



Evaluating the climatic suitability for camping in South Africa: an application of the Camping Climate Index (CCI)

Zandizoloyiso Mnguni & Jennifer M. Fitchett

To cite this article: Zandizoloyiso Mnguni & Jennifer M. Fitchett (2025) Evaluating the climatic suitability for camping in South Africa: an application of the Camping Climate Index (CCI), South African Geographical Journal, 107:3, 340-366, DOI: [10.1080/03736245.2024.2405503](https://doi.org/10.1080/03736245.2024.2405503)

To link to this article: <https://doi.org/10.1080/03736245.2024.2405503>



© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.



Published online: 21 Sep 2024.



[Submit your article to this journal](#)



Article views: 715



[View related articles](#)



[View Crossmark data](#)



OPEN ACCESS



Evaluating the climatic suitability for camping in South Africa: an application of the Camping Climate Index (CCI)

Zandizoloyiso Mnguni^a and Jennifer M. Fitchett^b 

^aSchool of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa; ^bUniversity of the Witwatersrand, Johannesburg, South Africa

ABSTRACT

Nature-based tourism is a prominent component of the tourism sector in South Africa, attracting both domestic and international travellers. Camping plays a crucial role, providing both affordable lodging and an opportunity to engage more directly and continuously with the natural environment. Climate is a key determinant of the feasibility of camping activities and has been empirically established as a significant influence in tourists' decision-making process when selecting a destination. The climate in South Africa, while highly heterogenous, has been generally classified as 'ideal' for tourism. The Camping Climate Index (CCI) has recently been developed to quantify the climatic suitability of diverse camping locations, and the suitability of the index confirmed for South Africa. This study applies the CCI to 33 stations across South Africa for the period 1990–2022 or for the longest time period for which data are available. The average annual CCI scores range from 3.5 ('unfavourable') for Sutherland to 5.3 ('acceptable') for King Shaka International Airport. Mean monthly scores for the common period 2017–2021 range from 2.7 ('unfavourable') for Sutherland in August to 6.2 ('good') for Springbok in January and December. This facilitates the advancement of the tourism sector in South Africa by providing a quantitative assessment of the climatic conditions suitable for camping activities.

ARTICLE HISTORY

Received 7 March 2024

Accepted 11 September 2024

KEYWORDS

Camping; nature-based tourism; meteorological data; climatic suitability; climate change; South Africa

1. Introduction

Camping tourism, as both a recreational pursuit and form of lodging (Brooker & Joppe, 2014), is highly reliant on the natural environment, making it particularly susceptible to the impacts of climate variability and change (Amelung & Nicholls, 2014; Mikulic et al., 2017). Comparable vulnerabilities are reported in Europe, where climate variations similarly affect camping tourism (Bacsi & Szanati, 2021; Ferrante et al., 2018; Hewer et al., 2017; Jeuring, 2017). Enterprises engaged in camping activities should adopt proactive and reactive approaches to strategies for mitigating climate change (Craig, 2019), and to maximize the competitive economic advantage that the weather and climate resources can offer to the sector (Craig et al., 2023). In South Africa, tent camping

CONTACT Jennifer M. Fitchett  Jennifer.Fitchett@wits.ac.za  University of the Witwatersrand, Private Bag X3, WITS, BP002 Bernard Price Building, Johannesburg WITS 2050, South Africa

© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

takes precedence over RV camping, a notable difference from the prevailing trend in the United States of America (Rogerson & Rogerson, 2020b). This distinction amplifies the climatic sensitivity of camping activities, as campers are more exposed to environmental conditions (Ma et al., 2020; Wong et al., 2021). Camping has gained significant popularity in South Africa, notably among domestic tourists, due in part to its cost-effectiveness relative to alternative lodging options (Rogerson & Rogerson, 2020b). Furthermore, investigating the nexus between nature-based tourism and climate change is crucial due to its significant economic repercussions (Craig, 2019; Hewer et al., 2015).

South Africa has established itself as a prominent tourism destination within Africa, renowned for its diverse climatic zones that support a wide range of outdoor tourist activities (Saarinen et al., 2022; Slabbert & Du Plessis, 2013). Generally, South Africa's climate is deemed 'ideal' for tourism, as classified by the Tourism Climate Index (TCI), TripAdvisor reviews, and tourist interviews (Fitchett & Hoogendoorn, 2018; Fitchett et al., 2017; Giddy et al., 2017). The TCI, a biometeorological index that quantifies and classifies the climatic suitability for tourism on the basis of input meteorological data, reveals that South Africa has bimodal, summer and winter peak distributions in climatic suitability for tourism across various destinations, suggesting that the climatic heterogeneity of the country as a whole offers suitable conditions for tourism throughout the year (Fitchett et al., 2017). However, it is important to note that the suitability of climate for camping tourism may differ from other tourism climate index classifications due to the heightened exposure to weather (Ma et al., 2020). While general tourism indices may categorize an area as suitable despite adverse weather components, camping tourists cannot evade the impacts of unsuitable weather (Ma et al., 2020, 2021; Matthews et al., 2021). The Camping Climate Index (CCI) therefore includes a set of critical meteorological variables, and if the respective threshold of any of these variables is exceeded, the index score is set to a maximum of '3', and thus classified as 'unfavourable', regardless of how suitable the thermal comfort or sunshine hours might be (Ma et al., 2020). The CCI was developed in the United States of America based on campground visitation data and considered the climate variability in tent, cabin and RV to develop a comprehensive index. It is important to assess camping climatic suitability separately from the rest of the tourism sector. The applicability and suitability of the CCI in South Africa has been confirmed and recommended, dependent on the availability of appropriate meteorological data (Fitchett & Meyer, 2023). Furthermore, the adverse condition thresholds proposed by Ma et al. (2020) have been confirmed for South Africa (Fitchett & Meyer, 2023). To advance our understanding of the climatic suitability for tourism in South Africa, and particularly to quantify the climatic suitability of destinations across the country for camping given the popularity in the country, the local-scale application of the index is important.

This study is the first to evaluate the climatic suitability of camping tourism at a local scale outside of the United States of America, computing CCI scores and classifying these across 33 diverse locations in South Africa. We apply CCI calculations at monthly, seasonal, and annual intervals for the period 1990–2022 and for the longest period of robust data for each respective location. Seasonal and interannual variabilities in CCI scores are investigated, and spatial variability is explored. The quantification of climatic suitability of South African destinations for tourism enables the forecasting of the sustainability of tourism in the region, to facilitate the direction of adaptation measures

(Fitchett et al., 2016a). The CCI has been applied on a global scale through the utilization of gridded datasets (Ma et al., 2021). However, the integration of ground-based data is imperative for validating the gridded data results. This methodology distinguishes itself from previous studies by relying on data acquired from terrestrial meteorological stations.

2. Study region

South Africa is located between 22–35°S and 17–33°E, spanning the mid-latitudes and subtropics (Braun et al., 2017; Tyson & Preston-Whyte, 2000), with climate zones varying from arid, semi-arid, sub-tropical, temperate and sub-alpine regions (Nicholson, 2000) resulting in nine distinct biomes (Todd et al., 2016). Variability in the position of the Intertropical Convergence Zone (ITCZ), the semi-permanent subtropical high-pressure systems and interannual forcings such as the El Nino Southern Oscillation (ENSO), Indian Ocean Dipole and Southern Annular Mode influence the South African climate and relate to South Africa's rainfall variability (Tyson & Preston-Whyte, 2000). The temperature varies from daytime highs of 32°C during the summer and to below 0°C at night at higher altitudes during winter (Jawtusich, 2014). The ocean currents off the east and west coast, the cold Benguela current and warm Agulhas current, respectively, influence the coastal and interior climate (Fitchett et al., 2017). The interior plateau is bounded by the Great Escarpment (Lennard, 2019). South African rainfall is a result of the intersection between the tropical, subtropical and temperate atmospheric pressure systems (Roffe et al., 2019). This results in three distinct rainfall zones: Winter Rainfall Zone (WRZ), Summer Rainfall Zone (SRZ) and Year-round Rainfall Zone (YRZ; Roffe et al., 2019).

The tourism sector in South Africa offers a diverse range of activities, encompassing outdoor tourism (Fitchett et al., 2016b, 2016a; Utomo, 2021), rural tourism (Boonzaaier & Philip, 2010), cultural tourism (Chivandi et al., 2020; Meyer, 2021), coastal tourism (Rogerson & Rogerson, 2020a), adventure tourism (Giddy, 2016), sport tourism (Nyikana et al., 2014) and nature-based tourism (Cole, 2004; Ramaano, 2021). Prior to the COVID-19 pandemic, the tourism sector experienced consistent growth, primarily driven by domestic tourism and local excursions, accounting for a majority of travel in the country (Rogerson, 2015). The quantity of caravan parks and campsites in South Africa is progressively increasing due to the rising popularity of camping (Rogerson & Rogerson, 2020b). In 2019, a total of 629 caravan parks were reported across the country (MapStudio, 2018), with close to 107,000 registered caravans (Van Heerden, 2008, 2010). In 2010, the estimated 1,300 camping facilities were operational in South Africa (Van Heerden, 2010).

