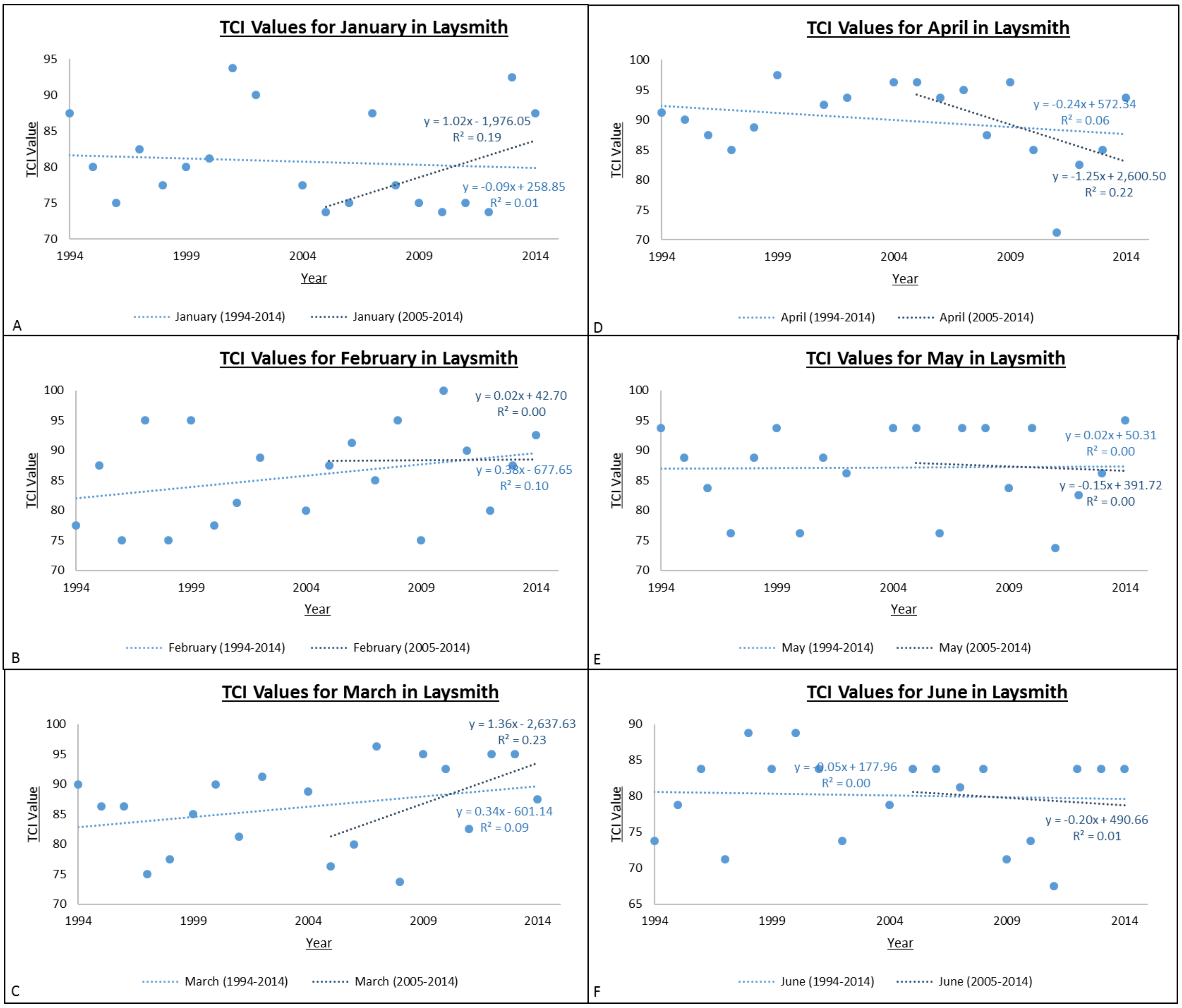
Appendix C.22: The correlation between the mean monthly TCI scores and time Durban for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1993-2014.



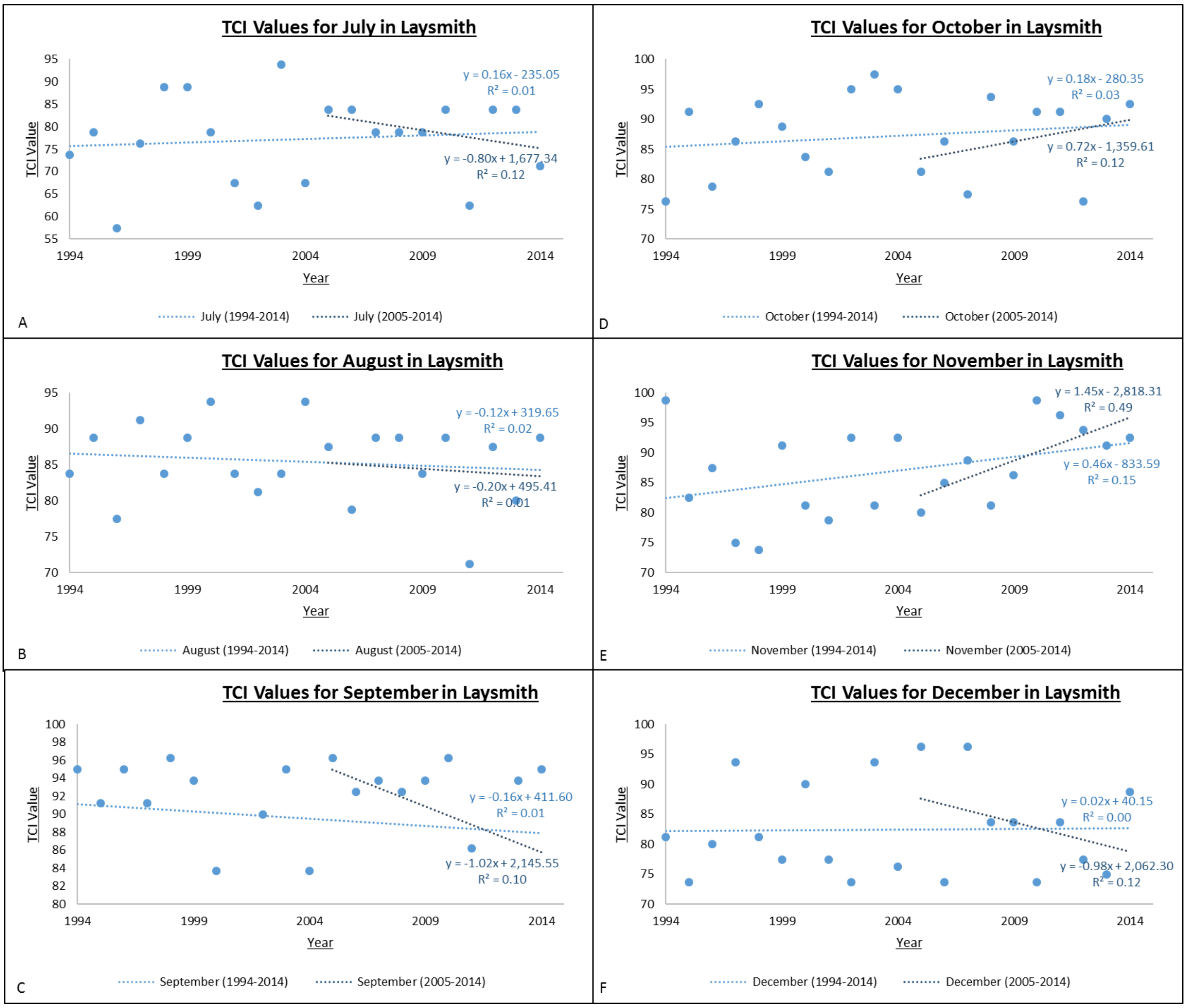
Appendix C.23: The correlation between the mean monthly TCI scores and time in Knysna for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1997-2014.



