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Rising sea level and its implications on coastal tourism development in Cape Town, South Africa

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ABSTRACT

While there is agreement among tourism role-players on tourism's potential to contribute to socio-economic and environmental development, the industry is under severe threat from the increased impact of climate variability and change. This study examines the implications of rising sea level on coastal tourism in Cape Town, South Africa. Making use of mean sea level data from permanent sea level markers, remote sensing and field observations, supported by key informant interviews, the study found that coastal tourism is under threat from rising sea level. Current and projected rising sea level, as well as other extreme weather events such as the increased storm intensity trigger massive waves and tides that result in storm surges, which overtop and encroach into the land surface area. At least 80% of the city's 2019/2020 Blue Flag beaches are now under threat from rising sea level and coastal erosion. The study also found that some of the iconic tourist attractions such as the Cape Point, V&A Waterfront, Robben Island and several beaches along the False Bay area are under the same threat. Other tourism facilities under threat of weather extremes from climate change include servitudes, coastal roads, railway facilities and tidal pools: all threatening the attractiveness of some resorts.

Management implications: Rising sea level is a huge challenge that requires innovative solutions for the city of Cape Town. Given the threat that the industry is facing, there is a need for a public-private partnership aimed at ensuring that there are sufficient resources to help the tourism sector is capable of adapting to climate change. Increase insurance cover is a must to protect businesses from anticipated increased damage from rising sea levels and associated weather extreme events. Continued risk assessment is a must to ensure the industry is abreast with the continued changes which are threats to coastal tourism resorts and infrastructure.

1. Introduction

The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels warned that human beings had caused global temperature to increase by about 1 °C and that it was on course to reach the tipping point of 1.°C by 2030 if greenhouse gas (GHG) emissions are not drastically reduced (Intergovernmental Panel on Climate Change - IPCC, 2018). The increase in carbon emissions and consequent increase in temperature has been marked by a spike in extreme weather events inland and near coastal areas (WMO, 2020). Of note has been the most violent weather events experienced in the year 2019 characterised by extreme wildfires, droughts, floods and extreme rainfall across the world. The Southern Africa region was not spared either where two extremes in the form of a severe drought and two tropical cyclones, namely, Tropical Cyclone Idai and Tropical Cyclone Kenneth that affected almost every country in the region with severe implications on people's socio-economic livelihoods.

Such weather extremes have been blamed partly on the increase in anthropogenic GHG emissions. The WMO (2019:1) in 2018 noted that "high greenhouse gas concentrations reached new highs, with globally averaged mole fractions of carbon dioxide (CO2) at 407.8 ± 0.1 parts per million (ppm), methane (CH4) at 1869 ± 2 parts per billion (ppb) and nitrous oxide (N2O) at 331.1 ± 0.1 ppb. These values constitute, respectively, 147%, 259% and 123% of pre-industrial 1750 levels." Human-induced (anthropogenic) climate change has drastically changed ocean behaviour, resulting in rising sea levels and tidal waves that now threaten coastal communities.

In its Special Report on Oceans and Cryosphere (SROCC), the IPCC bemoans the impact of climate change on oceans and coastal

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communities (IPCC, 2019). While events in 2019 have highlighted and enabled the global communities to pay more attention to the worldwide climate crisis, in Africa, much is yet to be learnt with regards to how climate change will affect the tourism products (Hoogendoorn & Fitchett, 2018). To this end, there is a need for the continent to wake up, given that climate change impacts are site-specific, varying from place to place. The impact of climate change on most iconic tourism attractions is mainly unknown across Africa.

With regards to coastal tourism, Hall (2018) argued that "substantial knowledge gaps exist on the impact of climate change on coastal tourism with regards to specific locations". Some studies have pointed out to vulnerabilities of tourism in coastal areas to extreme drought (Dube, Nhamo, & Chikodzi, 2020) and flood risks (Fitchett et al., 2016). No empirical studies, however, have been conducted to ascertain the impact of sea level rise on tourism in Africa. To this end, this study sought to respond to this knowledge gap. The study raises the following research questions: (i) What has been the trend regarding rising sea level in Cape Town, South Africa? (ii) What has been the impact of such rising sea level and associated weather extremes on coastal tourism in Cape Town? (iii) What are the prospects of coastal tourism in Cape Town under the rising sea level?