To ensure that the results are representative of the diverse climate conditions in South Africa and a range of camping destinations, a total of 33 study sites were used spanning the nine provinces of the country (Figure 1). These study locations were chosen on the basis of data availability, but span a wide range of climatic zones across the country, and are proximate to a range of camping attractions. Applying global station density calculations to South African climate research, Van Der Walt and Fitchett (2022) find that a minimum of 21 stations distributed across the three rainfall zones, nine provinces and relatively equally distributed across the eastern, western, northern and southern

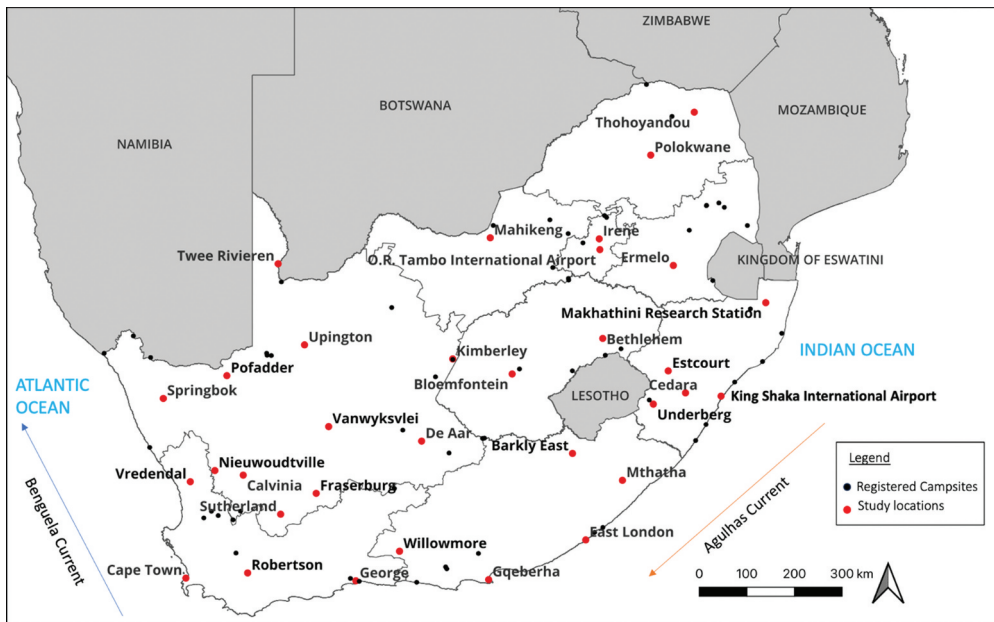


Figure 1. Map of the 33 study locations and select registered campsites across the country.

quadrants of the country would be representative. These 33 stations (Figure 1) exceed this requirement.

3. Methods

3.1. Data acquisition

Daily resolution maximum temperature ($^{\circ}\text{C}$), minimum temperature ($^{\circ}\text{C}$), average temperature ($^{\circ}\text{C}$), average relative humidity (%), rainfall (mm), wind (km/h) and sunshine hour data were obtained from the South African Weather Service (SAWS) for the 33 locations for which the requisite data were available (Figure 1; Table 1) for the period 1990–2022 or the longest period possible within that time range. SAWS performs basic quality checks prior to disseminating their data, but further exploratory data analysis was conducted to identify any outliers and to fill data gaps.

The primary constraint in choosing the study locations and the applicability of the CCI was the availability of consistent and detailed meteorological data for all the necessary climatic variables required for the index, specifically sunshine hours as it is seldom recorded in South Africa (Fitchett et al., 2016a). A number of the locations that are popular for camping did not have nearby meteorological stations that have all the meteorological variables needed to calculate the CCI (Fitchett & Meyer, 2023). Sunshine hours were recorded for only 33 of the over 200 South African Weather Service meteorological stations (Fitchett & Meyer, 2023), and some of the 200 stations did not record maximum temperature, minimum temperature, or humidity data. Fortunately, those 33 weather stations for which sunshine hours were recorded, also recorded the other requisite meteorological data, and could be included in the study (Table 1). The common

Table 1. Details of the study sites selected for the study.

Location	GPS coordinates	Altitude (m.asl)	Mean annual temperature (°C)	Mean total annual rainfall (mm)	Tourist attractions
Barkly East	30.9691° S, 27.5907° E	1,790	13.8	567	Tiffindell Ski Resort Barkly East Museum Barkly Pass Bastervoetpad Pass Bottleneck Pass Wall Hiking Trail Hluleka Wildlife Reserve Trails Mdumbi River Kayak Coffee Bay Beach Dwesa and Cwebe Nature Reserve Kragga Kamma Game Park Addo Elephant Park Sunday River Norm-Hudlin trails Art in the Park Donkin Reserve Pyramid and Lighthouse Hobie Beach Kings Beach Nahoon Beach East London Museum Nahoon Estuary Nature Reserve Hemingways Mall The Venom Pit Snake Park Avalon Market Fort Glamorgan The Historical Graveyard The Jewish Influence Historical Boer Graveyard Bakers Dam The Old Blackstone Power Station Die Wonderboom LIONSROCK Big Cat Sanctuary Basotho Cultural Village Huskyromi Wolf Sanctuary Bethlehem Museum Olive Day Spa Golden Gate Highlands National Park
Mthatha	31.6067° S, 28.7781° E	698	16.6	1044	
Gqeberha	33.9608° S, 25.6022° E	117	17.3	597	
East London	33.0198° S, 27.9039° E	125	19.4	709	
Willowmore	33.2877° S, 23.4895° E	840	18.1	89.8	
Bethlehem	28.2423° S, 28.3111° E	1,700	14.7	790	

(Continued)

Table 1. (Continued).

Location	GPS coordinates	Altitude (m.asl)	Mean annual temperature (°C)	Mean total annual rainfall (mm)	Tourist attractions
Bloemfontein	29.0852° S, 26.1596° E	1,395	17.1	701	Free State National Botanical Garden Ultimate Cheetah Experience Bagamoya Wildlife Estate Oliewenhuis Art Gallery Anglo Boer War Museum Loch Logan Waterfront Langenhovenpark Boeremark Rietvlei Nature Reserve Camdeboo Day Spa Hazel Food Market Irene Village Theatre Voortrekker Monument Brainwaves Escape Rooms Groenkloof Nature Reserve Viva Safaris Emperors Palace East Rand Flea Market Elandsvlei Ebotse Golf and Country Estate Grootval Wetland Reserve Greater St Lucia Wetland Park (GSWP) GSWP Marine Reserve Hluhluwe-Imfolozi Game Reserve Mkuze Game Reserve Tembe Elephant Park Ndumu Game Reserve Cumberland Nature Reserve Sanctuary KZN Museum Wylie Park Pietermaritzburg Worlds View
Irene	25.8812° S, 28.2263° E	1,454	17	717	
O.R. Tambo International Airport	26.1345° S, 28.2264° E	1,694	16.5	688	
Makhathini Research Station	27.3953° S, 32.1764° E	73	21	450	
Cedara	29.5339° S, 30.2733° E	1,053	16.7	1100	

(Continued)

Table 1. (Continued).

Location	GPS coordinates	Altitude (m.asl)	Mean annual temperature (°C)	Mean total annual rainfall (mm)	Tourist attractions
King Shaka International Airport	29.6100° S, 31.1169° E	93	20.4	502	uShaka Marine World Beach Bush Berg Safaris and Dives Umhlanga Main Beach Gateway Theatre of Shopping Thompson's Bay Beach Whalebone Pier Crocodile Creek Zimballi Golf Course Tala Game Reserve Natal Lion Park Sani Pass
Shaleburn/Underberg	29.7929° S, 29.4918° E	1,557	12.6	1430	Drakensberg Pillar Cave Nelson Mandela Capture Site Fort Dunford Museum Wagendrift Nature Reserve Weenen Nature Reserve Albert falls Dam Nature Reserve Bloukrans Monument
Estcourt	29.0124° S, 29.8642° E	1,196	22.9	106.9	Midlands Birding Route Polokwane Game Reserve Meropa Casino Bird and Reptile Park
Polokwane	23.8962° S, 29.4486° E	1,310	18.7	435	Bakone Malapa Museum Mokopane Biodiversity Centre
Thohoyandou	22.8785° S, 30.4818° E	702	22.6	818	Lake Fundudzi Phiphidi Falls Sagole Big tree Tshatshingo Potholes Mapungubwe National Park Punda Maria Gate
Ermelo	26.5124° S, 29.9856° E	1,700	22.4	523	Nooitgedacht Dam Nature Reserve Ermelo Golf Club Songimvelo Game Reserve The Giant Footprint Nelshoogte Pass

(Continued)

Table 1. (Continued).

Location	GPS coordinates	Altitude (m.asl)	Mean annual temperature (°C)	Mean total annual rainfall (mm)	Tourist attractions
Mafikeng	25.8560° S, 25.6403° E	1,500	18.5	546	Mafikeng Museum Mafikeng Game Reserve Botsalano Game Reserve Madikwe Game Reserve Mmabatho Palms Hotel Casino Convention Resort Calvinia Museum Hantam Dutch Reformed Church Akkerendam Nature Reserve Tankwa Karoo National Park De Aar Solar Farm Doomkloof Nature reserve Karoo Gariep Conservancy Rolfontein Nature Reserve South African Large Telescope (SALT) Stargazing at Sterland The Big Hole McGregor Museum William Humphreys Art Gallery. Honoured Dead Memorial Mokala National Park Wildebeest Kuil Rock Art Centre Quiver Tree Forest Oorlogskloof Nature Reserve Vanrhyns Pass Hantam National Botanical Garden Nieuwoudtville Waterfall Nieuwoudtville Wild Flower Reserve Namaqua 4X4 Eco-trail Riemvasmaak Hot Springs Dassie Trail Augrabies Riemvasmaak MTB Route Klipspringer Hiking Trail
Calvinia	31.4832° S, 19.7830° E	970	17.1	135	
De Aar	30.6766° S, 24.0131° E	1,286	17.4	353	
Fraserburg	31.9149° S, 21.5134° E	1,385	23	112	
Kimberley	28.7282° S, 24.7499° E	1,184	18.6	435	
Nieuwoudtville	31.3746° S, 19.1107° E	720	23	105	
Pofadder	29.1252° S, 19.3954° E	992	27	43	

(Continued)

Table 1. (Continued).

Location	GPS coordinates	Altitude (masl)	Mean annual temperature (°C)	Mean total annual rainfall (mm)	Tourist attractions
Springbok	29.6655° S, 17.8880° E	950	17.1	167	Richtersveld National Park Namaqualand wildflower reserves Augrabies Waterfall Orbicule Hill South African Large Telescope (SALT) Blesfontein Farm Sutherland Planetarium Sutherland NG Kerk Sutherland Museum
Sutherland	32.4101° S, 20.6705° E	1,460	13.7	333	Kgalagadi Transfrontier Park Kij Kij Waterhole Aucherlonie Museum Augrabies Falls National Park Nossob 4x4 Eco Trail
Twee Rivieren	33.9531° S, 22.4806° E	888	22	250	Kgalagadi Transfrontier Park Orange River Cellars Kalahari-Oranje Museum Spitskop Nature Reserve Bezalel Wine and Brandy Estate
Upington	28.3953° S, 21.2368° E	835	21.2	221	Upington Slaghuis Tankwa Karoo National Park Akkerendam Nature Reserve Corbellel Houses
Vanwyksvlei	30.3325° S, 21.8092° E	957	19.6	19.4	Hantam National Botanical Garden Karoo Gariep Conservancy Karreijie Mense of the Karoo Meerkat Radio Telescope Kirstenbosch National Botanical Garden V&A Waterfront Two Oceans Aquarium Robben Island Cape of Good Hope Table Mountain National Park Lion's Head
Cape Town	33.9249° S, 18.4241° E	31	17.2	382	

(Continued)

Table 1. (Continued).

