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Climate change threats to two low-lying South African coastal towns: Risks and perceptions

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Climate change poses a considerable threat to low-lying coastal towns. Possible risks include flooding induced by sea-level rise, increased discomfort from changes in temperature and precipitation, more frequent extreme events, biodiversity shifts, and water shortages. For coastal towns that attract many tourists, these threats can have far-reaching economic effects and may compromise the continued viability of the tourism sector. A growing number of studies are being published on the inter-relationship between climate change and tourism in the global North. As yet, little equivalent research has been conducted in developing countries with economically significant tourism sectors. This paper presents a mixed-method pilot study on two adjacent coastal towns, St Francis Bay and Cape St Francis, in the Eastern Cape Province of South Africa. We explored the climate change threats in this region, and perceptions of these threats within the tourism sector. The tourism climate index results showed that the towns are climatically well suited to tourism, but a decrease in these index scores between 1978 and 2014 suggests that climate change experienced in recent decades has detrimentally affected tourist comfort. A digital elevation model sea-level projection for the towns indicated a high risk of sea-level induced flooding by 2050, particularly for properties along the coastline. Interviews with tourism establishment respondents showed that people are aware of climate change threats, yet little adaptation is forthcoming. Rather the government is deemed responsible for adaptation, despite its limited capacity. A disjuncture therefore exists between the perceived severity of risk and the risk that is evident from scientific analyses. This gap results in poor planning for the costs associated with adaptation.

Introduction

The success of tourism in a particular location depends largely on climatic conditions.[1] Climate is commonly used as a descriptive factor when marketing destinations, and thus selection between locations often includes consideration of their relative climate suitability for preferred tourism activities.[2] Intra-annual patterns in temperature, cloud cover, wind, and rainfall influence the length and timing of peak tourist seasons.[3] Climate is also one of the factors that control the availability of activities, and it influences the overall tourist satisfaction with a destination.[4-6] Climate change is increasingly identified as a significant threat to tourism, because of the reliance of tourism on predictable contemporary climatic conditions and seasonality.[6,7] Climate change is likely to affect the seasonality of tourism, and may threaten the infrastructure and natural environment required to accommodate and entertain tourists.[8] Predictable and ameliorable weather is critical to the feasibility of outdoor activities.[9]

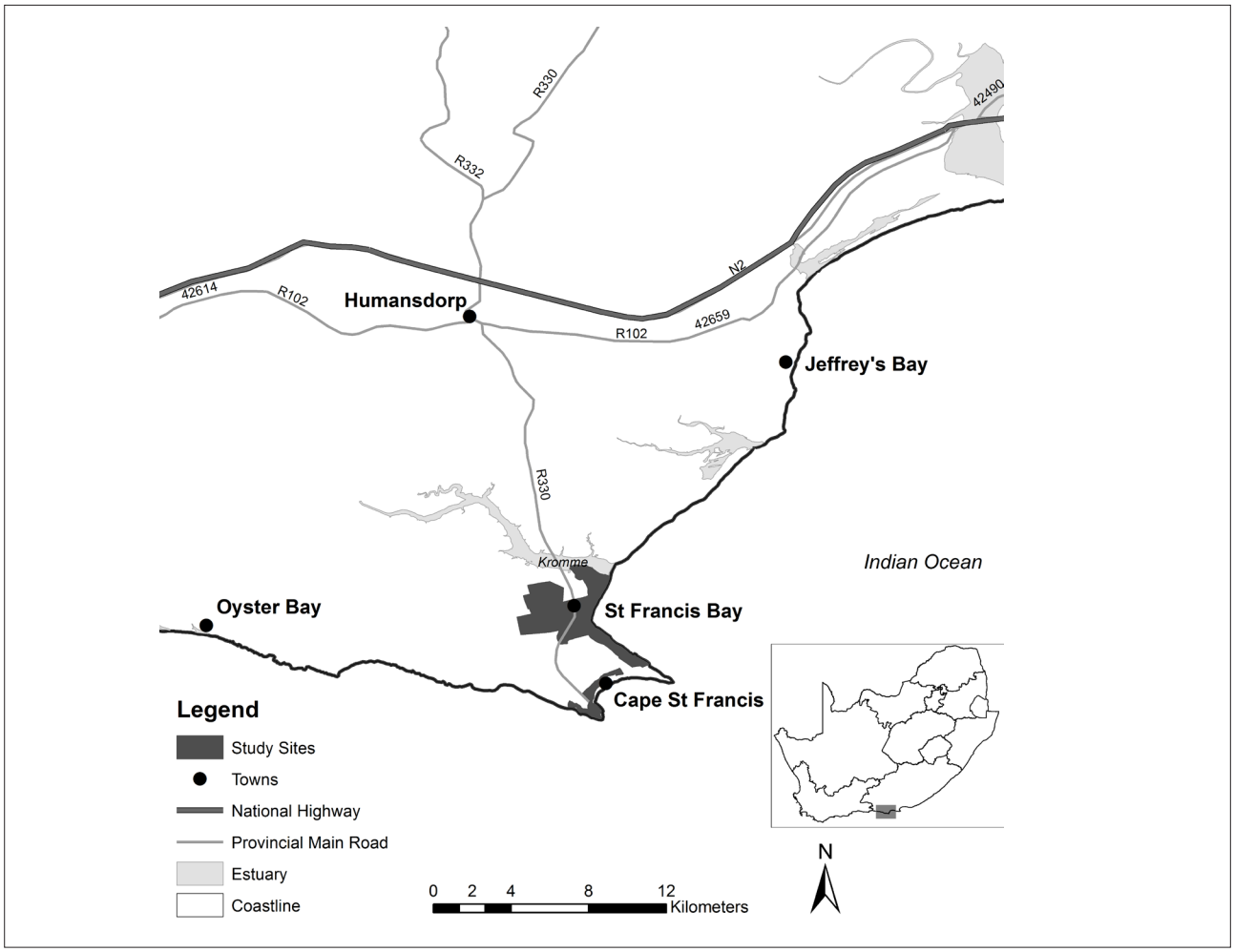
The increased variability in weather projected under climate change scenarios, together with associated risks of sea-level rise, render coastal destinations particularly vulnerable.[9] It is predicted that by 2050, the global tourism sector will experience substantial climate change impacts, with fluctuations in tourist numbers as tourists opt for better-suited locations.[10] The issue of climate change is therefore being integrated into sustainable tourism development initiatives and research.[11,12] To attain long-term sustainable development, the tourism sector must adapt to a range of projected climate change impacts.[13]

In the global South, a lack of integration between climate change and tourism research is of concern because it limits future adaptation potential.[14] 'Adaptation' can be defined for the purposes of this study as '…the ability of a unit (e.g. a tourism operator or a community) to transform its structure, operations or organisation to survive under changes threatening its existence and success'[15].