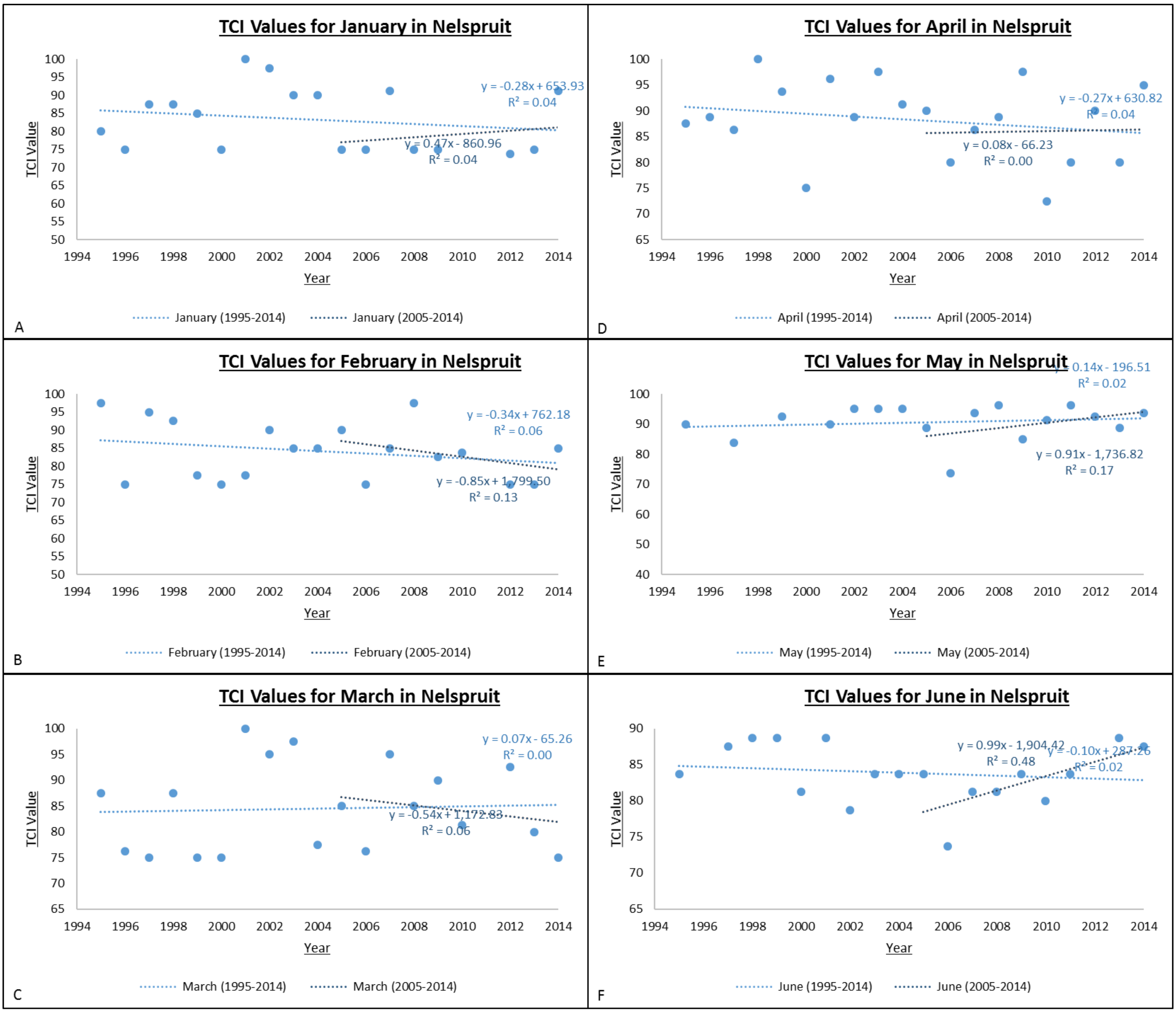
Appendix C.24: The correlation between the mean monthly TCI scores and time Knysna for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1997-2014.



Appendix C.25: The correlation between the mean monthly TCI scores and time in Ladysmith for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1994-2014.