Location	GPS coordinates	Altitude (masl)	Mean annual temperature (°C)	Mean total annual rainfall (mm)	Tourist attractions
George	33.9881° S, 22.4530° E	225	16.7	608	Outeniqua Transport Museum
					Redberry Farm
					Outeniqua Power Van
					Garden Route Botanical Gardens
					Victoria Bay
Robertson	33.8021° S, 19.8875° E	192	19.7	405	Herold Wines
					Outeniqua Pass
					Marbrin Olive Farm
					Springfield Estate Winery
					De Wetshof Estate
Vredendal	31.6391° S, 18.5285° E	28	17.9	227	Owl's Rest Olive and Lavender Farm
					Van Loveren Family Cellar
					Graham Beck Robertson Estate
					Vijjoensdrift
					Cape Flower Route
					Stoumann's Wines
					Lutzville Vineyards
					Namaqua (Spruitdrift) Wines
					Strandfontein Beach
					Swart Tobie Trail
					Melkboomsdrift Boutique Wine

time period 2017–2021 was identified to facilitate comparability amongst the locations, in addition to the longest continuous data-set within each location. The full monthly and annual CCI scores for Twee Rivieren and Springbok could only be calculated for 10 years (2012–2022), 9 years for Cedara (2013–2021) and 5 years for Thohoyandou (2017–2022) as the sunshine hours were only recorded for those years. Bloemfontein did not have any wind data for the period 1990–2022 thus resulting in maximum ‘3’ scores from precipitation, minimum temperatures and maximum temperatures. King Shaka International Airport had the required meteorological data-set from 2009 to 2022 but sunshine hours were not recorded from January 2016 to January 2020 as well as missing minimum and maximum temperature data from January to September of 2022. The remaining 18 locations had at least 12 years of monthly CCI scores.

3.2. CCI calculation

To facilitate comparison with global results, the original formula developed by Ma et al. (2020) was applied to allow for comparability within the global North:

$$CCI = \begin{cases} 0.5TC + 0.5S \\ \text{Min}(CCI, 3) \text{ if } T_{\text{Min}} < 8^{\circ}\text{C, or } T_{\text{Max}} > 34^{\circ}\text{C,} \\ P > 10\text{mm, } W > 23\text{km/h} \end{cases} \quad (1)$$

where TC = thermal comfort is calculated using humidex; and S = daily sunshine hours, referring to the time between sunrise and sunset, minus hours of complete cloud cover.

Humidex is calculated by:

$$\text{Humidex} = (T_{\text{mean}} + \frac{5}{9} \times (6.112 \times 10^{\frac{7.5T_{\text{mean}}}{237.7 + T_{\text{mean}}}} \times \frac{H}{100} - 10)) \quad (2)$$

(Masterson & Richardson, 1979)

where T_{mean} = mean daily temperature and H = daily mean relative humidity.

The CCI applies maximum scores of ‘3’, classified as ‘unfavourable’ in any instance where threshold temperature, rainfall and wind are exceeded (Ma et al., 2020). The thresholds are set at: Minimum temperature ($T_{\text{min}} < 8^{\circ}\text{C}$), Maximum temperature ($T_{\text{max}} > 34^{\circ}\text{C}$), Precipitation ($p > 10\text{ mm}$) or Wind ($W > 23\text{ km/h}$) for the 24-h period. Therefore, as there was sufficient data for these thresholds to be calculated for all of the stations (as the thresholds did not include sunshine hours), these maximum scores of ‘3’ were assigned first. This allows for the calculation of the frequency of occurrences of the maximum score of ‘3’. Additionally, investigation into the causes of the maximum ‘3’ scores allow for further demonstrations of climatic suitability in the respective locations.

Where the CCI value calculated from sunshine hours and thermal comfort is < 3 , that score would remain. However, if any of the threshold conditions for unfavourable weather are exceeded and the value for sunshine hours and thermal comfort is > 3 , a value of 3 would replace this.

Thermal comfort and sunshine hours were each rated on a scale from 0 to 10 (Ma et al., 2020; Table 2), which was entered into the equation to determine the daily CCI scores ranging from 0 to 10.

Table 2. Weather variable-ranking scores (adapted from Ma et al., 2020).

Rating	Thermal Comfort (TC)	Sunshine Hours (S)
0	<2 >42	<4
1		
2		4–8
3	2–4	
4	5–8	7–9
5	9–12	
6	13–18	
7	17–20 35–42	
8	21–24	10–12
9	25–28	13–14
10	29–34	>14

Table 3. CCI classifications [adapted from Ma et al. (2020)].

Value	Category
0–3	Unfavourable
4–5	Acceptable
6–7	Good
8–10	Optimal

The overall CCI values were classified into categories from unfavourable (0) to optimal (10) for each location (Ma et al., 2020), quantifying the climate suitability of camping in South Africa (Table 3).

3.3. Data analysis

For the 22 stations which included all the requisite data, daily CCI scores were calculated and averaged to obtain monthly scores for each location for a common time period and for the longest period for which robust data exists, including the occurrences of maximum ‘3’ scores. These mean monthly CCI scores were then classified for their climatic suitability for camping tourism using Ma et al. (2020) thresholds (Table 3). Thereafter, the average monthly CCI scores were utilized to classify seasonality using Scott and McBoyle’s (2001) typologies: Optimal, Poor, Summer Peak, Winter Peak, Bimodal-shoulder Peaks and Dry Season Peak. Monthly CCI scores were then averaged to obtain mean annual scores for climatic suitability for each location.

4. Results

4.1. Unfavourable weather: incidence of maximum ‘3’ scores

The climatic conditions experienced over the study period were averaged for each location to illustrate climatic variability between the regions. The weather variables examined are those included for the thresholds, further informing the overall climatic unsuitability for camping.

Table 4. Average climate conditions for all 33 stations.

Location	Mean Max Temperature (°C)	Mean Min Temperature (°C)	Mean Precipitation (mm)	Mean Wind Speed (km/h)
Barkly East (1992–2022)	20.8	5.6	1.8	11.3
Mthatha (1990–2022)	24.7	11.5	1.9	10.9
Gqeberha (1990–2022)	22.6	12.9	1.6	19.4
East London (1990–2022)	23.5	14.5	2.3	16.9
Willowmore (1990–2022)	23.9	9.4	0.7	9.7
Bethlehem (1990–2022)	22.5	6.6	2.0	10.5
Bloemfontein (1990–20,220)	25.2	7.2	1.5	13.9
Irene (1990–2022)	24.5	11.4	1.9	11.5
O.R. Tambo International Airport (1990–2022)	22.5	10.2	2.0	14.0
Makhathini Research Station (1990–2022)	29.4	16.6	1.5	12.0
Cedara (1990–2022)	23.1	9.9	2.2	8.5
King Shaka International Airport (2009–2022)	25.1	16.5	2.4	13.8
Shaleburn/Underberg (1990–2022)	22.4	5.4	2.8	6.0
Estcourt (1990–2022)	24.6	10.1	2.1	4.9
Polokwane (1992–2022)	25.5	11.8	1.3	13.1
Thohoyandou (1996–2022)	27.7	14.9	2.3	8.9
Ermelo (1993–2022)	21.8	9.0	2.0	15.9
Mahikeng (1990–2022)	26.9	11.9	1.5	13.9
Calvinia (1990–2022)	24.8	8.5	0.5	15.7
De Aar (1990–2022)	25.0	9.8	0.9	17.3
Fraserburg (1990–2022)	24.2	7.5	0.5	12.0
Kimberley (1990–2022)	26.9	9.9	1.1	13.9
Nieuwoudtville (2003–2022)	25.1	8.1	0.9	9.7
Pofadder (1990–2022)	26.8	12.2	0.3	12.1
Springbok (1990–2022)	23.8	12.4	0.6	16.8
Sutherland (1990–2022)	21.1	3.3	0.7	11.3
Twee Rivieren (1990–2022)	31.0	11.3	0.8	4.9
Upington (1990–2022)	29.7	12.6	0.6	13.0
Vanwyksvlei (1990–2022)	27.8	10.3	0.5	11.4
Cape Town (1990–2022)	22.5	12.0	1.3	18.7
George (1990–2022)	21.8	11.7	1.8	12.4
Robertson (1990–2022)	25.3	11.1	0.9	8.0
Vredendal (1990–2022)	27.3	11.4	0.4	7.6

The mean climatic conditions illustrate the climatic variability between the regions over the study period. Barkly East, with the smallest average maximum temperature of 20.8°C and a minimum of 5.6°C, experiences relatively cool temperatures, while Twee Rivieren and Upington record the highest mean maximum temperatures at 31°C and 29.4°C, respectively (Table 4). Sutherland experienced the lowest average minimum temperature at 3.3°C, closely followed by Underberg at 5.4°C (Table 4). Precipitation levels vary across locations, with Pofadder having the smallest mean precipitation of 0.3 mm and Underberg experiencing the largest at 2.8 mm (Table 4). Calvinia, Fraserburg and Vanwyksvlei had an average rainfall of 0.5 mm (Table 4). Wind speeds also differ, with Twee Rivieren and Estcourt reporting the smallest mean wind speed of 4.9 km/h, whereas Gqeberha has the highest at 19.4 km/h (Table 4).

The assignment of maximum ‘3’ scores occurred for all 33 stations. Therefore, we first explore the proportion of days for which the maximum ‘unfavourable’ classification is calculated for the individual contributions of the threshold variables to the overall maximum ‘3’ scores.

Table 5. Number of days demonstrating extreme weather events variables attributing to maximum '3' scores.