South Africa has a growing tourism sector, which contributes considerably to the local economy.[16] The country has a wide range of tourism attractions, many of which rely on the comparatively good climate of the region,[17] characterised by warm weather and clear skies. A large proportion of the sector involves beach and nature based tourism, which rely heavily on continued ameliorable climatic conditions.[18] In addition, South Africa has numerous small towns that are largely economically dependent on tourism. Although there is some variation in tourist offerings, many involve outdoor attractions – including beaches, game drives, water sports and fishing.[19]

South Africa is predicted to experience temperature increases as high as 4 °C by the year 2100, as well as changes in the timing, amount, and severity of precipitation; changes in wind direction and strength; and rising sea levels.[20,21] Given that tourists are highly mobile, even a few weeks of poor weather during the tourist season can affect the long-term viability of the sector in terms of destination attractiveness.[22] Information on climatic conditions is easily accessible for a range of possible tourist locations, both locally and internationally, and tourists inevitably select destinations that are relatively less risky in terms of the weather.[23] Climate change therefore has the potential to economically cripple tourist establishments and activities, as well as tourism-led towns – and indeed the South African tourism economy – if sufficient adaptation is not achieved.

It is insufficient to implement adaptation measures only after climate change impacts become evident; forward planning is essential.[24,25] Policy documents indicate that such planning and adaptation to climate change threats are not forthcoming in the study region. We explored these climate change threats and people's perceptions within the tourist sector regarding the level of risk, to determine the levels of preparedness. This study is of value in determining the likely impacts of climate change on the tourism sector in the study areas, and broader patterns of response in terms of climate change adaptation in the tourism sector regionally.



Source: Authors' map drawn for the study

Figure 1: Map indicating the location of study sites.

Study site

Our study examined two adjacent coastal towns, St Francis Bay and Cape St Francis, in the Eastern Cape Province of South Africa (Figure 1). These towns provide examples of tourism-reliant locations that face multiple climate change threats. Located on a gently sloping coastal plain, the towns are at risk of sea-level rise, which could encroach on the beach and eventually inundate much of the developed area. This area would include tourism establishments and roads and bridges, prohibiting access to the towns.[26,27] Changes in temperature, rainfall and wind are also of concern. Both towns provide predominantly outdoor tourist attractions and have distinct peak tourist seasons associated with warm temperatures and clear skies.[20] Additional concerns for these towns include the Kromme River Estuary and Canal, which pose flood risks, and the position of nearby sand dunes, which could result in dust storms.[20,27]

St Francis Bay covers a land area of 10.04 km^2 at an altitude ranging from 0 masl to 34 masl.[28] Cape St Francis comprises a smaller area of 4.38 km^2 at altitudes from 0 masl to 15 masl.[28] Census 2011 data give the population of St Francis Bay as 4933 people, and 342 in Cape St Francis.[29]

A series of canals and waterways, ideal for water sports, attracts tourists to St Francis Bay. A large number of holiday homes in both towns are rented out to tourists. Many are located along the canal system, an area of St Francis Bay commonly known as 'Little Venice'.[30] A nature reserve connects the two towns and provides a popular eco-tourism destination.[31]

The towns are situated in a zone that receives year-round rainfall, although more rain falls during the winter months.[32,33] Mean air temperatures range from 12.3 °C to 14.2 °C in winter and 18.9 °C to 20.8 °C in summer.[32,34] There is marked seasonality in wind trajectories. In winter, the wind blows from west to southwest, driven by the northward trajectory of the westerly belt, and in summer it blows easterly to southeast, when atmospheric circulation is dominated by the tropical easterlies.[33,35]

Methodology

We adopted an interdisciplinary mixed-method approach in this study. We wanted to determine the climate change risks to the towns, and to explore accommodation establishment proprietors' perceptions of those threats.

Climate change risks to the towns were classified on the basis of the towns' proximity to the sea and the reliance of tourism on ameliorable weather to encourage outdoor activities. The risk of sea-level rise was determined using a digital elevation model (DEM) with overlaid sea-level projections. The climatic suitability of the region for tourism was determined using the tourism climate index (TCI).

We probed the perceptions of accommodation establishment proprietors through individual face-to-face interviews in which open-ended questions were posed, and respondents were also asked to rank their concerns on a Likert-type scale. Qualitative data from these interviews were interpreted using thematic analysis. All respondents were presented with a consent letter before the interview commenced, indicating the purpose of the study and assuring them of confidentiality. The ethics requirements of the University of the Witwatersrand were adhered to prior to the commencement of this study.

Table 1: Components of tourism climate index (TCI)

Sub-index	Climatic variable	Influence on TCI	Weight (%)
Daytime Comfort Index (CID)	Maximum daily air temperature (°C) Minimum daily relative humidity (%)	Thermal comfort when maximum tourist activity occurs	40
Daily Comfort Index (CIA)	Mean daily air temperature (°C) Mean daily relative humidity (%)	Thermal comfort over 24-hour period including night time	10
Precipitation (R)	Total precipitation (mm)	A negative factor on overall experience	20
Sunshine (S)	Total hours of sunshine (hours)	A positive factor on overall experience	20
Wind (W)	Average wind speed (m/s)	Dependent on air temperature: evaporative cooling effect in hot climates; wind chill in cold climates	10

Source: after Perch-Nielsen et al.[48]

Digital elevation model

To model sea-level rise for St Francis Bay and Cape St Francis, and to plot regions likely to be affected by consequent flooding, a DEM for the region was created. The input data were acquired from Viewfinder Panoramas using the DEM World Coverage Map (2014). Raw data were acquired from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), an imaging instrument on board the Terra satellite.[36,37] ASTER Global DEM Version 2, produced at a 3 arc-second resolution (~90 m), was used.

To perform an initial sea-level rise vulnerability assessment, we used a simple inundation model known as the 'bathtub approach'.[38] This method maps land that is adjacent to the sea and is situated below a given elevation threshold to project inundated areas.[39] The mapping process uses a deterministic line to indicate inundation, relative to the sea-level rise and ground elevation.[40] This approach does not account for coastal dynamics including wind, waves or tide, and therefore excludes the heightened risk of storm surges.[40,41] However, it facilitates the visual identification of locations at highest risk for flooding directly from sea-level rise, and provides a projection of the 'best-case scenario'.

The inundation levels were created using the raster calculator function in the spatial analyst tool in ArcGIS®. Sea-level rise scenarios were projected for the years 2050 and 2100, using sea-level rise projections of 0.4 m for 2050 and 1.6 m for 2100,[42-45] based on an average rate of change of 0.3 mm/year along the south coast of South Africa.[46] This tested the Boolean statement at each cell of the DEM (interrogating whether the value within the cell was less than or equal to 0.4 m and 1.6 m, respectively).