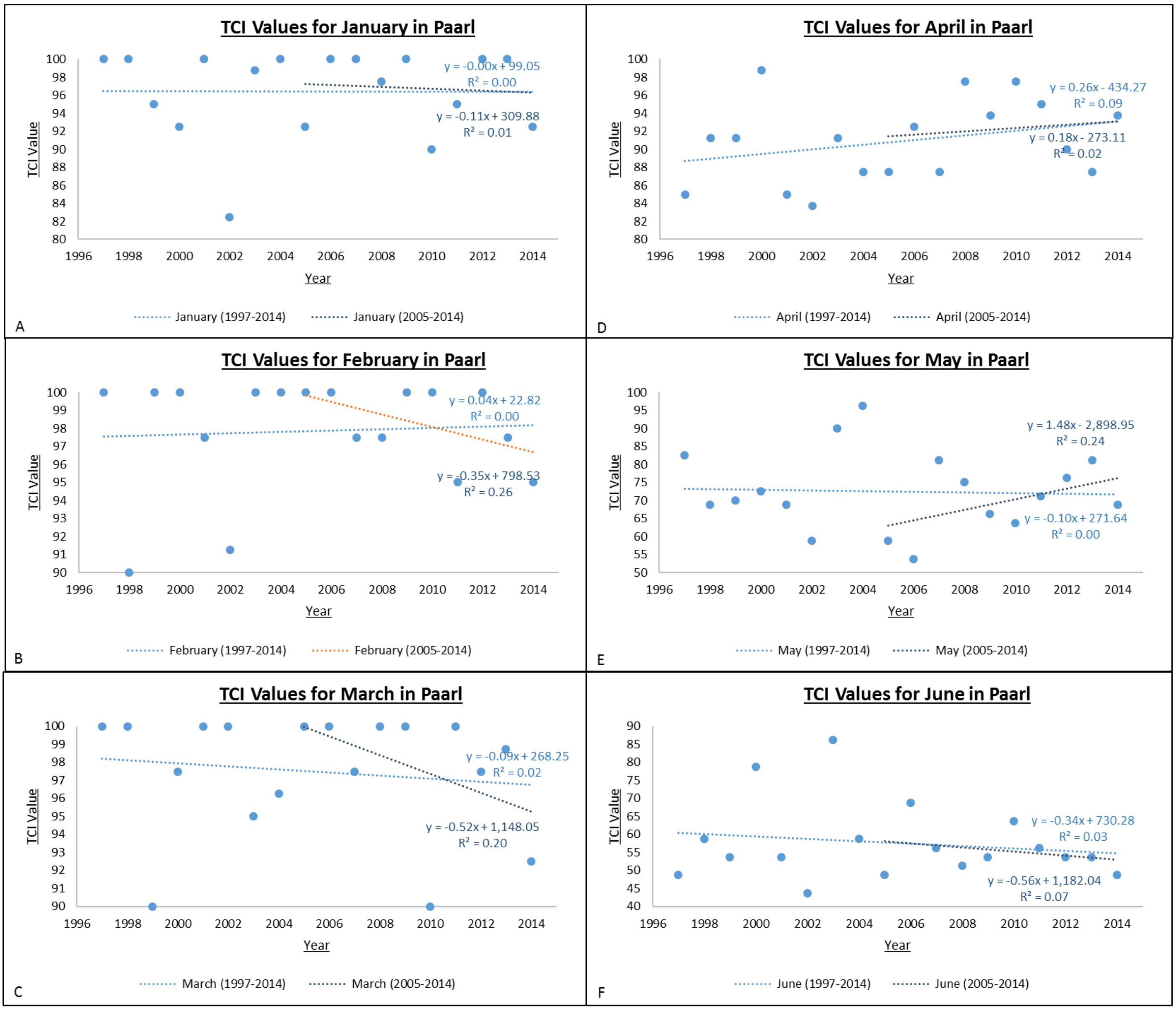


Appendix C.26: The correlation between the mean monthly TCI scores and time Ladysmith for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1994-2014.