Location	T _{max}	T _{min}	P	W	Days with more than 1 "unfavourable" factor	Number of maximum "3" days	Total number of days	Overall %
Barkley-East (1992–2022)	11 (0.14%)	6668 [88.9%]	621 (7.7%)	724 (8.3%)	518 (6.9%)	7504	11323	66.3
East London (1990–2022)	92 (3.4%)	525 (19.3%)	780 [28.7%]	1474 [54.3%]	153 (5.6%)	2716	12053	22.5
Gqeberha (1990–2022)	90 (1.7%)	1780 [34.4%]	553 [10.7%]	3255 [62.8%]	469 (9.1%)	5180	12053	43.0
Mthatha (1990–2022)	519 (12.3%)	3023 [71.5%]	680 [16.1%]	163 (3.9%)	152 (3.6%)	4229	12053	35.1
Willowmore (1990–2022)	829 (14.5%)	4554 [79.9%]	240 (4.2%)	249 (4.4%)	168 (2.9%)	5701	12053	47.3
Bethlehem (1990–2022)	15 (0.2%)	6166 (89%)	709 (10.2%)	232 (3.3%)	182 (2.6%)	6930	12053	57.5
Bloemfontein (1990–2022)	566 (8.1%)	5952 (85%)	515 (7.4%)	0 (0%)	30 (0.4%)	7003	12053	58.1
Irene (1990–2022)	50 (1.2%)	3221 (78.8%)	742 [18.1%]	143 (3.5%)	64 (1.6%)	4090	12053	33.9
O.R. Tambo International Airport (1990–2022)	2 (0.04%)	3697 (73%)	770 (15.2%)	595 [11.7%]	242 (4.8%)	5064	12053	42.0
Makhathini Research Station (1990–2022)	1777 (43)	583 (14.1%)	512 [12.4%]	1817 (44%)	533 (12.9%)	4130	12053	34.3
Cedara (1990–2022)	151 (3%)	4103 (80.9%)	762 (15%)	183 (3.6%)	125 (2.5%)	5069	12053	42.1
King Shaka International Airport (2009–2022)	29 (4.7%)	23 (3.8%)	288 (47.1%)	295 [48.2%]	23 (3.8%)	612	4792	12.8
Shaleburn/Underberg (1990–2022)	19 (0.3%)	6689 (88.2%)	977 [12.9%]	196 (2.6%)	296 (3.9%)	7584	12053	62.9
Estcourt (1990–2022)	276 (5.5%)	4005 (80.2%)	765 [15.3%]	0 (0%)	52 (1%)	4994	12053	41.4
Polokwane (1991–2022)	184 (4.7%)	2971 (76.7%)	440 [11.4%]	349 (9%)	68 (1.8%)	3876	11499	33.7
Thohoyandou (1996–2022)	872 (73.3%)	215 [18.1%]	111 (9.3%)	7 (0.6%)	14 (1.8%)	1190	9588	12.4
Ermelo (1993–2022)	1 (0.02%)	4139 (76.9)	696 (12.9%)	1102 [20.5%]	535 (9.9%)	5384	10898	49.4
Mahikeng (1990–2022)	755 (14.4%)	3284 [62.6%]	548 [10.5%]	885 [16.9%]	225 (4.3%)	5243	12053	43.5
Calvinia (1990–2022)	1065 (14.6%)	5509 [75.5%]	177 (1.6%)	1136 (15.6%)	560 (7.7%)	7292	12053	60.5
De Aar (1990–2022)	916 (13.3%)	4650 [67.5%]	327 (4.7%)	1781 (25.8%)	769 (11.2%)	6893	12053	57.2
Fraserburg (1990–2022)	812 (11.4%)	6051 [84.7%]	171 (2.4%)	413 (5.8%)	301 (4.2%)	7145	12053	59.3
Kimberley (1990–2022)	1602 (22.8%)	4451 [63.5%]	432 (6.2%)	1012 (14.4%)	465 (6.6%)	7013	12053	58.2
Niewoudtville (2003–2022)	759 (25.3%)	2210 [73.9%]	90 (3%)	14 (0.5%)	75 (2.5%)	2991	7305	41
Pofadder (1990–2022)	1963 (35.6%)	3195 [57.9%]	107 (1.9%)	426 (7.7%)	173 (3.1%)	5516	12053	45.8
Springbok (1990–2022)	604 (12.2%)	2725 [55.2%]	188 (3.8%)	1420 (28.8%)	588 (11.9%)	4937	12053	41
Sutherland (1990–2022)	79 (0.9%)	8823 (97.2%)	197 (2.2%)	523 (5.8%)	513 (5.7%)	9076	12053	75.3
Twee Rivieren (1990–2022)	4395 (51.4%)	4156 [48.6%]	179 (2.1%)	52 (0.6%)	229 (2.7%)	8553	12053	71
Upington (1990–2022)	3730 (48.8%)	3438 (45%)	218 (2.9%)	579 (7.6%)	304 (4%)	7640	12053	63.4
Vanwyksvlei (1990–2022)	2782 (35.9%)	4669 [60.2%]	180 (2.3%)	324 (4.2%)	195 (2.5%)	7758	12053	64.4

(Continued)

Table 5. (Continued).

Location	T _{max}	T _{min}	P	W	Days with more than 1 “unfavourable” factor	Number of maximum “3” days	Total number of days	Overall %
Cape Town (1990–2022)	125 (2.3%)(42.6%)	2304 (9%)(52.3%)	486 (9%)(52.3%)	2879 (6.7%)	363 (6.7%)	5406	12053	44.9
George (1990–2022)	128 (3.9%)(70.3%)	2333 (15.2%)(16.8%)	505 (5.8%)	556 (2.1%)	193 (5.8%)	3318	12053	27.5
Robertson (1990–2022)	976 (21%)(73%)	3388 (6.1%)(2%)	282 (2.1%)	91 (2.1%)	97 (2.1%)	4640	12053	38.5
Vredendal (1990–2022)	1692 (37.3%)(61.5%)	2786 (1.9%)(0.7%)	86 (0.7%)	32 (1.4%)	64 (1.4%)	4532	12053	37.6

Minimum temperature is observed as the dominant cause for the unfavourable conditions experienced in 24 locations (Table 5). Sutherland, located in the Northern Cape province, recorded the largest proportion of maximum ‘3’ scores attributable to minimum temperature with 8823 days (97.2%), and experienced the largest percentage of the overall maximum ‘3’ scores at 9076 days (75.3%; Table 5). The overall number of ‘unfavourable’ days for Barkly East, Bethlehem, Bloemfontein, Cedara, Underberg, Estcourt and Fraserburg are largely due to below-threshold minimum temperatures, with proportions ranging from 80.9% for Cedara to 89% for Bethlehem (Table 5). Twee Rivieren, located in the Northern Cape, received the second largest percentage of ‘unfavourable’ classifications at 8553 days (71%; Table 5). This outcome was primarily influenced by the occurrence of minimum and maximum temperatures, which accounted for 4156 days (48.6%) and 4395 days (51.4%), respectively (Table 5).

Tohoyandou, located in the Limpopo province, exhibits the largest proportion of maximum ‘3’ scores resulting from the maximum temperature having been exceeded, accounting for 872 days (73.3%) of the observed cases (Table 5). Other locations such as Upington, Makhathini Research Station, Vredendal, Vanwyksvlei and Pofadder also demonstrate notable percentages of extreme maximum temperature events, with values of 3730 days (48.8%), 1777 days (43%), 1692 days (37.3%), 2782 days (35.9%) and 1963 days (35.6%), respectively (Table 5). Maximum temperatures contribute less than 25% to the overall maximum ‘3’ scores of the other study locations (Table 5). For example, the maximum temperature only accounts for 128 days (3.9%) for George and 2 days (0.04%) for O.R. Tambo International Airport (Table 5).

The wind speed threshold has a limited impact on the output of maximum ‘3’ scores, with the exception of the coastal towns of Gqeberha and East London in the Eastern Cape, Cape Town in the Western Cape and King Shaka International Airport in KZN (Table 5). Wind speed contributes 295 days (48.2%) for King Shaka International Airport, 2879 days (52.3%) for Cape Town, 1474 days (54.3%) for East London and 3255 days (62.8%) for Gqeberha (Table 5). Estcourt demonstrated zero instances of wind speed exceeding the threshold (Table 5). A significant amount of intense precipitation was recorded in East London at 780 days (28.7%) and King Shaka International Airport at 288 days (47.1%), while the remaining regions experienced less than 20% of precipitation induced ‘unfavourable’ conditions (Table 5). For example, extreme rainfall was experienced 680 days (16.1%) in Mthatha and 240 days (4.2%) in Willowmore (Table 5).

The smallest proportion of maximum ‘3’ classifications are exhibited for King Shaka International Airport at 612 days (12.8%) and Thohoyandou at 1190 days (12.4%), despite demonstrating large proportions of individual unfavourable climatic events (Table 5). Alongside Sutherland, the proportion of ‘unfavourable’ days for Barkly East at 7504 days (66.3%) and Twee Rivieren at 8553 days (71%) distinguish them as the least climatically suitable locations (Table 5).

For all the locations, the occurrence of maximum ‘3’ scores resulted from exceeding the thresholds of more than one meteorological factor. Among these locations, Springbok and Makhathini Research Station have the largest proportion of combined extreme weather events at 588 days (11.9%) and 533 days (12.9%), respectively (Table 5). De Aar demonstrates the second largest percentage of combined extreme weather days at 769 days (11.2%; Table 5). The limited availability of wind speed data for Bloemfontein is a contributing factor to the relatively low occurrence of combined ‘unfavourable’ conditions (0.4%; Table 5).

4.2. Mean CCI scores

For the common time period and longest continuous meteorological datasets, the mean annual scores exist within the ‘unfavourable’ and ‘acceptable’ classification across the country (Figure 2). The average annual scores for the longest uninterrupted meteorological dataset for each location vary from 3.6 at Twee Rivieren to 5.3 at King Shaka International Airport. The mean annual scores of all the stations remain consistent, with minimal variation between the two time periods. In certain cases, no discernible difference is detected.

The cities of Gqeberha, Kimberley, Upington, Cape Town, George, Cedara, Thohoyandou and Bloemfontein have maintained the same ‘acceptable’ average annual scores over the specified time periods (Table 6). Twee Rivieren also maintained the same ‘unfavourable’ average annual score of 3.6 between the two time periods (Table 6). The remaining locations demonstrated a marginal variation of 0.1 in the average annual scores between their corresponding time intervals (Table 6). Furthermore, the 18 locations that encountered ‘unfavourable’ months still obtained acceptable classifications owing to the presence of mitigating variables such as coastal currents (Figure 1; Table 6). The occurrence of eight ‘unfavourable’ months for Sutherland resulted in ‘unfavourable’ annual scores for both time intervals (Table 6).