Tourism climate index

The TCI is a numerical model that was developed to evaluate and compare tourist destinations, based on the suitability of their climates for tourists.[47,48] Daily climate data for the closest registered weather station, Port Elizabeth, were sourced from the South African Weather Service for the period 1978–2014 (the total period for which complete datasets were available).

To calculate the TCI, five main sub-indices were used, comprising seven climatic factors[47] (Table 1). These factors were each given a weighting (based on work by Perch-Nielsen et al.[48]) and each climate variable was rated.[48] We then used the standard TCI formula[47,48]:

$$TCI = 2(4CID + CIA + 2R + 2S + W) \quad \text{Equation 1}$$

Mean annual and mean monthly TCI scores were calculated for the period 1978–2014, based on mean climate variables. This calculation determined the long-term climatic suitability of the region, whilst accounting for inter-annual climate variability for the southwest Indian Ocean because of El Niño Southern Oscillation, Quasi-Biennial Oscillation, and the Indian Ocean Dipole.[49] In addition, changes in annual TCI scores were explored for the period 1978–2014 using linear regression, to detect progressive changes in the climatic suitability for tourism. The TCI scores were classified according to climate suitability (Table 2).

Table 2: Rating categories of the tourism climate index

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

Source: Mieczkowski[47]

Interviews

Semi-structured interviews with respondents, who were all tourism accommodation proprietors, were conducted in St Francis Bay and Cape St Francis. During the period of fieldwork, 57 establishments existed in St Francis Bay (Figure 2) and 31 in Cape St Francis (Figure 3).

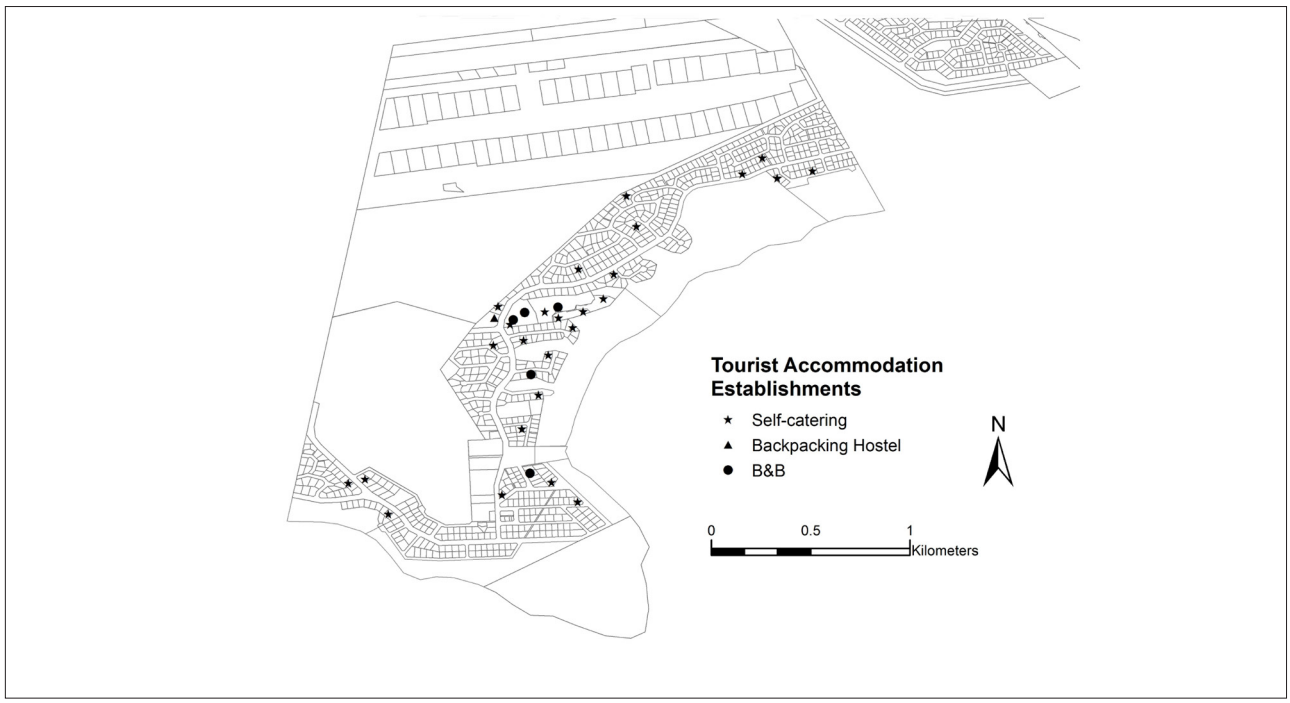
Among these 88 establishments, we interviewed 36 respondents in St Francis Bay and 17 respondents in Cape St Francis (a total of 53 people). Interviews were conducted during the off-season period of September 2014. The interview schedule included questions relating to the proprietors' understanding of climate change, their concerns regarding climate change risks to their establishments, their experiences of weather-related damage in recent years, and their climate change adaptation strategies. 'Perception' is defined in this study as 'the process of interpreting sensory information received through environmental stimuli and actions taken in responding to stimuli'[50].

Accommodation establishments were contacted telephonically prior to the interview to arrange a suitable time, and the interviews were later conducted in person. The interviews were transcribed and coded according to key themes. The frequency of the appearance of these key themes was then explored in relation to the geographic locations of each of the accommodation establishments, mapped using ArcGIS®.



Source: Authors' map drawn for the study

Figure 2: Map indicating the locations and types of tourism accommodation establishments in St Francis Bay.



Source: Authors' map drawn for the study

Figure 3: Map indicating the locations and types of accommodation establishments in Cape St Francis.

Results and analysis

Digital elevation model sea-level rise projection

Many accommodation establishments are situated at low elevations along the coastline. Sea-level rise is thus a particular concern for the towns we studied, both directly through the flooding of accommodation establishments and indirectly through damage to local infrastructure, which impedes access for tourists. The results of our DEM predict a considerable reduction of the beach area, with extensive coastal squeeze, by 2050, with the worst effect being predicted for the Sea Vista area of St Francis Bay (Figure 4).

Sea-level rise projected for 2050 is modelled to result in the permanent opening of the Kromme River Estuary, with a resultant increase in the salinity of the estuary and a heightened flood risk for the Kromme River. The artificial spit which currently protects the canal system from salt water incursion is projected to be inundated by 2050, compromising freshwater supply to the towns. By 2100, the DEM projects inundation of low-lying regions of the two towns, including areas in which tourism accommodation establishments are located. The Marina Glades area is projected to be at the highest risk area of inundation by 2100.