2. Literature review

Regardless of the considerable knowledge gaps in recent years, there have been some advances in research, mainly by tourism geographers from South Africa such as Fitchett et al. (2016) and also Dube and Nhamo (2020a) who have written on the impact of tourism on national parks and other sectors of the tourism economy. Nonetheless, there remain some significant gaps in the region that is pinning its hopes on tourism to respond to most of the Sustainable Development Goals (SDGs) (Dube, 2020). Most of the empirical research emerging from southern Africa focuses on the impact of a few inland resorts such as the Victoria Falls (Dube & Nhamo 2018, 2019a), snow-based tourism (Hoogendoorn et al., 2020) the aviation sector in the region (Dube & Nhamo, 2019b), inland water-based attractions such as Kariba (Dube & Nhamo, 2020), Kruger National Park in South Africa (Dube & Nhamo, 2019c) and Serengeti National Parks (Kilungu et al., 2017). Other studies include the ones on mountain tourism such as Kilimanjaro Mountain (Kilungu et al., 2019). The perception studies have also been conducted to evaluate the impact of climate change on tourism in the southern African region, including one on the Okavango Delta (Dube et al., 2018), Hwange National Park in Zimbabwe (Mushawemhuka et al., 2018), Eastern Cape coastal communities (Fitchett et al., 2016) and the Kgalagadi South District (Saarinen et al., 2012) to name but a few. These studies point to clear sensitivity and vulnerability of the tourism sector, which requires adequate planning and response to ensure sector resilience for continued sustainability.

Regionally there are no empirical studies on how coastal tourism will play out in the face of increased vulnerability (Moreno & Becken, 2009). Perception studies conducted thus far; however, point to increased uneasiness about the impact of climate change on coastal tourism (Fitchett et al., 2016; Friedrich et al., 2020). Given the vulnerabilities of coastal areas to climate change, there has been an increased debate on how climate change will affect coastal areas (Dube, Nhamo, & Chikodzi, 2020), with a stifled discussion on how such changes will affect coastal tourism.

South Africa has more than 2850 km of coastline, which is home to 33 Blue Flag beaches as of 2019. The Blue Flag beach programme is an eco-label international accreditation awarded to beaches and marinas that comply with numerous criteria and standards that mostly focused on user safety and good environmental governance. Scott et al. (2012:883) observed that "Despite the high value of tourism properties and economic activity in the coastal zone, the tourism sector is largely absent from the Sea Level Rise literature." This is concerning, particularly for South Africa that has such a vast coastline. Studies, mainly those conducted in Cape Town, indicate that coastal areas in South Africa are vulnerable due to climate-induced rising sea levels, rising tides, coastal erosion and other related extreme weather events (Brundrit & Cartwright, 2012; Colenbrander et al., 2015; Colenbrander & Sowman, 2015). There is a clear case for an understanding of the vulnerability of coastal tourism and the extent thereof as tourism is one of the crucial economic activities in coastal tourism cities such as Cape Town (Dube, Nhamo, & Chikodzi, 2020).

Coastal areas play a crucial role in the tourism sector as they remain favourite spots for tourism. This is because they offer a wide array of activities that can be enjoyed by tourists, which in turn trigger coastal economic development of many developed and developing countries across the world (Moreno & Becken, 2009; Scott et al., 2012). Coastal tourism is also considered as a significantly growing segment of global tourism (Hall, 2011). Regardless of the significance of the size of coastal tourism, it is considered to be one of the tourism segments that are most vulnerable to extreme weather events, most of which are driven by climate change.