The average monthly scores for the study locations are restricted to the classifications of ‘unfavourable’, ‘acceptable’ and ‘good’, with no months classified as ‘optimal’ conditions for camping at any of the stations (Table 6). These monthly scores serve as crucial comparative metrics for identifying optimal time frames for campsite visitations and seasonal patterns, enabling us to assess and contrast the climatic suitability across stations. The mean monthly scores for 2017–2022 range from a low of 2.6 (‘unfavourable’) in August for Sutherland to a high of 6.2 (‘good’) in January and December for Springbok (Table 6). Similarly, the mean monthly scores, derived from the longest continuous meteorological dataset span from 2.4 (‘unfavourable’) for Sutherland in July to 7.2 (‘good’) in January for King Shaka International Airport (Table 6).

The classification of ‘unfavourable’ conditions is consistently observed across all locations, primarily concentrated in the shoulder and winter months, except for East

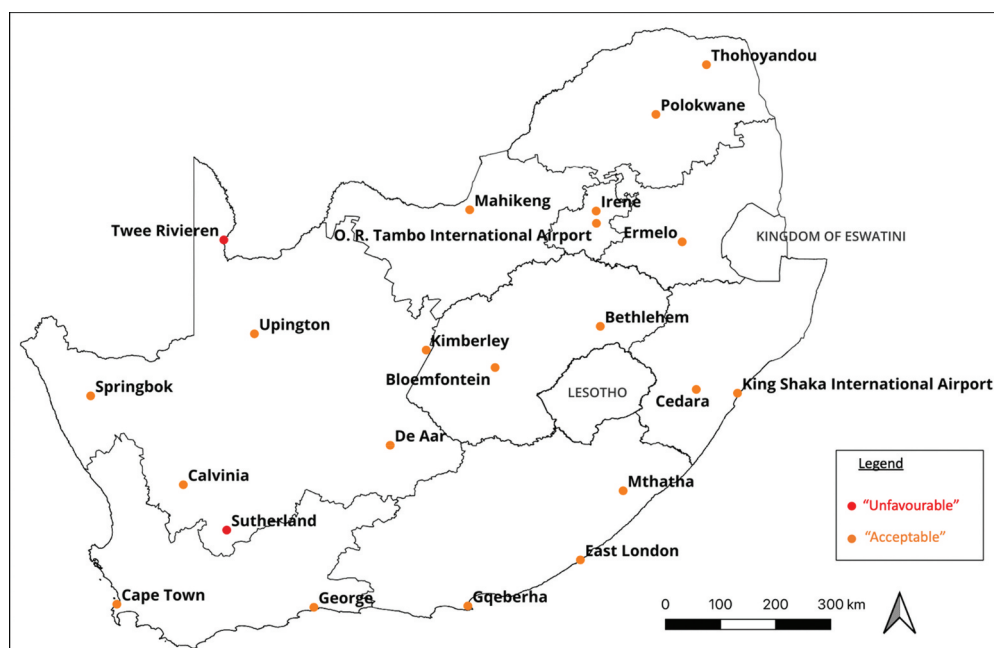


Figure 2. Map showing the mean annual CCI scores.

London and Cedara (Table 6). For instance, Sutherland experiences ‘unfavourable’ conditions from April (CCI = 3.2 and 3.4) to November (CCI = 3.5) in both time periods, with the lowest score occurring in July (CCI = 2.4; Table 6). Gqeberha experiences ‘unfavourable’ conditions between June and August for the longest dataset (CCI = 3.4–3.7), while King Shaka International Airport records ‘unfavourable’ conditions in October for the common time period (CCI = 3.0; Table 6). Mahikeng experiences ‘unfavourable’ conditions for 3 months of (CCI = 3.1 and 3.9) from June to August for the continuous dataset and 4 months (May–August) for 2017–2021 (Table 6). Bethlehem endures ‘unfavourable’ climatic conditions, with scores ranging from 2.8 to 3.9, spanning 6 months from April to September for both time intervals. However, it experiences ‘acceptable’ weather conditions (CCI = 4.2–5.7) from October to March (Table 6). Twee Rivieren stands out with the highest number of ‘unfavourable’ monthly classifications, totalling 11 months (CCI = 3.0–3.8; Table 6). Notably, this station only attains ‘acceptable’ scores (CCI = 4.7 and 4.8) during the month of April for both time intervals (Table 6).

East London and Cedara only experience ‘acceptable’ conditions throughout both time periods, rendering them the most suitable camping locations year-round (Table 6). Springbok has ‘good’ climatic conditions (CCI = 6.0–6.3) for 4 months, specifically from December to March (Table 6). Mahikeng maintains an ‘acceptable’ categorization, spanning 9 months (CCI = 4.1–5.9) for the period 1993–2022 and 8 months (CCI = 4.6–5.9) for 2017–2021 (Table 6). Locations within the same province tend to share similar CCI scores, exemplified by Calvinia, De Aar and Twee Rivieren observing ‘unfavourable’ classifications during the same months (May to September). Nevertheless, distinctions emerge in the climatic conditions across provinces, such as Polokwane and Irene both experiencing ‘good’ conditions in March (CCI = 6.1 and 6.0, respectively), while Thohoyandou and O.

Table 6. Mean monthly CCI scores for the period 2017–2021 and the longest continuous dataset for each location.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
East London	2017-2021	5.0	5.3	5.8	5.4	5.2	4.7	4.4	4.5	4.6	4.9	4.6	5.0	5.0
	1997-2022	5.2	5.4	5.6	5.3	5.0	4.4	4.2	4.5	4.6	4.5	4.6	5.4	4.9
Mthatha	2017-2021	5.1	5.1	5.1	4.9	4.1	3.2	3.2	3.4	4.1	4.6	4.7	5.1	4.4
	1996-2022	5.2	5.2	5.2	5.1	4.3	3.2	3.2	3.7	4.3	4.7	4.8	5.0	4.5
Gqeberha	2017-2021	4.7	4.7	5.3	4.9	4.3	3.8	3.5	3.6	4.0	4.4	4.4	5.5	4.4
	1992-2022	4.9	5.0	5.5	4.7	4.2	3.5	3.4	3.7	4.0	4.2	4.4	5.5	4.4
Sutherland	2017-2021	5.3	5.4	4.2	3.4	2.9	2.7	2.7	2.6	3.0	3.2	3.5	4.7	3.6
	1990-2022	5.2	5.2	4.1	3.2	2.8	2.5	2.4	2.6	2.9	3.2	3.5	4.8	3.5
Calvinia	2017-2021	5.6	5.3	5.4	4.9	3.8	3.2	3.2	2.9	3.4	3.8	4.9	5.8	4.4
	1990-2022	5.4	5.3	5.3	4.6	3.6	3.0	3.0	3.1	3.4	4.1	4.7	5.6	4.3
De Aar	2017-2021	5.2	5.6	5.9	5.1	3.9	3.1	3.0	3.2	4.1	4.3	5.0	5.0	4.5
	1993-2022	5.2	5.5	5.7	4.9	3.7	3.0	3.0	3.3	3.9	4.6	4.9	5.0	4.4
Twee Rivieren	2017-2021	3.6	3.7	3.6	4.7	3.7	3.1	3.0	3.2	3.6	3.8	3.7	3.6	3.6
	2012-2021	3.5	3.6	3.8	4.8	3.7	3.1	3.0	3.2	3.7	3.8	3.8	3.4	3.6
Springbok	2017-2021	6.2	6.0	6.1	5.8	5.0	3.8	3.7	3.8	4.2	4.7	5.8	6.2	5.1
	2012-2022	6.1	6.0	6.0	5.7	4.9	3.6	3.5	3.8	4.1	4.9	5.6	6.3	5.0
Kimberly	2017-2021	4.4	5.5	5.5	4.7	3.5	3.0	3.0	3.2	3.7	4.2	4.7	4.5	4.2
	1993-2022	4.8	5.1	5.5	4.7	3.5	3.0	3.0	3.3	3.9	4.6	4.7	4.8	4.2
Upington	2017-2021	3.9	4.0	4.4	5.5	4.7	3.4	3.3	3.5	4.2	4.6	4.7	4.2	4.2
	1993-2022	3.9	3.9	4.7	5.4	4.3	3.3	3.3	3.5	4.1	4.7	4.6	4.1	4.2
Cape Town	2017-2021	4.9	5.0	5.6	5.1	4.3	3.5	3.3	3.4	3.9	4.6	4.6	5.8	4.5
	1993-2022	4.9	4.9	5.7	4.9	4.1	3.4	3.3	3.4	3.9	4.5	4.6	5.8	4.5
George	2017-2021	5.4	5.8	5.4	4.9	4.4	3.7	3.6	3.4	3.9	4.4	5.1	5.4	4.6
	1992-2022	5.6	5.7	5.4	4.9	4.3	3.5	3.4	3.5	3.9	4.5	5.0	5.5	4.6
Cedara	2017-2021	5.4	5.4	5.6	5.0	4.7	4.1	4.2	4.3	4.8	4.9	5.0	5.0	4.9
	2013-2021	5.5	5.6	5.5	5.0	4.7	4.2	4.1	4.4	4.7	4.9	5.0	5.3	4.9
King Shaka International Airport	2017-2021		6.0								3.0			
	2010-2018;2022	7.2	5.8		5.0	4.5	4.5	4.7	5.8	5.3	5.1	5.3	4.9	5.3
Polokwane	2017-2021	5.9	5.6	6.1	5.4	4.5	3.2	3.1	4.2	5.3	5.4	5.5	5.6	5.0
	1993-2022	5.9	5.9	5.8	5.4	4.3	3.1	3.1	3.8	5.1	5.3	5.3	5.6	4.9
Thohoyandou	2017-2021	4.6	5.1	5.7	5.5	4.9	3.8	3.5	4.4	4.9	4.7	4.5	4.2	4.7
	2017-2022	4.7	5.3	5.7	5.5	4.9	3.7	3.5	4.5	4.8	4.7	4.6	4.3	4.7
O.R. Tambo International Airport	2017-2021	5.5	5.0	5.5	4.9	4.2	3.4	3.4	4.1	5.0	5.2	5.1	5.3	4.7
	1990-2022	5.3	5.5	5.3	4.7	3.9	3.2	3.2	3.7	4.7	5.0	5.1	5.2	4.6
Irene	2017-2021	5.8	5.6	6.0	5.2	4.7	3.4	3.3	4.6	5.5	5.6	5.8	5.6	5.1
	1993-2022	5.6	5.9	5.7	5.2	4.1	3.2	3.1	4.0	5.3	5.5	5.5	5.6	4.9
Ermelo	2017-2021	5.3	5.2	5.4	4.6	3.4	2.9	2.9	3.2	4.1	4.4	4.7	4.8	4.2
	1994-2022	5.2	5.5	5.2	4.5	3.4	3.0	2.9	3.2	4.2	4.4	4.6	5.0	4.3
Mahikeng	2017-2021	5.3	5.7	5.9	5.5	3.8	3.1	3.1	3.9	4.8	4.8	4.6	5.2	4.6
	1993-2022	5.6	5.9	5.9	5.4	4.1	3.1	3.1	3.9	5.1	5.0	5.2	5.5	4.8
Bethlehem	2017-2021	5.7	5.4	5.2	3.9	3.0	2.9	2.9	2.9	3.4	4.3	5.3	5.3	4.2
	1990-2022	5.6	5.6	5.0	3.7	3.0	2.9	2.8	3.0	3.3	4.2	4.9	5.5	4.1
Bloemfontein	2017-2021	5.6	5.7	5.5	4.2	3.1	2.9	2.8	3.0	3.5	4.3	4.8	5.3	4.2
	1990-2022	5.4	5.7	5.3	3.9	3.0	2.8	2.8	3.0	3.4	4.5	5.0	5.5	4.2

Legend: Red = "Unfavourable"; Orange = "Acceptable"; Yellow = "Good"

Legend: Red = "Unfavourable; Orange = "Acceptable"; Yellow = "Good".