Our DEM projections indicate that the Santareme area of St Francis Bay has the lowest threat of inundation. Of direct relevance to the tourism accommodation establishments, despite the projected high risk for Sea Vista, only one establishment is located in that region. By contrast, Marina Glades has 12 establishments that may be affected; however, only two of these are at high risk as they are located near the spit.

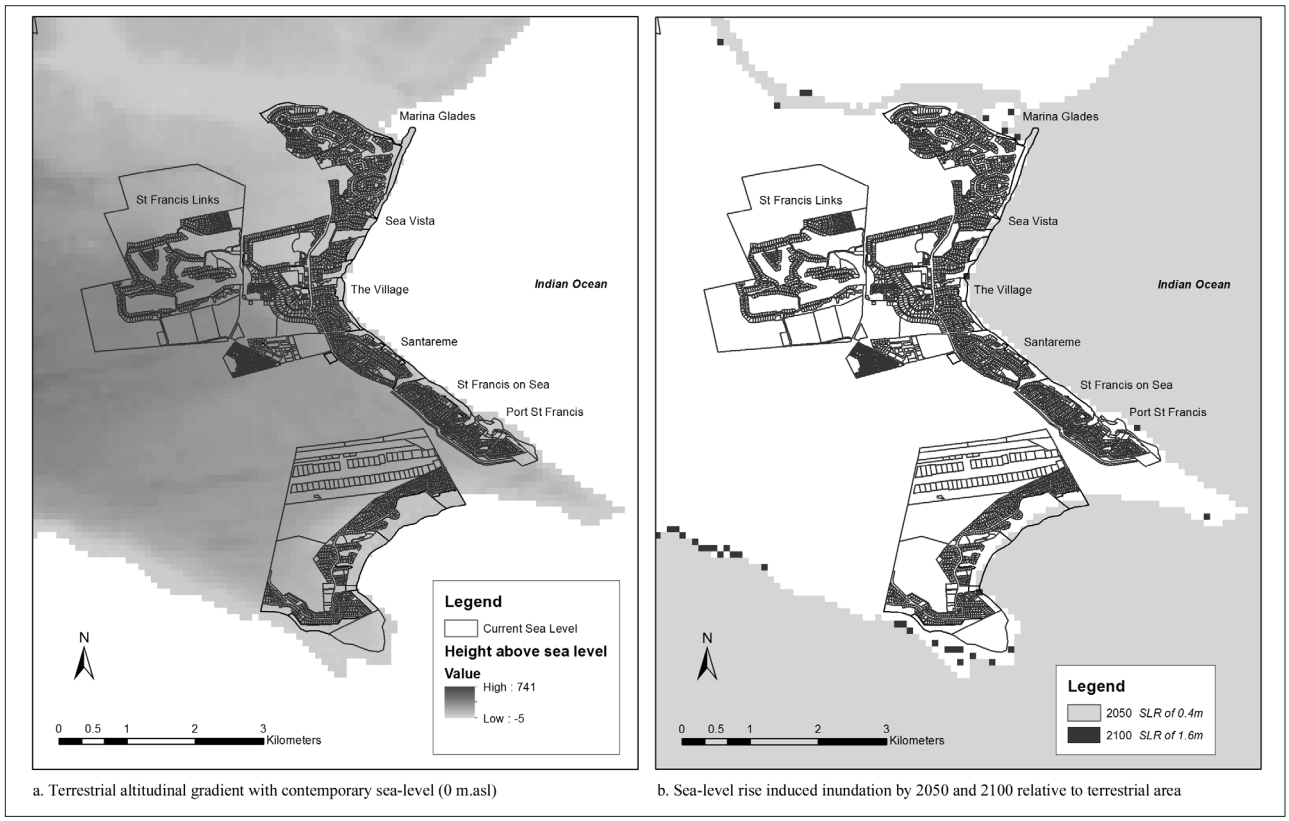
Cape St Francis is similarly projected to lose almost half of its beach area by 2050 owing to coastal squeeze. The town is situated relatively further inland, thus none of its accommodation establishments appear to be at risk under the 2050 sea-level rise projections. DEM sea-level projections for 2100 suggest partial inundation of the town, centred behind the Seal Point Headland. Three accommodation establishments are located behind this headland, and according to our projections are likely to be affected. Our DEM projections also indicated that by 2100 the beach will be completely inundated, which would remove the primary tourist attraction of the town. It would also heighten flood risk for the 11 beachfront accommodation establishments.

Sea-level rise additionally results in an increased risk of storm surges for low-lying areas.[25,51] Furthermore, climate change projections indicate changing wind patterns, and a southward trajectory of mid-latitude cyclones, both of which would further heighten the risk of storm surges.[20,49] Storm surges pose the greatest threat to coastal accommodation establishments, but severe events could also result in considerable damage to town infrastructure. Flooding related to storm surges has already resulted in considerable damage to St Francis Bay during 1996[26] and 2007[52]. Hence, our DEM projections likely provide an underestimate of the flooding potential for the region and can be regarded as a 'best-case' scenario.

Tourism climate index scores

The annual TCI scores that we calculated for the region over the period 1978–2014 ranged from 73 to 86. These scores represent 'very good' to 'ideal' climatic suitability for tourism, respectively. The long-term annual average TCI score for the period 1978–2014 was 80, categorised as 'excellent' (see Table 2). An identical score was obtained for the short-term average for the period 2009–2014.

The monthly TCI scores for the region, averaged between 1978 and 2014, peaked during the local summer months (December to February). This pattern is consistent with the accommodation establishments' recorded periods of peak tourist arrivals in the two towns (Figure 5). The pattern is notable from a climatic perspective, as the region is located within the year-round rainfall zone and is thus less likely to experience a unimodal distribution.[53] The variation does, however, occur within a small range of TCI scores, all categorised as either 'very good' or 'ideal'.



a. Terrestrial altitudinal gradient with contemporary sea-level (0 m.asl)

b. Sea-level rise induced inundation by 2050 and 2100 relative to terrestrial area

Figure 4: Digital elevation model illustrating predicted sea-level rise for both towns for the years 2050 and 2100. (a) Terrestrial altudinal gradient with contemporary sea level (0 masl) and (b) sea-level rise (SLR) induced inundation relative to terrestrial area.

At both the annual and monthly scales, the daytime comfort index (CID) and wind achieved consistently high scores. The CID reflects the maximum daily temperature and minimum daily relative humidity. Both these variables thus contributed positively to the high TCI scores, whereas the effects of rainfall and sunshine hours resulted in more moderate TCI scores (i.e. closer to the central tendency).