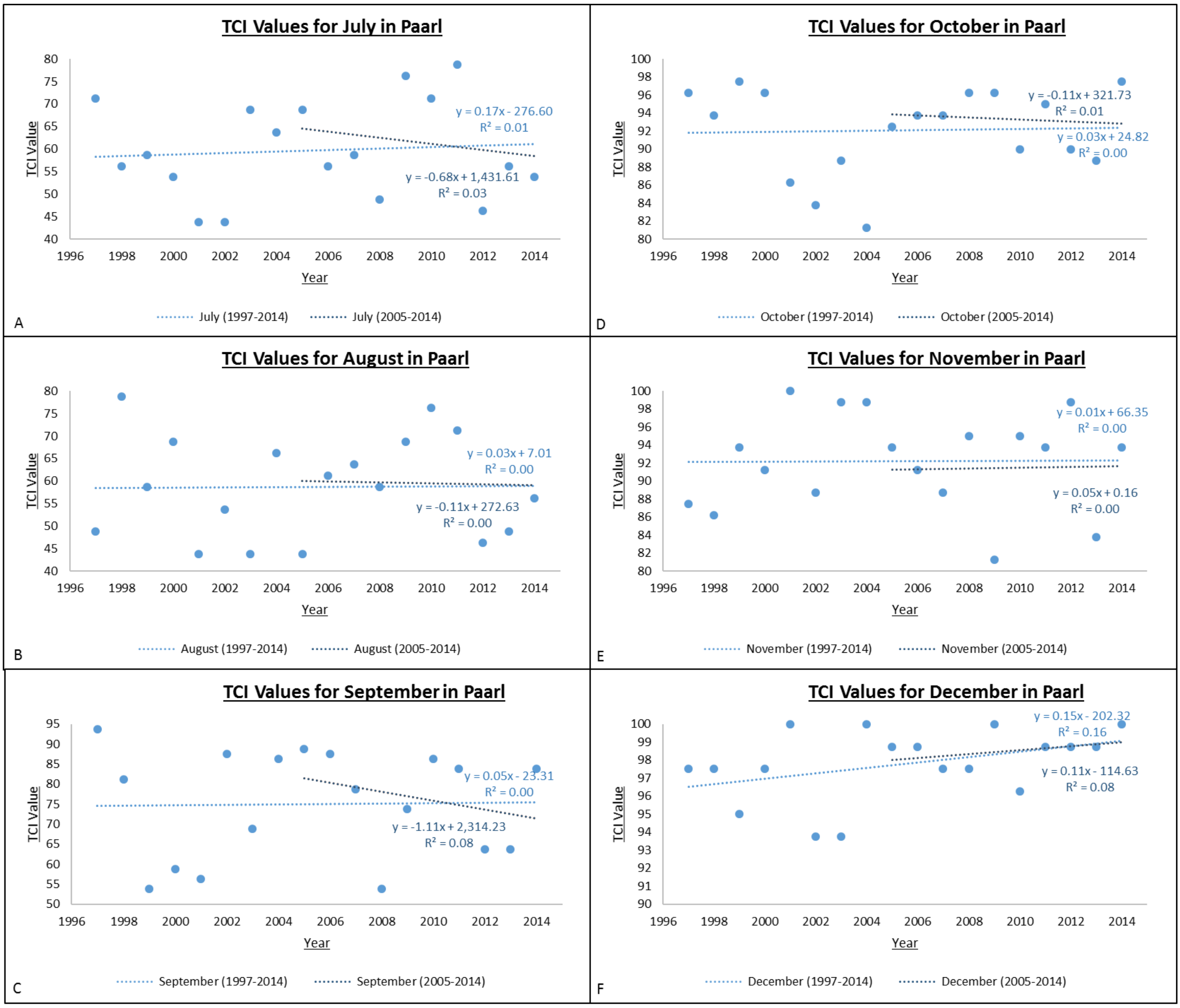


Appendix C.27: The correlation between the mean monthly TCI scores and time in Nelspruit for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1995-2014.

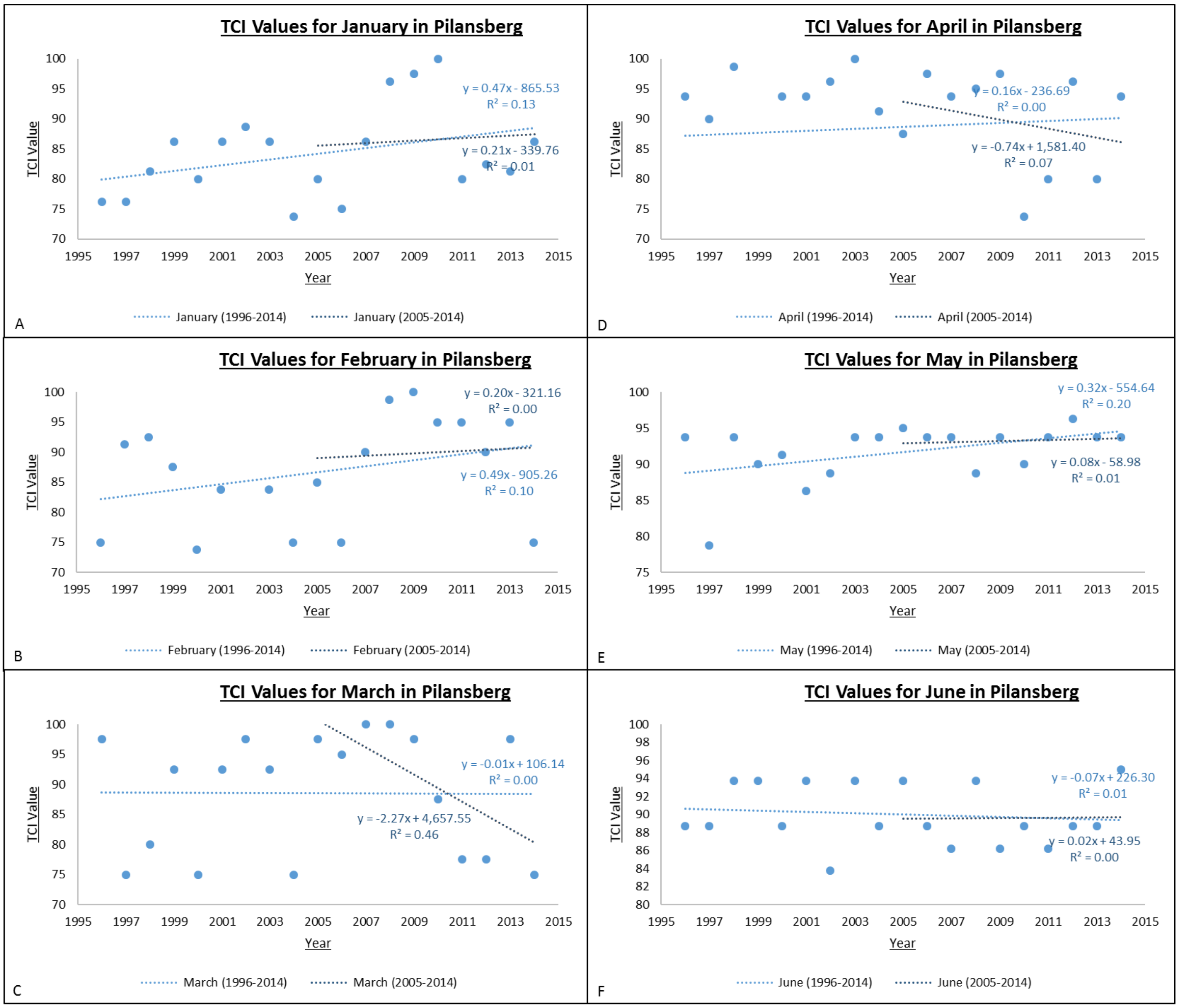
<u>Appendix C.28:</u> The correlation between the mean monthly TCI scores and time Nelspruit for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1995-2014.