R. Tambo International Airport experience ‘acceptable’ and ‘unfavourable’ conditions (Table 6). These observations underscore the substantial climatic variability observed across provinces and the entire country (Table 6).

Scott and McBoyle (2001) argue that the tourism climate resources can be categorized into one of six annual tourism climate distributions of seasonality. The bimodal-shoulder peak distribution is observed for nine locations in this study (Figure 3). These locations have winter temperatures that are too cold to be considered suitable for tourism, but the temperatures and other climatic variables are more suitable during spring or autumn. All the locations that fall under this distributional category, are locations that are situated inland except for Cape Town, King Shaka International Airport, East London and Gqeberha (Figure 1). The inland locations experience far greater extreme temperature differences between winter and summer due to the effects of continentality, whilst the two coastal towns have climates influenced by the Warm Agulhas and Cold Benguela oceanic currents.

The summer-season peak distribution is observed for 13 stations (Figure 4). These locations observe ‘unfavourable’ conditions in winter months (Table 6). For example, Irene demonstrates ‘acceptable’ classifications from August to May (CCI = 4.0-5.9) and ‘unfavourable’ conditions occur in June and July (CCI = 3.1-3.4; Table 6). The low temperatures experienced during the winter months for Bethlehem and Bloemfontein results in the dominance of ‘unfavourable’ conditions for camping from April to September (Table 6).

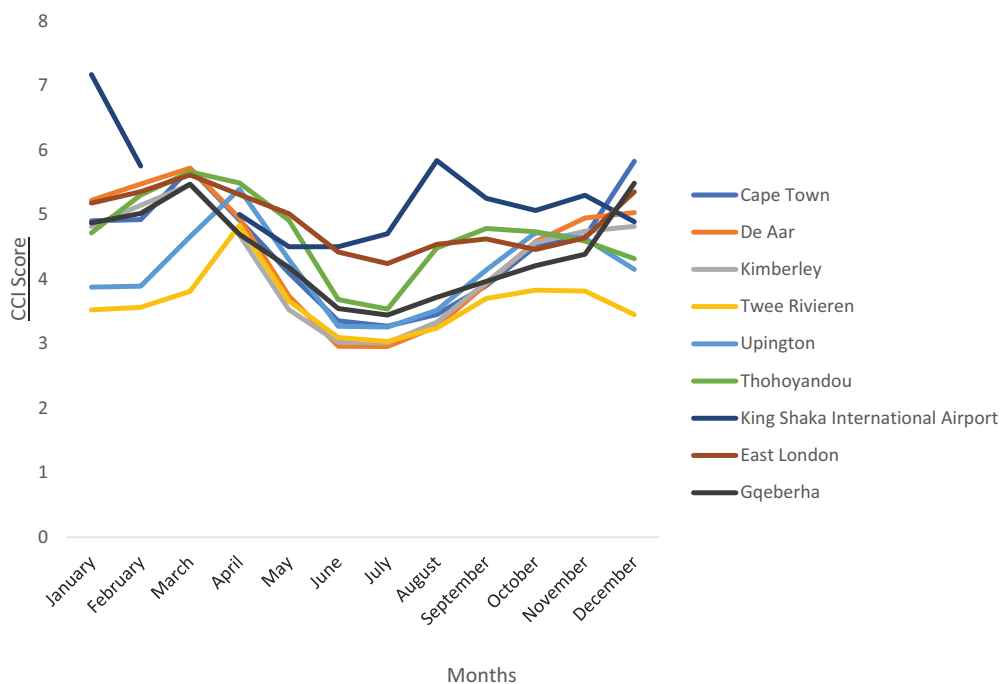


Figure 3. Locations that demonstrate a bimodal-shoulder peak distribution in mean monthly CCI scores.

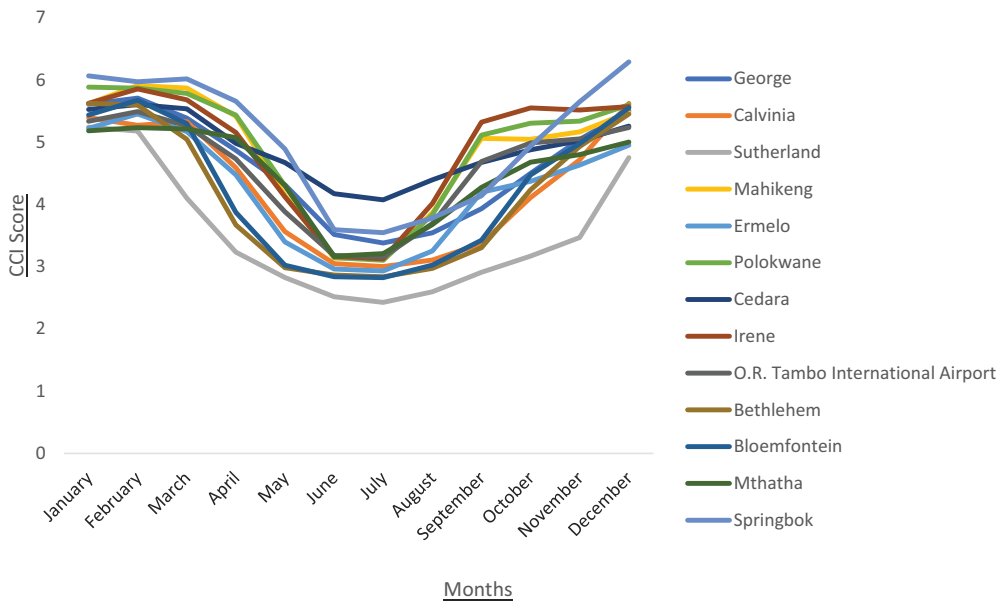


Figure 4. Locations that demonstrate a summer season peak distribution in mean monthly CCI scores.

5. Discussion

5.1. Climatic suitability for camping

The 'excellent' and 'ideal' categorizations obtained from mean annual TCI scores calculated revealed that the overall South African climate is a positive factor contributing to tourism, particularly outdoor activities aligning well with the country's marketing as 'sunny South Africa' (Fitchett & Hoogendoorn, 2019; Fitchett et al., 2017). Positive reflections on the climate can also be found in TripAdvisor reviews from tourists staying in hotels, guest-houses and backpackers (Fitchett & Hoogendoorn, 2019). However, when it comes to camping, the suitability of the climate is markedly lower, primarily due to the unique exposure of campers to the natural elements which are accounted for through the inclusion of threshold values for 'unsuitable' conditions in this index (Mikulic et al., 2017; Rogerson & Rogerson, 2020b; Van Heerden, 2020). The consideration of the threshold of maximum 'unfavourable' days is crucial in assessing the climatic suitability of a location for camping. In light of the analysis of maximum '3' scores, it is recommended that the threshold be set at 75%, as this level represents a significant proportion of 'unfavourable' climatic conditions that can largely alter the camping experience; the likelihood of encountering adverse weather events during camping activities is high when 75% of days are classified as 'unfavourable'. It is also important to note the climatic variability of locations and there may be situations where a camping destination falls into a cautionary range of 50–74%. While the climatic conditions may not be highly 'unfavourable' or represent extreme climatic events, they can still impact the camping experience. Locations such as Sutherland and Twee Rivieren experience large proportions of days classified by 'unfavourable' conditions and further highlight the need for these recommended thresholds. This information can help campers make informed decisions about the optimal time to visit

a region, particularly when the likelihood of encountering unfavourable conditions is reduced to a rating of '3' or lower.

The most common climatic factor that reduces the suitability for camping in South Africa is the minimum temperature (Table 5). Unlike hotels and other forms of permanent accommodation, campers have considerably less protection from the low temperatures at night (Ma, Craig, & Feng, 2021,c). The data reveals that stations such as Bethlehem, Bloemfontein, Calvinia, De Aar, Kimberley, Ermelo and George experience significant percentages of 'unfavourable' days due to their minimum temperatures (Table 5). Tents, which are dominantly used for camping in South Africa, offer limited insulation against the cold, and campers heavily rely on sleeping bags for warmth (Cena et al., 2003). By contrast, traditional forms of accommodation provide better insulation, bedding and heating options, making them less vulnerable to cold temperatures (Anand et al., 2017; Latha et al., 2015).

Another crucial adverse weather factor is maximum temperature, especially in locations such as Upington, Makhathini Research Station, Vredendal, Vanwyksvlei and Pofadder (Table 5). The material of tents prevents them from effectively regulating temperature, and due to the lack of amenities such as air conditioning or fans, which are commonly found in hotels and guesthouses, it is difficult to reduce heat. Thus, campers are more susceptible to the heat on hot days, and tents can potentially trap heat, making camping less comfortable during extreme heatwaves. As noted by Collins and Kearns (2010), some holidaymakers may alternate between staying in hotels and campgrounds. This flexibility highlights that the challenges associated with camping, such as limited access to basic facilities and exposure to temperature extremes, are often a choice rather than necessity (Collins & Kearns, 2010; Rogerson & Rogerson, 2020a).