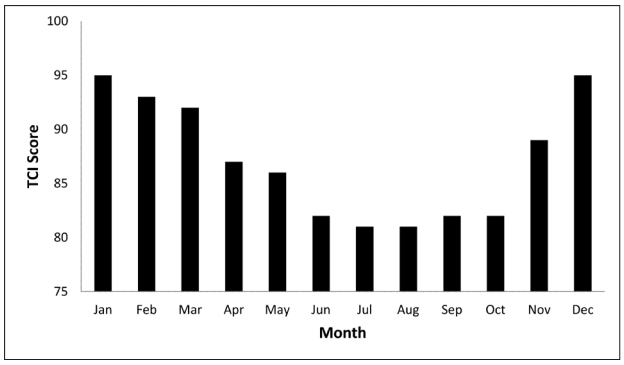


Figure 5: Mean monthly tourism climate index (TCI) scores for 1978–2014 for the region (St Francis Bay and Cape St Francis).

As evidenced by the equal TCI scores for the 35-year and 5-year calculation periods, there has been no considerable change in the climatic suitability of the region we studied. Over the period 1978–2014, the inter-annual variability in TCI score was more pronounced than any consistent long-term trend. Notably low TCI scores were evident for 1996, 2011 and 2012, and particularly high scores were evident in 1987 and 2013 (Figure 6). A weak trend towards lower TCI scores for the region, at a drop of 0.3 units per decade, was observed.

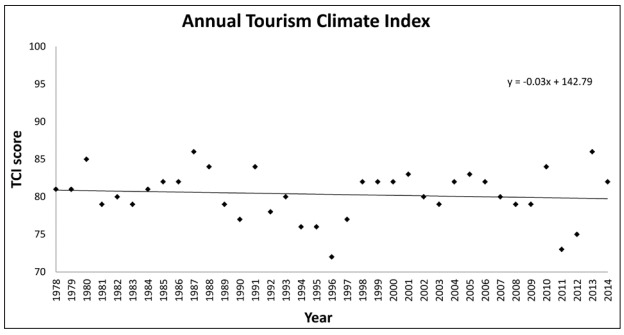


Figure 6: Mean annual TCI scores for 1978–2014, indicating long-term trend.

The climate suitability of the region for tourism is therefore not as great a threat as sea-level rise. However, the trend of a slow drop in TCI scores indicates the importance of continual monitoring of changes in meteorological variables in the region. This would help in making adaptation plans to address these changes before they detrimentally affect the region's ability to attract tourists.

Climate change perceptions

The interview data showed that 35 proprietors of tourism accommodation establishments believed that climate change was a cause for concern. Among all 53 respondents, 42 proprietors believed they were already experiencing the effects of climate change, and the remaining 11 felt these effects will be experienced only in 100 years' time. Respondents from establishments located closest to the coast showed more concern for climate change than those further inland.

Respondents from establishments situated along the Kromme River estuary and in the Marina Glades canal system had a medium to high level of concern regarding the threat of climate change. This finding was understandable given the risk of these water bodies flooding. Respondents whose establishments were relatively protected from possible coastal flooding reported fairly low levels of concern. They were situated at a higher altitude than the rest of the town, with large boulders along the beach which could provide defence against flooding. Thirteen respondents, with accommodation establishments scattered across the study area, did not believe that climate change would negatively affect their establishments.

More than half of the respondents (35) believed that climate change would negatively affect the towns themselves. Many of these respondents had been affected by or been within close proximity to the fires which had destroyed numerous houses on the canals in 2012. Some had also been affected by floods that occurred near the St Francis Links Golf Course in 2011. Owners of properties located close to the coast in Cape St Francis largely agreed that the town is vulnerable to the negative effects of climate change.

Fourteen respondents had experienced damage to infrastructure as a result of extreme weather events during the past 5 years. These events included a bridge in St Francis Bay being washed away four times within a 2-year period, compromising access to some of the tourism establishments. The establishments that had experienced flooding were located along the Marina Glades canal system and along the coast near the Santareme area of St Francis Bay. Cape St Francis respondents had also experienced flooding along the main road, which washed away the Sand River Bridge, hindering access to the town. Certain establishments had experienced direct problems from heavy rainfall, with water leaks causing damage to their accommodation rooms. The majority of respondents (44) felt that climate change would affect their establishments in the future. Most respondents mentioned flooding, with the threat of bridges being frequently washed away. This raised concerns about a loss of revenue.

Sea-level rise was perceived to be the largest threat for beachfront properties, with owners fearing flood damage or the infrastructure collapsing entirely if foundations become damaged. Beach erosion was mentioned, with respondents worried about coastal retreat. At the town level, concerns about infrastructure were centred on damage to roads. Overall, respondents said that the greatest impact of climate change would be a decrease in the number of guests and changes in reservation patterns. Concern was raised by respondents that climate change would lessen the ability of the towns to offer tourism activities, including fishing and hiking, which would reduce their competitive advantage relative to other coastal towns.

When asked who should be responsible for mitigating the negative effects of climate change, many respondents felt that government should be responsible for the future provision of climate change adaptation plans. They felt these plans should include the provision of information about climate change adaptation and covering the costs involved. They believed that the lack of information from local government was an indication of the minimal extent of climate change risks. A number of respondents were concerned about hotter, more humid weather, and had installed air-conditioning systems to make their establishments more comfortable for tourists under such conditions. The promotion of tourism during winter months or during adverse weather conditions was being pursued by some establishments, through increasing the range of indoor activities available, such as lounge areas with digital satellite television, DVD players, Wi-Fi, and a selection of books and board games.

Although respondents demonstrated a good understanding of climate change threats, they appeared to underestimate the severity. None of the respondents mentioned relocating their business in response to sea-level rise. Rather, sea-level rise was classified as a town-level issue, to be addressed by government through the use of sea defences, including *dolosse* (interlocking concrete blocks) in the port of St Francis Bay. Some respondents believed that the effects of climate change are distant, and that they would no longer be alive by the time such change occurs. Others believed that adaptations would only become necessary when climate change directly affects their businesses. This view was interesting to us, because of the regular flooding which participants said they have already experienced, with considerable damage to individual establishments. However, such opinions might be influenced by the high cost of infrastructural change, or a belief that insurance will pay for flood damage.

Discussion

Our research identified climate change threats and risks to coastal tourism, and compared this reality with the perceptions of proprietors of tourism accommodation establishments. We examined the vulnerability of the coastal area to climate change in the context of the broader tourism sector. Our DEM sea-level rise projections indicated considerable risk to beach attractions in both towns by 2050, and risk to the infrastructure and to accommodation establishments in the towns by 2100. Accommodation establishments located closest to the coastline or inland water are at the highest risk, although a combination of natural and man-made barriers protects certain properties within these areas.