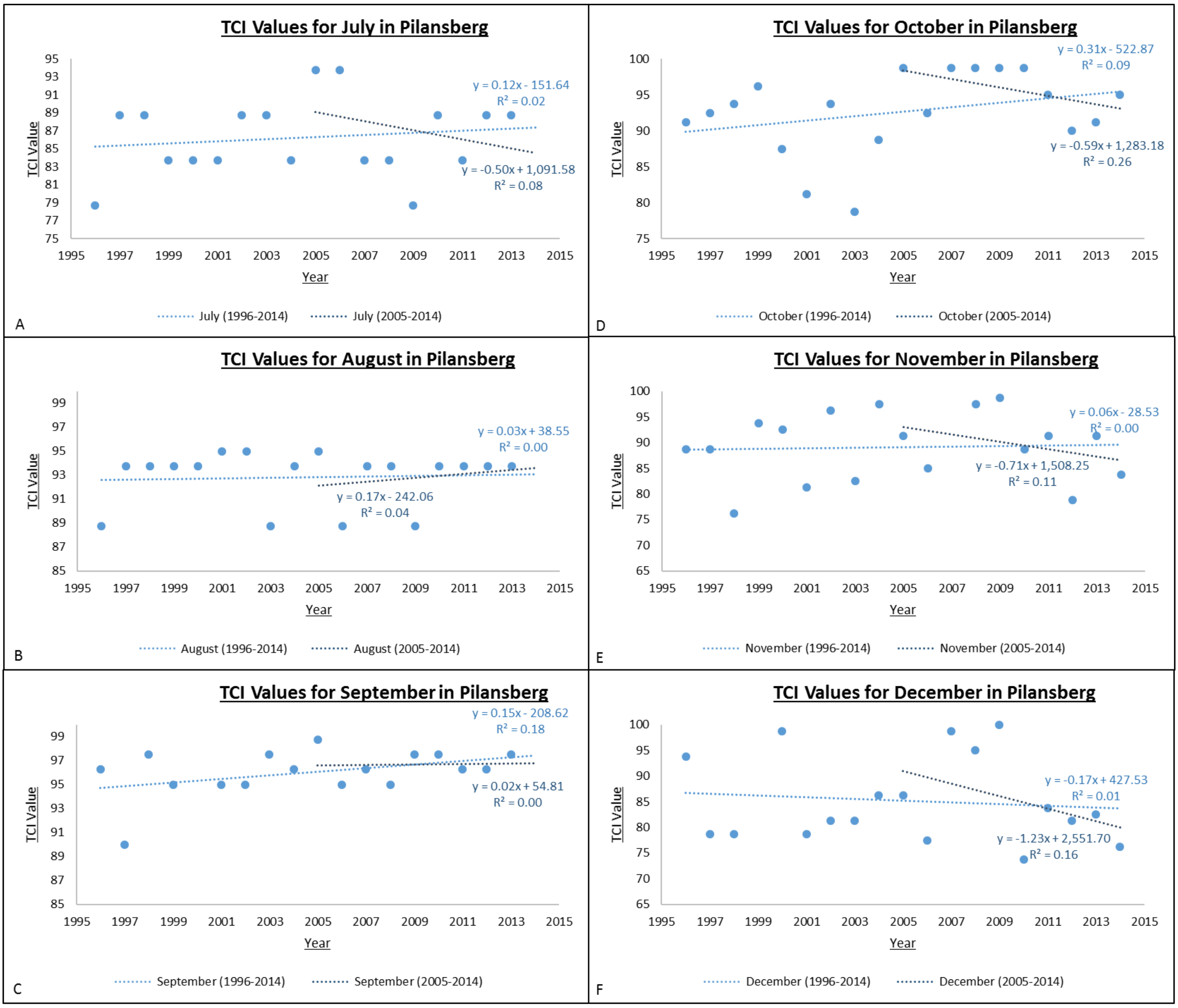
Appendix C.29: The correlation between the mean monthly TCI scores and time in Paarl for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1997-2014.



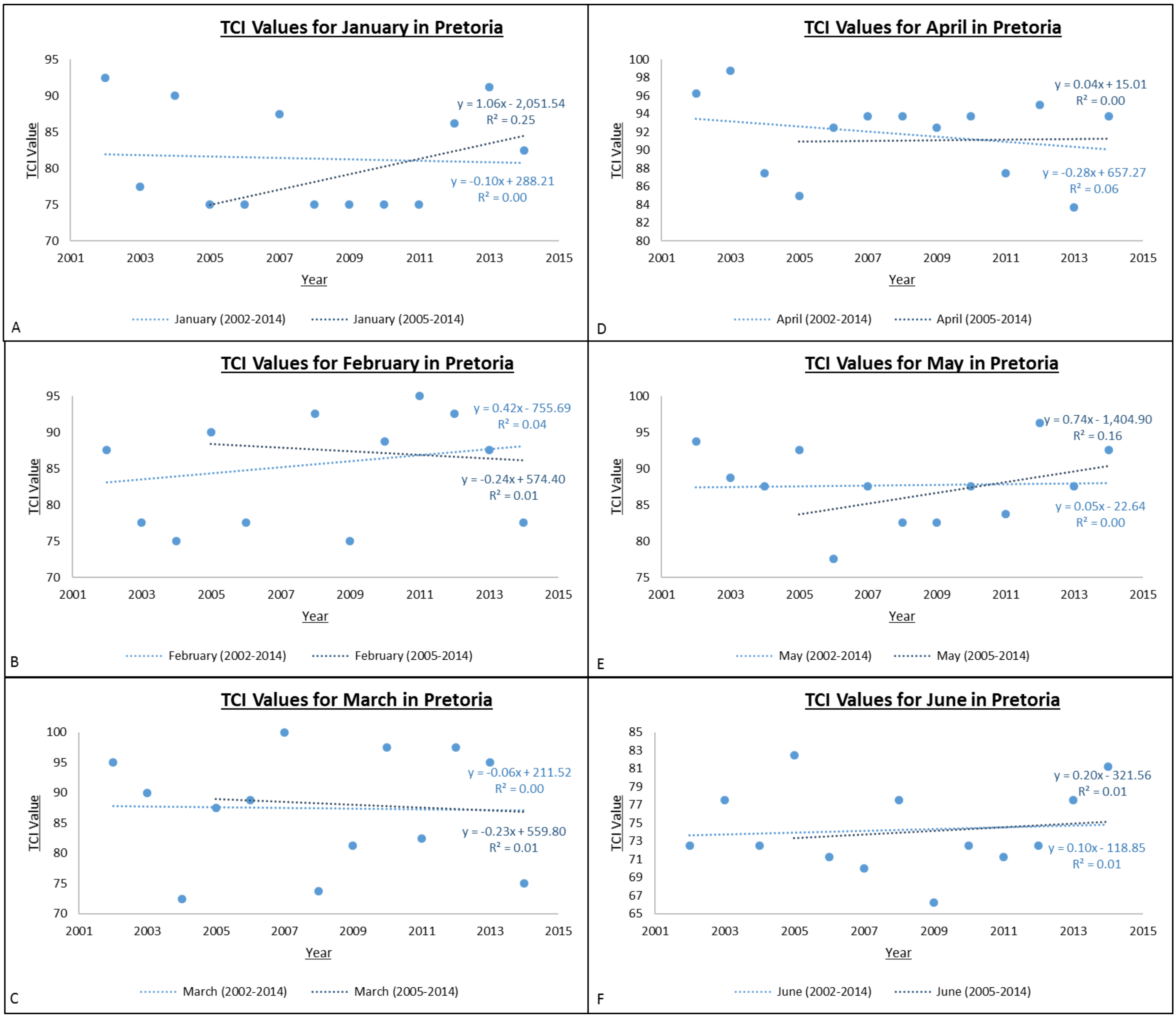
Appendix C.30: The correlation between the mean monthly TCI scores and time Paarl for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1997-2014.