5.2. Adapting to adverse camping conditions

To adapt to adverse camping conditions, tourists have several options (Brooker & Joppe, 2013). First and foremost, they can choose to camp during the season that is most climatically suitable for camping for a particular destination (Hewer et al., 2015). For instance, if a location has an 'unfavourable' score during the shoulder or winter months due to cold minimum temperatures, tourists can plan their camping trips for the warmer months when the climate is more suitable. Conversely, locations with consistently high temperatures may be unsuitable for camping throughout the year such as Twee Rivieren, in which case tourists could explore other forms of accommodation if they are specifically interested in visiting Twee Rivieran, or find an alternate destination if camping is an important component of the trip. The calculation of CCI scores is therefore particularly important in determining the seasonality of camping and choice of destination (Ma et al., 2020).

Although campers appreciate the natural surroundings, modern camping seeks a balance between experiencing outdoor tourism and maintaining a level of comfort and convenience (Brooker & Joppe, 2013). Short-term campers usually travel on weekends or vacations which results in a periodic interaction with weather conditions (Brooker & Joppe, 2013; Rogerson & Rogerson, 2020a). However, more frequent or longer-term campers can invest in equipment and gear designed to mitigate the

challenges posed by extreme weather conditions (Craig & Ma, 2022). For cold minimum temperatures, sleeping bags with cold ratings can provide extra warmth. High wind speeds can be addressed by choosing camping sites that offer natural windbreaks or creating windbreaks using tents or other materials. To combat high maximum temperatures, campers can seek shade during the hottest parts of the day and use ventilation techniques such as portable fans to cool down their tents.

New trends in camping including glamping offer lodging choices with better facilities (Craig, 2020). These more permanent tented accommodation offerings can more easily and effectively provide conveniences like electricity, air conditioning, insulation and sheltered structures (J. M. Fitchett & Meyer, 2023; Ma et al., 2021). Most notable has been the emergence of 'Africamps', a tourism operation offering glamping in a range of locations across South Africa with permanent tents on stilts, with air conditioning, a jacuzzi and a pizza oven (Africamps, 2024). In addition to glamping, caravans remain used in South Africa as an alternative to tent-based camping (Rogerson & Rogerson, 2020b). Unlike countries such as the U.S.A. where recreational vehicle (RV) travel is common (Craig & Ma, 2022), and locations such as Spain where camper-vans have recently emerged as a key tourist offering (Mundet et al., 2023), these forms of camping are not common in South Africa.

With effective communication of the science, governments and tourism authorities can use CCI scores to promote the most suitable camping seasons for various regions and conveying these findings to campgrounds, national parks, tourism authorities and even to the campers themselves (Scott & Lemieux, 2010). The investment of infrastructure that addresses the challenges posed by adverse camping conditions, such as providing shaded camping areas or low-cost caravan structures for campers who prefer more comfortable accommodations can increase the tourists' satisfaction and revenue of the camping sector (Craig, 2020; Radovic et al., 2021). However, in communicating these results to a range of tourism operators and tourists, it is important to keep in mind the limitations inherent in any index as an approximation of the experiences of a diverse group of tourists, travelling from a wide range of climatic environments. Moreover, while this study does have a comparatively large number of meteorological stations for the terrestrial land area (Van Der Walt & Fitchett, 2022), not all of the weather stations are in close proximity to all campsites in the country. While ground-based meteorological data are more accurate than gridded-data for much of South Africa, continued improvements in this domain, coupled with enhanced satellite remote sensing capabilities, are likely to enhance the capacity to calculate campsite location-specific tourism climate index scores in South Africa and further afield across the African continent.

6. Conclusion

This study presents the first application of the CCI for 33 destinations in South Africa, with full calculations for 22 of these locations. The quantification of 'unfavourable' classifications reveals that Sutherland is climatically unsuitable whilst 11 locations fall under the recommended cautionary range. This study highlights the importance of the CCI as a tool to quantify the climatic suitability of camping tourism in South Africa and allows for the comparison of locations within South Africa and globally. The CCI scores are expected to decrease as 'unfavourable' conditions will become more prevalent, and all

the extreme weather variables will exceed the thresholds more frequently and affect the climatic suitability of camping in South Africa. The maximum '3' classifications will account for most of the scores, highlighting the necessary implementations of mitigation strategies including funding for climate science research (Overland et al., 2022). Although data limitations have the potential to hinder the calculations of CCI scores for many stations in developing countries, the use of gridded reanalysis data for the wider-scale investigation of the CCI for countries dependent on nature-based activities will facilitate the forecast of climate-related impacts and enhance climate change mitigation strategies within global tourism management.

Acknowledgments

The South African Weather Service is acknowledged for the provision of the climate data used in this study. JF receives funding from the University of the Witwatersrand Friedel Sellschop Grant.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the University of the Witwatersrand Friedel Sellschop Grant [JFTC022].

ORCID

Jennifer M. Fitchett  <http://orcid.org/0000-0002-0854-1720>

References

- Africamps. (2024). *Boutique glamping in South Africa*. Retrieved August 25, 2024, from. <https://africamps.com>
- Amelung, B., & Nicholls, S. (2014). Implications of climate change for tourism in Australia. *Tourism Management*, 41, 228–244. <https://doi.org/10.1016/j.tourman.2013.10.002>
- Anand, P., Deb, C., & Alur, R. (2017). A simplified tool for building layout design based on thermal comfort simulations. *Frontiers of Architectural Research*, 6(2), 218–230. <https://doi.org/10.1016/j.foar.2017.03.001>
- Bacsi, Z., & Szanati, A. (2021). Influence of national culture and environmental awareness on the demand for domestic camping tourism—a cross-country analysis among European countries. *Geografický časopis - Geographical Journal*, 73(2), 143–160. <https://doi.org/10.31577/geogrcas.2021.73.2.08>
- Boonzaaier, C. C., & Philip, L. (2010). Community-based tourism and its potential to improve living conditions among the hananwa of Blouberg (Limpopo Province), with particular reference to catering services during winter. *Journal of Family Ecology and Consumer Sciences / Tydskrif vir Gesinsekologie en Verbruikerswetenskappe*, 35(1). <https://doi.org/10.4314/jfec.v35i1.52914>
- Braun, K., Bar-Matthews, M., Ayalon, A., Zilberman, T., & Matthews, A. (2017). Rainfall isotopic variability at the intersection between the winter and summer rainfall regimes in coastal South

- Africa (Mossel Bay, Western Cape Province). *South African Journal of Geology*, 120(3), 323–340. <https://doi.org/10.25131/gssajg.120.3.323>
- Brooker, E., & Joppe, M. (2013). Trends in camping and outdoor hospitality—an International review. *Journal of Outdoor Recreation and Tourism*, 3-4, 1–6. <https://doi.org/10.1016/j.jort.2013.04.005>
- Brooker, E., & Joppe, M. (2014). A critical review of camping research and direction for future studies. *Journal of Vacation Marketing*, 20(4), 335–351. <https://doi.org/10.1177/1356766714532464>
- Cena, K., Davey, N., & Erlandson, T. (2003). Thermal comfort and clothing insulation of resting tent occupants at high altitude. *Applied Ergonomics*, 34(6), 543–550. [https://doi.org/10.1016/S0003-6870\(03\)00084-X](https://doi.org/10.1016/S0003-6870(03)00084-X)
- Chivandi, A., Samuel, O., & Muchie, M. (2020). African cultures as tourism innovative capability in South African tourism sector: A Gauteng province perspective. *Geojournal of Tourism and Geosites*, 30(2 supplement), 917–925. <https://doi.org/10.30892/gtg.302spl19-523>
- Cole, D. N. (2004). Impacts of hiking and camping on soils and vegetation: A review. In R. Buckley (Ed.), *Environmental impacts of ecotourism* (pp. 41–60). CABI Publishing.
- Collins, D., & Kearns, R. (2010). Pulling up the tent pegs?: The significance and changing status of coastal campgrounds in New Zealand. *Tourism Geographies*, 12(1), 53–76. <https://doi.org/10.1080/14616680903493647>
- Craig, C. A. (2019). The weather-proximity-cognition (WPC) framework: A camping, weather, and climate change case. *Tourism Management*, 75, 340–352. <https://doi.org/10.1016/j.tourman.2019.06.005>
- Craig, C. A. (2020). Camping, glamping, and coronavirus in the United States. *Annals of Tourism Research*, 89, 103071. <https://doi.org/10.1016/j.annals.2020.103071>
- Craig, C. A., & Ma, S. (2022). Weather and recreational vehicle camping businesses. *Annals of Tourism Research Empirical Insights*, 3(2), 100063. <https://doi.org/10.1016/j.annale.2022.100063>
- Craig, C. A., Ma, S., & Feng, S. (2023). Climate resources for camping: A resource-based theory perspective. *Tourism Management Perspectives*, 45, 101072. <https://doi.org/10.1016/j.tmp.2022.101072>
- Ferrante, M., Magno, G. L. L., & De Cantis, S. (2018). Measuring tourism seasonality across European countries. *Tourism Management*, 68, 220–235. <https://doi.org/10.1016/j.tourman.2018.03.015>
- Fitchett, J., & Hoogendoorn, G. (2018). An analysis of factors affecting tourists' accounts of weather in South Africa. *International Journal of Biometeorology*, 62(12), 2161–2172. <https://doi.org/10.1007/s00484-018-1617-0>
- Fitchett, J. M., Grant, B., & Hoogendoorn, G. (2016b). Climate change threats to two low-lying South African coastal towns: Risks and perceptions. *South African Journal of Science*, 112(5/6), 9. <https://doi.org/10.17159/sajs.2016/20150262>
- Fitchett, J. M., & Hoogendoorn, G. (2019). Exploring the climate sensitivity of tourists to South Africa through TripAdvisor reviews. *South African Geographical Journal*, 101(1), 91–109. <https://doi.org/10.1080/03736245.2018.1541022>
- Fitchett, J. M., Hoogendoorn, G., & Robinson, D. (2016a). Data challenges and solutions in the calculation of tourism climate index (TCI) scores in South Africa. *Tourism: An International Interdisciplinary Journal*, 64(4), 359–370.
- Fitchett, J. M., & Meyer, C. A. (2023). The applicability and suitability of the camping climate index for South Africa. *Journal of Outdoor Recreation and Tourism*, 42, 100619. <https://doi.org/10.1016/j.jort.2023.100619>
- Fitchett, J. M., Robinson, D., & Hoogendoorn, G. (2017). Climate suitability for tourism in South Africa. *Journal of Sustainable Tourism*, 25(6), 851–867. <https://doi.org/10.1080/09669582.2016.1251933>
- Giddy, J. K. (2016). Adventure tourism in South Africa: Challenges and prospects. *Tourism: An International Interdisciplinary Journal*, 64(4), 451–455.