The TCI results confirmed that the climate of the region is presently very well suited to tourism, particularly during the summer months. The small range of scores stems from the use of the international TCI model, which does not account for the relatively ideal climates throughout South Africa compared with much of the northern hemisphere. The greatest detriment to the TCI scores are rainfall and cloud cover, both of which predominate in the winter months. Notably, temperatures during winter do not detract from the TCI score. However, a weak downward trend in scores from 1978 to 2014 suggests that climate change might already be altering the climate suitability of the region for tourism. This trend is predominantly driven by changes in precipitation in the region over the 35-year period.

Although summer temperatures are currently within the bracket of climate suitability, continued increase would further detriment the TCI scores for the region if the comfort threshold is exceeded.[53] Because of the towns' proximity to the ocean, as well as warm water from the Agulhas current retroflection[54] and a large area of inland water,[55] such temperature increase would be associated with a proportional increase in humidity. This would further decrease the region's TCI scores.

Comparing the perceptions of respondents to the results of our TCI and DEM analyses, a low level of concern amongst respondents regarding sea-level rise is notable. Based on our findings and other studies,[24] we strongly recommend that accommodation establishment proprietors in St Francis Bay and Cape St Francis should consider implementing their own mitigation measures as a matter of urgency.

Little information on climate change adaptation plans for the study sites is available from the local municipality.[56,57] This lack of concern bodes ill for future adaption and mitigation, particularly given the perception by respondents that government is responsible for and will provide adaptation that is sufficient to protect the local tourism sector from the threat of climate change.[58,59]

Respondents were particularly concerned about changes to the environmental comfort of their patrons. This finding is interesting, as the DEM and TCI results indicate that sea-level poses a greater threat in a shorter time than changes in the climatic suitability of the region for tourism. Respondents acknowledged that sea-level rise may pose a threat, but they did not perceive the immediacy or extent of the problem – namely that their establishments could be severely damaged or entirely destroyed within the next 50 to 100 years.[60,61] Furthermore, many respondents said that in 50 to 100 years they will no longer be active in the tourism sector and therefore this is not an issue they will personally face.

Little consideration is made for the long-term sustainability of the tourism sector in the region. Respondents appear to be making cost–benefit assessments regarding the implementation of adaptation measures, by comparing the cost of specific forms of mitigation against the probability of a climate threat occurring, whilst considering additional benefits or detriments of such measures should the climate threat not be realised. They demonstrate willingness to adapt to changing meteorological conditions by installing air-conditioning to improve comfort during hot days, and satellite television and Wi-Fi to provide alternative activities on increasingly frequent rainy days. These climate events are more tangible than sea-level rise, given the recent occurrence of heat waves, cold fronts, and rainy days. Such adaptation measures also improve the amenities of establishments under any climatic conditions, which will afford visitors greater relaxation and business facilities. Finally, they are relatively low-cost adaptations. Therefore, the proprietor is likely to recoup the costs of such adaptation measures over a short period, with no harm should climate change not occur in the projected period.

Our study showed that the respondents were not yet investing in infrastructural changes to address flooding induced by sea-level rise. Although floods have occurred in the recent past, they were discrete events that are often assumed to be freak accidents rather than indicative of progressive change. Owing to substantial fluctuations in the return rates of flood events and the heightened variability under climate change, there is no certainty that a flood could occur the next year – or even in the next 10 years. Therefore, the cost outlay to make infrastructure changes might not be offset by a direct or immediate benefit.[25] Infrastructural changes, such as building retaining walls, are considerably more expensive than installing satellite television, with potentially no payback for the current proprietor. Furthermore, unlike satellite television and Wi-Fi, which contribute positively to the establishment under current conditions, infrastructural changes could negatively affect the amenities of an establishment by blocking sea views. Finally, as discussed above, many respondents said the government is responsible for infrastructural changes to prevent flooding induced by rising sea levels. Such action by the state would render personal retaining walls and other infrastructural adaptations unnecessary and would mean poor strategic spending by individuals.

Although such decisions can be understood from the perspective of proprietors' perceptions of the contemporary climate, they are not consistent with modelled climate change risks for the region. The results of our DEM sea-level rise projections indicate that sea water incursion, with further flood risk from storm surges, is likely to occur by 2050. This requires urgent action to improve infrastructure to adapt to the rising sea levels. Climate models for the region[20,21] and the results of our TCI time-trend analysis suggest that decreases in climatic suitability of the region will take longer to be detected by tourists, and thus require less urgent adaptation. Although the adaptation measures that the respondents are already implementing are relatively cheap and provide immediate additional benefits, they are not a substitute for infrastructural adaptation. They would be insufficient if an establishment is flooded, if the beach retreats, or if the arterial roads are flooded and this prevents tourist access.[24]

Conclusion

This research quantified the nature and extent of two predominant climate change threats and risks to the tourism sector in St Francis Bay and Cape St Francis. These main threats are sea-level rise and climatic suitability for tourism. Climatic suitability for tourism was explored over the historical period of the three most recent decades, using the TCI, with future trends inferred on the basis of climate forecasts. For sea-level rise, the threats were predicted using DEMs. The results showed that sea-level rise poses a serious threat to sustained tourism in the region, whereas a drop in the climatic suitability of the region is a less immediate concern.

Tourism accommodation establishments in the region have made small-scale adaptations to these threats, but these predominantly focus on climatic suitability. The reasons for this approach are the relatively low cost of such adaptations and the perception that government is responsible for larger-scale infrastructural changes to mitigate the negative effects of sea-level rise. Many respondents said they will not witness in person the future negative effects of climate change in the region. In addition, none appeared to be considering relocating because of any current risks or threats. Should mitigatory actions not be undertaken sufficiently by government and tourism accommodation establishments, the tourism sector in the region will likely be negatively affected. The current adaptation measures are inadequate to protect the beaches and prevent infrastructural damage. Over time, this will result in individual establishments losing their competitive advantage to regions with a lower flood risk or those with more robust and proactive adaptation plans.

South Africa has a varied climate and natural environment, attracting a range of tourists with a large spectrum of interests. The findings

of this pilot study provide initial insight into climate change risks and perceptions in low-lying coastal towns that rely heavily on beach and outdoor attractions. Although inland tourism destinations experience different climate change threats, the ambivalence of respondents to climate change threats in St Francis Bay and Cape St Francis might well be shared. In general, the sustainability of the tourism sector in South Africa relies on adequate and timely adaptation to climate change threats, so as not to lose tourists to destinations that become better climatically suited. Such adaptation requires an understanding of the nature and extent of climate change threats, and appropriate measures to protect individual establishments and towns. There is an urgent need for further studies in this line, especially given the dominance of the tourism sector in the South African economy. Our pilot study provides a valuable methodological framework for continued research.