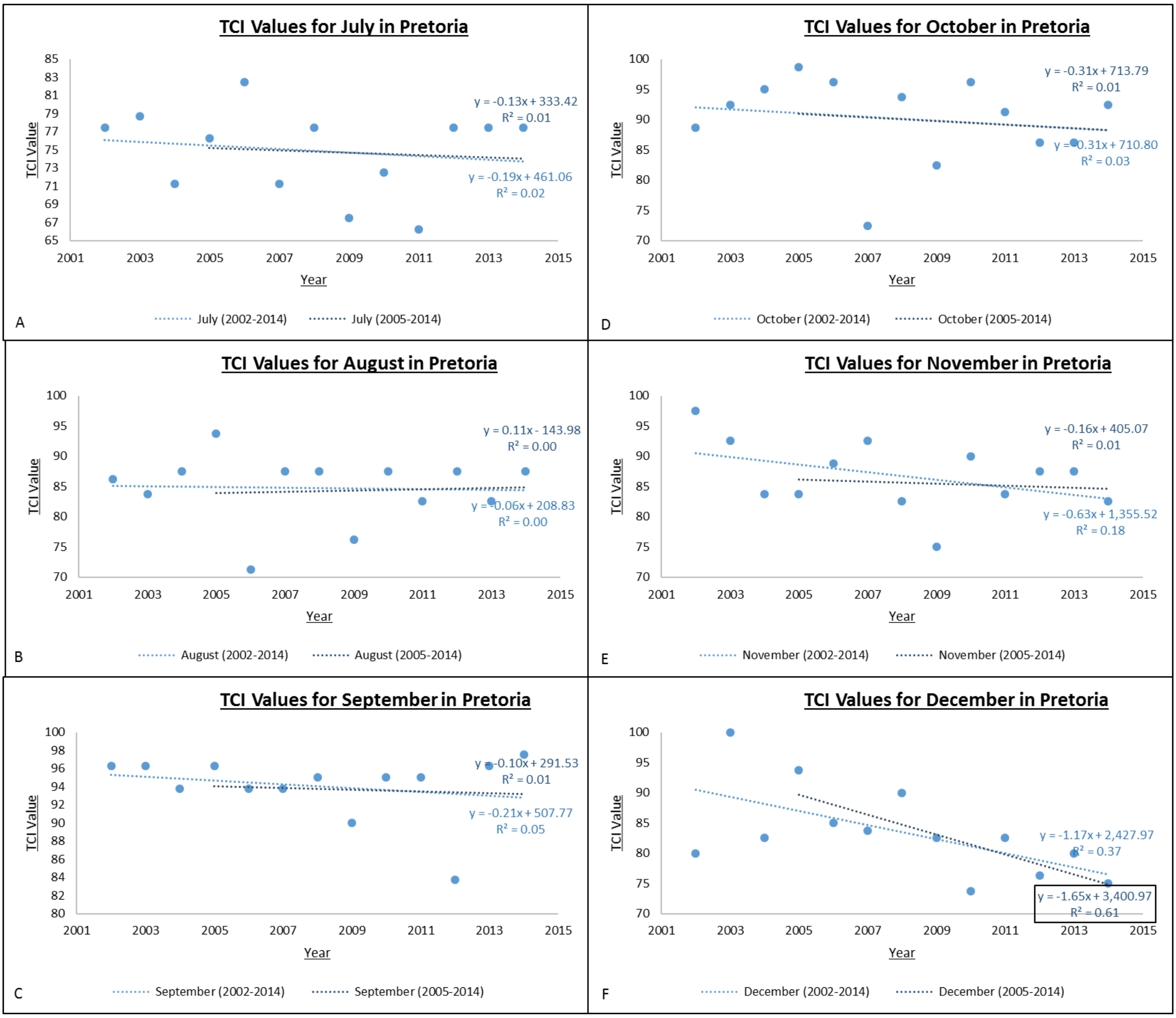
Appendix C.31: The correlation between the mean monthly TCI scores and time in Pilanesberg for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1996-2014.