- Giddy, J. K., Fitchett, J. M., & Hoogendoorn, G. (2017). Insight into American tourists' experiences with weather in South Africa. *Bulletin of Geography Socio-Economic Series*, 38(38), 57–72. <https://doi.org/10.1515/bog-2017-0034>
- Hewer, M. J., Scott, D., & Gough, W. A. (2015). Tourism climatology for camping: A case study of two Ontario parks (Canada). *Theoretical and Applied Climatology*, 121(3–4), 401–411. <https://doi.org/10.1007/s00704-014-1228-6>
- Hewer, M. J., Scott, D. J., & Gough, W. A. (2017). Differences in the importance of weather and weather-based decisions among campers in Ontario parks (Canada). *International Journal of Biometeorology*, 61(10), 1805–1818. <https://doi.org/10.1007/s00484-017-1364-7>
- Jawtusich, J. (2014). *Climate change and disaster risk guide: Which climate and disaster risks affect South African and how do they affect South Africa?* Retrieved January 16, 2015, from. http://www.brotfueralle.ch/fileadmin/deutsch/2_Entwicklungspolitik_allgemein/
- Jeuring, J. H. G. (2017). Weather perceptions, holiday satisfaction and perceived attractiveness of domestic vacationing in the Netherlands. *Tourism Management*, 61, 70–81. <https://doi.org/10.1016/j.tourman.2017.01.018>
- Latha, P. K., Darshana, Y., & Venugopal, V. (2015). Role of building material in thermal comfort in tropical climates—A review. *Journal of Building Engineering*, 3, 104–113. <https://doi.org/10.1016/j.jobe.2015.06.003>
- Lennard, C. (2019). Multi-scale drivers of the South African weather and climate. In J. Knight & C. M. Rogerson (Eds.), *The geography of South Africa* (pp. 81–89). Springer.
- Ma, S., Craig, C. A., & Feng, S. (2020). The camping climate index (CCI): The development, validation, and application of a camping-sector tourism climate index. *Tourism Management*, 80, 104105. <https://doi.org/10.1016/j.tourman.2020.104105>
- Ma, S., Craig, C. A., & Feng, S. (2021). Camping climate resources: The camping climate index in the United States. *Current Issues in Tourism*, 24(18), 2523–2531. <https://doi.org/10.1080/13683500.2020.1846503>
- Ma, S., Craig, C. A., Feng, S., & Liu, C. (2021). Climate resources at United States national parks: A tourism climate index approach. *Tourism Recreation Research*, 48(5), 710–724. <https://doi.org/10.1080/02508281.2021.1946652>
- Ma, S., Craig, C. A., Scott, D., & Feng, S. (2021). Global climate resources for camping and Nature-based tourism. *Tourism and Hospitality*, 2(4), 365–379. <https://doi.org/10.3390/tourhosp2040024>
- MapStudio. (2018). *Camp and caravan*. <https://www.mapstudio.co.za/product/camp-and-caravan/?srsltid=AfmBOoqZz7IbXx30enilTgQAjnsywJb-55YfWF76qOpfyT7yXo0sJDZD>
- Masterson, J. M., & Richardson, F. A. (1979). Humidex, a method of quantifying human discomfort due to excessive heat and humidity. *Environment Canada, Downsview*. http://ptaff.ca/humidex/?lang=en_CA
- Matthews, L., Scott, D., & Andrey, J. (2021). Development of a data-driven weather index for beach parks tourism. *International Journal of Biometeorology*, 65(5), 749–762. <https://doi.org/10.1007/s00484-019-01799-7>
- Meyer, F. D. (2021). An assessment of the impact of the tourism sector on regional economic development in Gauteng Province, South Africa. *Peripheral Territories, Tourism, and Regional Development*. <https://doi.org/10.5772/intechopen.95810>
- Mikulic, J., Prebezac, D., Seric, M., & Kresic, D. (2017). Campsite choice and the camping tourism experience: Investigating decisive campsite attributes using relevance- determinance analysis. *Tourism Management*, 59, 226–233. <https://doi.org/10.1016/j.tourman.2016.07.020>
- Mundet, L., Grijalvo, M., & Marin, J. (2023). Are camper travel lovers the New wave of tourism? A growing trend for destinations. *International Journal of Hospitality & Tourism Administration*, 25(5), 1–22. <https://doi.org/10.1080/15256480.2023.2175290>
- Nicholson, S. E. (2000). The nature of rainfall variability over Africa on time scales of decades to millenia. *Global and Planetary Change*, 26(1), 137–158. [https://doi.org/10.1016/S0921-8181\(00\)00040-0](https://doi.org/10.1016/S0921-8181(00)00040-0)
- Nyikana, S., Tichaawa, T. M., & Swart, K. (2014). Sport, tourism and mega-event impacts on host cities: A case study of the 2010 FIFA world cup in Port Elizabeth. *African Journal for Physical*,

- Health Education, Recreation & Dance*, 20(2:1), 548–556. <https://journals.co.za/doi/abs/10.10520/EJC155174>
- Overland, I., Fossum Sagbakken, H., Isataeva, A., Kolodzinskaia, G., Simpson, N. P., Trisos, C., & Vakulchuk, R. (2022). Funding flows for climate change research on Africa: Where do they come from and where do they go? *Climate and Development*, 14(8), 705–724. <https://doi.org/10.1080/17565529.2021.1976609>
- Radovic, T. C., Loncaric, D., & Bonifacic, J. C. (2021). Camping tourism experience, satisfaction and loyalty: An empirical study from Croatia. *Tourism in Southern and Eastern Europe*, 6, 817–834. <https://doi.org/10.20867/tosee.06.54>
- Ramaano, A. I. (2021). Potential for tourism to promote indigenous resources for community development in musina municipality, vhembe district, limpopo province, South Africa. *Forestry Economics Review*, 3(1), 53–78. <https://doi.org/10.1108/FER-02-2021-0006>
- Roffe, S. J., Fitchett, J. M., & Curtis, C. J. (2019). Classifying and mapping rainfall seasonality in South Africa: A review. *South African Geographical Journal*, 101(2), 158–174. <https://doi.org/10.1080/03736245.2019.1573151>
- Rogerson, C. M. (2015). Restructuring the geography of domestic tourism in South Africa. *Bulletin of Geography Socio-Economic Series*, 29(29), 119–135. <https://doi.org/10.1515/bog-2015-0029>
- Rogerson, C. M., & Rogerson, J. M. (2020a). Camping tourism: A review of recent international scholarship. *Geojournal of Tourism and Geosites*, 28(1), 349–359. <https://doi.org/10.30892/gtg.28127-474>
- Rogerson, C. M., & Rogerson, J. M. (2020b). Municipal caravan parks in South Africa: Geography, management and planning. *Bulletin of Geography Socio-Economic Series*, 49(49), 109–124. <https://doi.org/10.2478/bog-2020-0027>
- Saarinen, J., Fitchett, J. M., & Hoogendoorn, G. (2022). *Climate change and tourism in Southern Africa*. Routledge.
- Scott, D., & Lemieux, C. (2010). Weather and climate information for tourism. *Procedia Environmental Sciences*, 1, 146–183. <https://doi.org/10.1016/j.proenv.2010.09.011>
- Scott, D., & McBoyle, G. (2001). Using a modified “tourism climate index” to examine the implications of climate change for climate as a natural resource for tourism. In: A. Matzarakis & C. R. de Freitas (Eds.) *Proceedings of the First International Workshop on Climate, Tourism and Recreation*. (pp. 69–88). International Society of Biometeorology, Neos Marmaras, Halkidiki.
- Slabbert, E., & Du Plessis, E. (2013). Do socio-demographic factors influence the travel behaviour of visitors to nature-based tourism products in South Africa? *African Journal for Physical, Health Education, Recreation & Dance*, 19(3), 639–660. <https://journals.co.za/doi/10.10520/EJC142295>
- Todd, S. W., Hoffman, M. T., Henschel, J. R., Cardoso, A. W., Brooks, M., & Underhill, L. G. (2016). The potential impacts of fracking on biodiversity of the Karoo Basin, South Africa. In S. Esterhuysen & J. Glazewski (Eds.), *Hydraulic fracturing in the Karoo: Critical legal and environmental perspectives* (pp. 278–301). Juta Publishers, Cape Town.
- Tyson, P. D., & Preston-Whyte, R. A. (2000). *The atmosphere and weather of southern Africa* (2nd ed.). Oxford University Press Southern Africa. <https://doi.org/10.1002/joc.725>
- Utomo, S. R. S. P. (2021). Analysis of potential community-based camping attraction in Gambung Village, Mekarsari. *Journal of Tourism Sustainability*, 1(2), 95–101. <https://doi.org/10.35313/jtos.v1i2.18>
- Van Der Walt, A. J., & Fitchett, J. M. (2022). Extreme temperature events (ETEs) in South Africa: A review. *South African Geographical Journal*, 104(1), 70–88. <https://doi.org/10.1080/03736245.2021.1907219>
- Van Heerden, C. H. (2008). Leisure motorhoming: The case of the motorhome club of South Africa. *South African Journal for Research in Sport, Physical Education and Recreation*, 30(1), 125–136. <https://doi.org/10.4314/sajrs.v30i1.25988>
- Van Heerden, C. H. (2010). An exploratory analysis of leisure caravanning in the Kruger National Park in South Africa. *Innovative Marketing*, 6(1), 66–72.

- Van Heerden, C. H. (2020). Motivation and involvement in camping – A gender perspective. *African Journal of Hospitality, Tourism & Leisure*, 9(1), 1–14.
- Wong, J.-Y., Hsiung, M.-L., Lee, S.-J., & ChouHuang, C.-Y. (2021). The relationship between endurance involvement and travel behavior in camping and the moderating effect of place attachment. *Sustainability*, 13(9), 5016. <https://doi.org/10.3390/su13095016>