Authors' contributions

J.F., B.G. and G.H. conducted the research. J.F and G.H. conceptualised the project and developed the experimental design. J.F. compiled and wrote the sections on the digital elevation model and tourism climate index methods and results, and compiled the first draft. G.H. wrote the section on perceptions. B.G. collected the raw data.

References

1. Hernandez AB, Ryan G. Coping with climate change in the tourism industry: A review and agenda for future research. Journal of Tourism and Hospitality Management. 2011;17(1):79–90.
2. Berritella M, Bigano A, Roson R, Tol RSJ. A general equilibrium analysis of climate change impacts on tourism. Tourism Management. 2006;27:913–924. http://dx.doi.org/10.1016/j.tourman.2005.05.002
3. Valls JF, Sarda, R. Tourism expert perceptions for evaluating climate change impacts on the Euro-Mediterranean tourism industry. Tourism Review. 2009;64(2):41–51. http://dx.doi.org/10.1108/16605370910963518
4. Becken S. Harmonizing climate change adaptation and mitigation: the case of tourist resorts in Fiji. Global Environmental Change. 2005;15(4):381–393. http://dx.doi.org/10.1016/j.gloenvcha.2005.08.001
5. Kyriakidis A, Felton J. Too hot to handle? The hospitality industry faces up to climate change. In: Blanke J, Chiesa T, editors. The Travel & Tourism Competitiveness Report. Geneva: World Economic Forum; 2008.
6. Gössling S, Scott D, Hall CM, Ceron JP, Dubois G. Consumer behaviour and demand response of tourists to climate change. Annals of Tourism Research. 2012;39(1):36–58. http://dx.doi.org/10.1016/j.annals.2011.11.002
7. Patterson T, Bastianoni S, Simpson M. Tourism and climate change: Two-way street, or vicious/virtuous circle? J Sustain Tour. 2006;14(4):339–348. http://dx.doi.org/10.2167/jost605.0
8. Moreno A. Climate change and tourism: Impacts and vulnerability in Coastal Europe [thesis]. Maastricht: Maastricht University; 2006.
9. Zaninović K, Matzarakis A. The bioclimatological leaflet as a means conveying climatological information to tourists and the tourism industry. Int J Biometeorol. 2009;53(4):369–374. http://dx.doi.org/10.1007/s00484-009-0219-2
10. Berritella M, Bigano A, Roson R, Tol RSJ. A general equilibrium analysis of climate change impacts on tourism. Working Papers 127. Hamburg: Centre for Marine and Atmospheric Science; 2004.
11. Williams PW, Ponsford IF. Confronting tourism's environmental paradox: Transitioning for sustainable tourism. Futures. 2009;41:396–404. http://dx.doi.org/10.1016/j.futures.2008.11.019
12. Hall CM, Amelung B, Cohen S, Eijgelaar E, Gössling S, Higham J, et al. On climate change skepticism and denial in tourism. J Sustain Tour. 2015;23(1):4–25. http://dx.doi.org/10.1080/09669582.2014.953544
13. Turton S, Hadwen W, Wilson R. The impacts of climate change on Australian tourism destinations: Developing adaptation and response strategies – a scoping study. Gold Coast: CRC for Sustainable Tourism; 2009.
14. Simpson MC, Gössling S, Scott D, Hall CM, Gladin E. Climate change adaptation and mitigation in the tourism sector: Frameworks, tools and practices. Paris: UNEP; 2008.
15. Kaján E, Saarinen J. Tourism, climate change and adaptation: A review. Curr Issues Tourism. 2013;16(2):167–195. http://dx.doi.org/10.1080/13683500.2013.774323
16. Rogerson CM. Reviewing Africa in the global tourism economy. Dev South Afr. 2007;24(3):361–379. http://dx.doi.org/10.1080/03768350701445350
17. Rogerson CM. The tourism-development nexus in sub-Saharan Africa – progress and prospects. African Insight. 2012;42(2):28–45.
18. Preston-Whyte RA, Watson HK. Nature tourism and climate change. Clevedon: Channel View Publications; 2005. p. 130–142.
19. Van Staden JW, Marais L. The tourism potential of Beaufort West: A study based on visitor demand. Dev South Afr. 2005;22(2):233–249. http://dx.doi.org/10.1080/03768350500163147
20. Theron AK, Rossouw M. Analysis of potential coastal zone climate change impacts and possible response options in the southern African region. Pretoria: CSIR; 2008.
21. Davis C. Climate change handbook for north-eastern South Africa. Pretoria: CSIR; 2010.
22. Saarinen J, Tervo K. Perceptions and adaptation strategies of the tourism industry to climate change: The case of Finnish nature-based tourism entrepreneurs. Int J Innovation and Sustainable Development. 2006;2(2):214–228. http://dx.doi.org/10.1504/IJISD.2006.012423
23. Saarinen J, Hambira WL, Atlhopheng J, Manwa H. Tourism industry reaction to climate change in Kgalagadi South District, Botswana. Dev South Afr. 2012;29(2):273–285. http://dx.doi.org/10.1080/0376835X.2012.675697
24. Kwadijk JCJ, Haasnoot M, Mulder JPM, Hoogvliet MMC, Jeuken ABM, Van Der Krogt RAA, et al. Using adaptation tipping points to prepare for climate change and sea-level rise: A case study from the Netherlands. WIREs Climate Change. 2010;1(5):729–740. http://dx.doi.org/10.1002/wcc.64
25. Nicholls RJ, Cazenave A. Sea-level rise and its impact on coastal zones. Science. 2010;382:1517–1520. http://dx.doi.org/10.1126/science.1185782
26. Illenberger WK. Nuclear power station ('nuclear 1') and associated infrastructure: Addendum to dune geomorphology impact assessment: Debris flows in the Sand River and potential for flood damage to the R330. Port Elizabeth: Arcus GIBB; 2010.
27. James N, Hermes J. Insights into impacts of climate change on the South African marine and coastal environment. Pretoria: SAEON; 2011.
28. Eliassen A. Saint Francis Bay, Eastern Cape (South Africa) [article on the Internet]. c2013 [cited 2014 March 7]. Available from: http://www.yr.no/place/South_Africa/Eastern_Cape/Saint_Francis_Bay/
29. Frith A. Census 2011 [article on the Internet]. c2014 [cited 2014 February 14]. Available from: http://census2011.adrianfrith.com/place/268011
30. Mortimer B. Little Venice in the Cape [article on the Internet]. c2014 [cited 2014 April 12]. Available from http://www.safricavoyage.com/stfrancis.htm
31. Elsden M, Rossoux S. Exploring South Africa: A coastal odyssey. Vol. 1. Pretoria: Modus Associates Limited; 2009.
32. Cowling RM. The occurrence of C3 and C4 grasses in fynbos and allied shrublands in the South Eastern Cape, South Africa. Oecologia. 1983;58:121–127. http://dx.doi.org/10.1007/BF00384551
33. Lubke RA. Erosion of the beach at St Francis Bay, Eastern Cape, South Africa. Biol Conserv. 1985;31:99–127. http://dx.doi.org/10.1016/0006-3207(85)90080-1
34. Buzter KW, Helgren DM. Late Cenozoic evolution of the Cape coast between Knysna and Cape St Francis, South Africa. Quaternary Res. 1972;2:143–169. http://dx.doi.org/10.1016/0033-5894(72)90035-X
35. Schumann EH, Martin JA. Climatological aspects of the coastal wind field at Cape Town, Port Elizabeth and Durban. S Afr Geogr J. 1991;73(2):48–51. http://dx.doi.org/10.1080/03736245.1991.9713548
36. J-Space Systems. ASTER GDEM [article on the Internet]. c2016 [cited 2016 May 25]. [First accessed 30 Oct 2014 from: http://gdem.ersdac.jspacesystems.or.jp/index.jsp] Available from: http://jspacesystems.or.jp/library/archives/ersdac/GDEM/E/index.html
37. National Aeronautics and Space Administration (NASA). ASTER [article on the Internet]. c2014 [cited 2014 September 21]. Available from: http://asterweb.jpl.nasa.gov/