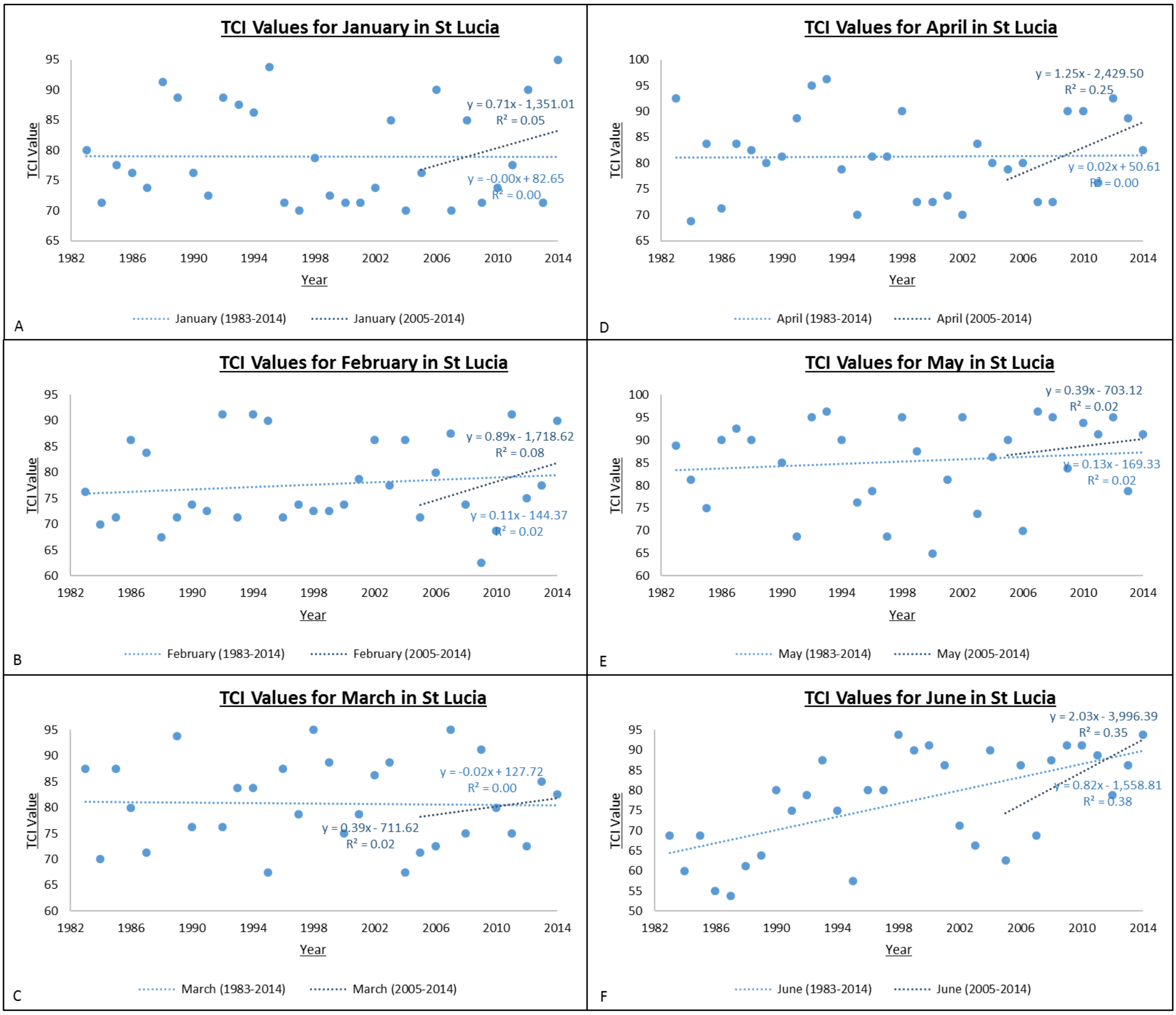
<u>Appendix C.32:</u> The correlation between the mean monthly TCI scores and time Pilanesberg for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1996-2014.



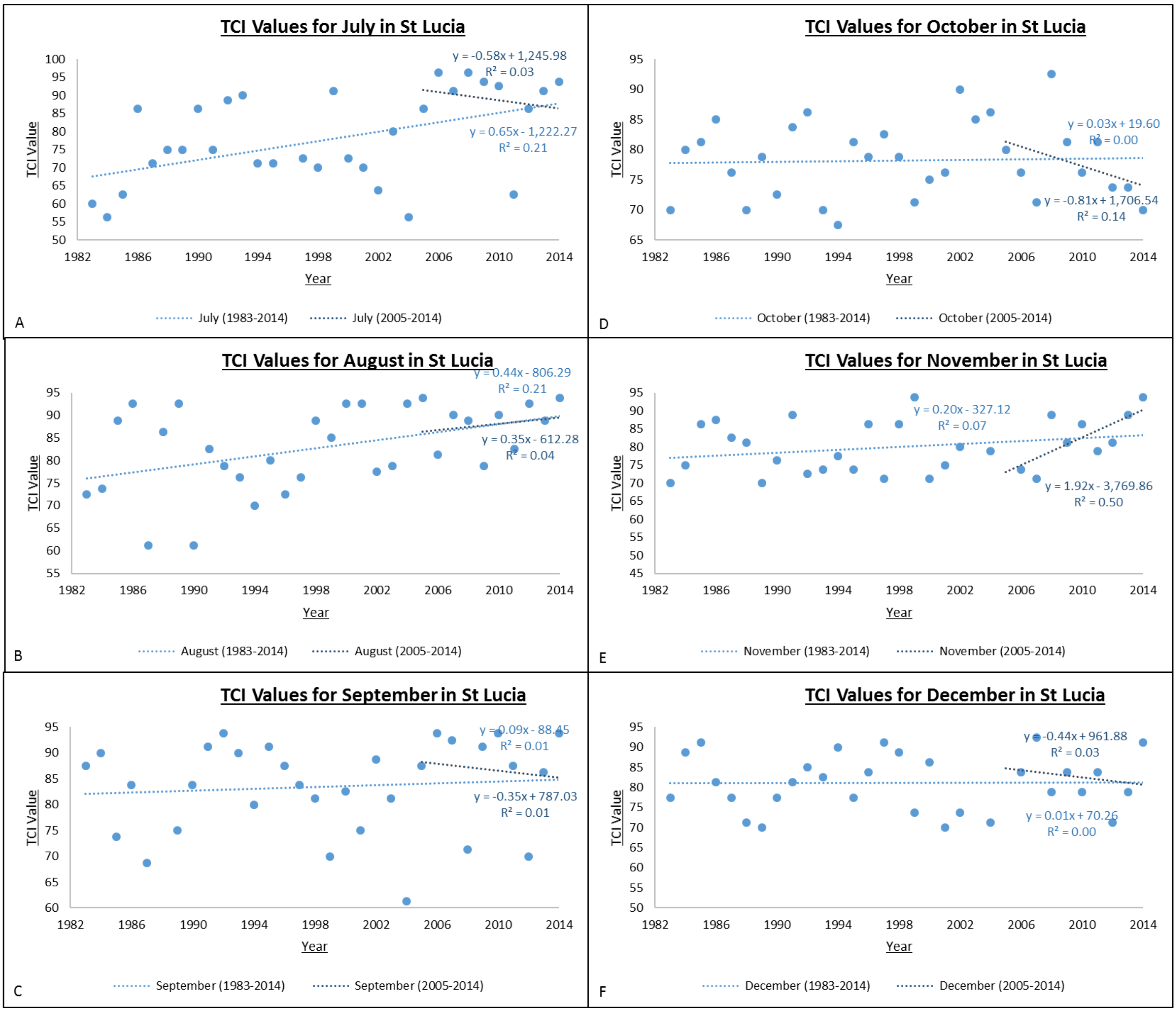
Appendix C.33: The correlation between the mean monthly TCI scores and time in Pilanesberg for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1996-2014.



Appendix C.34: The correlation between the mean monthly TCI scores and time Pilanesberg for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1996-2014.



<u>Appendix C.35:</u> The correlation between the mean monthly TCI scores and time in St Lucia for A) January B) February C) March D) April E) May F) June, for the period 2005-2014 and 1983-2014.



Appendix C.36: The correlation between the mean monthly TCI scores and time St Lucia for A) July B) August C) September D) October E) November F) December, for the period 2005-2014 and 1983-2014

Appendix D

Results for the calculated sunshine hours, using cloud cover as a proxy.

Table D.1: The correlation between the actual sunshine hours' data and the calculated sunshine hours' data for the longest continuous period at each location.

Location (Time Period)	Pearson Correlation Coefficient	p-value	Significance
Bloemfontein (1992-2014)	0.64	0.0005	Significant
Cape Town (1966-2014)	0.40	0.001	Significant
East London (1959-2014)	0.16	0.1	Non-Significant
Kimberley (1959-2014)	0.29	0.01	Significant
Polokwane (1993-2014)	0.90	0.0005	Significant
Port Elizabeth (1959-2014)	0.64	0.0005	Significant
Port Nolloth (1999-2014)	0.50	0.025	Significant

The correlation between the actual sunshine hours that were obtained from the South African Weather Service and the calculated sunshine hours (*section 4.2.2*) show varied correlation coefficients across each location (*Table D..1*). The varied results indicate that the calculated sunshine hours are not an accurate alternative that can be used across all the locations. Furthermore, it reinforces the notion that calculating the amount of sunshine hours at a location using cloud cover data as a proxy only produces an estimate due to the inherent difficulty of precisely measuring cloud cover data (Hulme *et al.*, 1995).

Appendix E

Participant Information Sheet.

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: GEOGRAPHY: TEL: +27 11 717-6503 • FAX: +27 086 651 6366
ARCHAEOLOGY: TEL: +27 11 717-6045 • FAX: +27 086 651 6366
http://www.wits.ac.za/geography/

Dear Sir/Madam/Prof/Dr

I am a master's student at the University of the Witwatersrand and I am currently busy with my master's dissertation, which is titled: *Exploring the Value of Tourism Climate Indices for 20 Locations in South Africa*. The aim of this study is to explore if Tourism Climate Indices can be used as an effective tool to measure climate suitability for tourism in South Africa. Additionally the study is attempting to see how accurate the Tourism Climate Indices are at detecting tourist's preferences as well exploring tourist's responsiveness to climate change in South Africa.

You are invited to participate in this study, by taking part in an interview. You were chosen to participate in this study due to your extensive knowledge surrounding the tourism sector in South Africa and its accompanying literature. You will be required to answer a set questions which I have formulated prior to the interview. Thereafter, a discussion will ensue, where you will be shown data and asked to comment on the data and provide your perceptions on issues like climate change and what is ultimately influencing tourist's choice of destination. The interview will last approximately 30 minutes can be conducted at a time and place that best suits you. You will not receive any payment or other compensation for your participation in this study. There will also be no cost to you for your participation. If you agree, the interview will be audio recorded and later transcribed- any personal information (not relevant to the study) will not be transcribed and the recording will be deleted.

The study and final report will need to make reference to you personally. A copy of the final report will be sent to you. The report will also be available on the Universities electronic thesis database and will be only used for academic purposes and knowledge production. The study or aspects of it may be published at a later date in reputable journal articles.

It is not likely that this research will benefit you directly. However, it may allow for a deeper understanding of what role climate plays in influencing tourism in South Africa and may also highlight the Tourism Climate Index as a suitable tool that can be used in South Africa and other developing contexts.

Your participation in this study is completely voluntary. If you do choose to take part in this study, you may withdraw at any time without consequence of any kind. You may also refuse to answer any questions during the interview that you don't feel comfortable with.

If you have any questions or concerns please feel free to contact:

Dean Robinson (Principal Researcher/Student): dean.robinson@vodamail.co.za/ 0782819546
Professor Gijsbert Hoogendoorn (Supervisor): ghoogendoorn@uj.ac.za/ (011) 559 4628
Doctor Raeesa Moolla (Supervisor): Raeesa.Moolla@wits.ac.za/ (011) 717 6522
Doctor Jennifer Fitchett (Supervisor): jennifer.m.fitchett@gmail.com

Appendix F

Formal Letter of Consent.

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: GEOGRAPHY: TEL: +27 11 717-6503 • FAX: +27 086 651 6366
ARCHAEOLOGY: TEL: +27 11 717-6045 • FAX: +27 086 651 6366
http://www.wits.ac.za/geography/

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Formal Consent Form

I, the participant in this study, confirm that:

I have read and understood the information presented to me in the *Letter of Participation* and that I was given the opportunity to ask any questions about the study and what my involvement entails. I also agree that I have the ability to withdraw from the study or reserve my right to not answer any questions that I don't feel comfortable answering. The researcher also made it clear that I will not receive any payment or any other compensation for my involvement in this study.

Additionally, the procedures regarding confidentiality and anonymity have been clearly explained. It was made clear to me that the data and final report will be available on the University of the Witwatersrand's intranet and that I and my organisation will receive a copy of the final report. It was explained that the research will only be used for academic purposes and will potentially be published in reputable journal articles at a later date.

I (DO/ DO NOT) give the researcher consent to audio record the interview.

I, along with the researcher, agree to sign and date this informed consent form:

Participant:

______________________	______________________	______________
Name of Participant	Signature	Date

Researcher:

______________________	______________________	______________
Name of Researcher	Signature	Date

Appendix G

Ethics clearance certificate.

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Robinson

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: H15/09/32**

PROJECT TITLE Exploring the value of tourism climate indices for 20 locationsin South Africa

INVESTIGATOR(S) Mr D Robinson

SCHOOL/DEPARTMENT GAES/

DATE CONSIDERED 18 September 2015

DECISION OF THE COMMITTEE Approved unconditionally

EXPIRY DATE 01 October 2018

DATE 02 October 2015 **CHAIRPERSON** J. Knight

(Professor J Knight)