38. Mcleod E, Poulter B, Hinkel J, Reyes E, Salma R. Sea-level rise impact models and environmental conservation: A review of models and their applications. Ocean Coast Manage. 2010;53(9):507–517. http://dx.doi.org/10.1016/j.ocecoaman.2010.06.009

39. Brunel C, Sabatier F. Potential influence of sea-level rise in controlling shoreline position on the French Mediterranean Coast. Geomorphology. 2009;107:47–57. http://dx.doi.org/10.1016/j.geomorph.2007.05.024

40. Schmidt K, Hadley B, Waters K. Mapping and portraying inundation uncertainty of bathtub-type models. J Coastal Res. 2013;30(3):548–561.

41. Levine NS, Kaufman CC, Sutherland M, Renaud L. Adapting HAZUS-MH to assess sea-level rise. Geological Society of America. 2008;40(6):84.

42. Stainforth DA, Allen MR, Tredger ER. Smith LA. Confidence, uncertainty and decision-support relevance in climate predictions. Phil Trans R Soc A. 2007;365(1857):2145–2161.

43. Breetzke T, Parak O, Cilliers L, Mather AA, Colenbrander D. Living with coastal erosion: A short term best practice guide. In: Proceedings of the International Association of Impact Assessors South Africa conference. Bloemfontein: University of the Free State; 2008.

44. Mather AA, Garland GG, Stretch DD. Southern African sea-levels: Corrections, influences and trends. Afr J Mar Sci. 2009;31(2):145–156. http://dx.doi.org/10.2989/AJMS.2009.31.2.3.875

45. Rouault M, Pohl B, Penven P. Coastal oceanic climate change and variability from 1982 to 2009 around South Africa. Afr J Mar Sci. 2010;32(2):237–246. http://dx.doi.org/10.2989/1814232X.2010.501563

46. Goschen WS, Schumann EH, Bernard KS, Bailey SE, Deyzel SHP. Upwelling and ocean structures off Algoa Bay and the south-east coast of South Africa. Afr J Mar Sci. 2012;34(4):525–536. http://dx.doi.org/10.2989/1814232X.2012.749810

47. Mieczkowski Z. The tourism climatic index: A method of evaluating world climates for tourism. Can Geogr. 1985;29(3):220–233. http://dx.doi.org/10.1111/j.1541-0064.1985.tb00365.x

48. Perch-Nielsen S, Amelung B, Knutti R. Future climate resources for tourism in Europe based on the daily tourism climatic index. Climatic Change. 2010;103(3–4):363–381. http://dx.doi.org/10.1007/s10584-009-9772-2

49. Fitchett JM, Grab SW. A 66-year tropical cyclone record for south-east Africa: Temporal trends in a global context. Int J Climatol. 2014;34(13):3604–3615. http://dx.doi.org/10.1002/joc.3932

50. Gössling S, Bredberg M, Randow A, Sandström E, Svensson P. Tourist perceptions of climate change: A study of international tourists in Zanzibar. Curr Issues Tourism. 2006;9(4–5):419–435. http://dx.doi.org/10.2167/cit265.0

51. Tandross M, Davis C, Engelbrecht F, Joubert A, Archer van Garderen E. Regional scenarios of future climate change over southern Africa. Pretoria: CSIR; 2011. http://dx.doi.org/10.1175/WCAS-D-11-00026.1

52. Thorpe H. Submission on Sand River bridge report. St. Francis Chronicle. 2014; p.10.

53. Roshan G, Yousefi R, Fitchett JM. Long-term trends in tourism climate index scores for 40 stations across Iran: The role of climate change and influence on tourism sustainability. Int J Biomet. 2015; http://dx.doi.org/10.1007/s00484-015-1003-0

54. Walker ND, Mey RD. Ocean/atmosphere heat fluxes within the Agulhas retroflection region. J Geophys Res. 1988;93(12):15473–15483. http://dx.doi.org/10.1029/JC093iC12p15473

55. Baird D, Heymans JJ. Assessment of ecosystem changes in response to freshwater inflow of the Kromme River Estuary, St. Francis Bay, South Africa: A network analysis approach. Water SA. 1996;22:307–318.

56. Carter A, McMaster A, Morris G, Whittington-Jones K, Constable L, Parramon M. Eastern Cape climate change response strategy. Eastern Cape: Department of Economic Development and Environmental Affairs; 2011.

57. Cartwright A. Coastal vulnerability in the context of climate change: A South African perspective. Cape Town: Centre for Criminology; 2011.

58. Mukheibir P, Ziervogel G. Developing a municipal adaptation plan (MAP) for climate change: The city of Cape Town. Environ Urban. 2007;19(1):143–158. http://dx.doi.org/10.1177/0956247807076912

59. Faling W, Tempelhoff JW, Van Niekerk D. Rhetoric or action: Are South African municipalities planning for climate change? Dev South Afr. 2006;29(2):241–257. http://dx.doi.org/10.1080/0376835X.2012.675695

60. Morton TA, Rabinovich A, Marshall D, Bretschneider P. The future that may (or may not) come: How framing changes responses to uncertainty in climate change communications. Global Environ Chang. 2011;21(1):103–109. http://dx.doi.org/10.1016/j.gloenvcha.2010.09.013

61. Miceli R, Sotgiu I, Settanni M. Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy. J Environ Psychol. 2008;28(2):164–173. http://dx.doi.org/10.1016/j.jenvp.2007.10.006



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