Given the popularity of the coastal areas for beach tourism and other aquatic activities, a lot of tourism infrastructure located along the coastline is at risk from the phenomenon of a coastal squeeze (Lithgow et al., 2019). According to Lithgow et al. (2019:43), coastal squeeze occurs when "there is a chronic loss of coastal habitats landward associated with long-term processes such as sea-level rise, land subsidence, sediment deficit and the occupation of space by infrastructure." Post the SROCC and the implications of the findings, and it is critical to revisit the debate on the impact of rising sea levels on coastal tourism that started as far back as 1987 (Gable, 1987). However, this has not attracted much-needed traction. Scott et al. (2012) lament this state of affairs, pointing out that there is a need to do much more and cited studies where such vital studies have been carried out. Buckley (2008:72–73) observed that "Most coastal tourism destinations seem to have remained remarkably blasé about rising sea levels, even though these are one of the best documented aspects of global change."

Although there has been some form of side-lining of empirical studies on the impact of climate change on coastal tourism and extreme weather events affecting coastal tourism, resorts have been witnessing increase damages over the years due to the increased pace of rising sea levels (Gössling et al., 2018; IPCC, 2019). The increase in sea level rise has been primarily due to global warming and polar ice melting (IPCC, 2019). Such changes, compounded with global change has been exerting a lot of pressure on coastal tourism economies across the world (López-Dóriga et al., 2019; Ruiz-Ramírez et al., 2019; Seekamp et al., 2019).

Vousdoukas et al. (2020), reported that a significant number of the world's sandy coastal sandy beaches were under severe threat from climate change-induced coastal erosion and sea level rise, with far reaching implications for coastal tourism. The study confirmed the findings made across the world, pointing to the fact that coastal destinations were disappearing. According to Jones and Phillips (2018), tourism development along the coastal line, which is synonymous with sun, sea and sand, was under severe threat from climate change. In Ghana, for example, Sagoe-Addy and Addo (2013) found that sea level was rising at a rate of 3.3 mm/year and a coastal erosion at 0.86 m/year, which resulted in the erosion of beaches and threatening many tourism accommodation establishments along the coastline. In the South Pacific, Kumar and Taylor (2015) reported coastal tourism infrastructure vulnerability due to rising sea level. In the Mediterranean region, several UNESCO World Heritage sites were also found to be at the risk of coastal flooding and erosion due to sea-level rise (Reimann et al., 2018).

Given the foregoing, the United Nations called for a Decade of Ocean Science for Sustainable Development (2021–2030). The call aims to champion efforts to reverse "the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework to ensure ocean science so as to fully support countries in creating improved conditions for sustainable development of the Oceans"

(United Nations, 2020). Given the understanding that climate change is one of the major threats to oceans and their contribution to SDG 14 on life below water (UN, 2015), there is need for the closing in of knowledge gaps that exist with regards to climate change impacts. Climate change impacts are unique to place and time as sea level rise is not uniform across the world. There is a risk some places will be left behind in adopting concrete measures to address their vulnerabilities if knowledge gaps are not addressed. The next section is dedicated to present the methods and materials used in generating and analysing data for the study.

3. Methods and materials

This study seeks to examine the implications of rising sea level on coastal tourism in Cape Town, South Africa. To this end, and in response to the research questions outlined earlier, the following objectives are spelt out: (i) To track the trend of rising sea level in the City of Cape Town, South Africa, (ii) To determine the impact of rising sea level and associated extreme weather events on coastal tourism and recreation in the City of Cape Town, and (iii) To consider the anticipated future of coastal tourism and recreation under climate change and offer some adaptation strategies that can be adopted by the industry. A mixed-method approach was utilised, where a number of data collecting tools were utilised to adequately answer various research questions that were raised earlier. The main data sources included the mean sea level data from permanent sea level markers, remote sensing and field observations. These were supported by key informant interviews (n = 30).

3.1. Site description

The study was conducted in selected coastal areas in the Western Cape province, with a focus on Cape Town beach resorts and bays (Fig. 1). The study also focused on many beaches that form part of the selected bays. During the past couple of years, the regions have witnessed several climate-related natural disasters, which include droughts, flooding and loss of biodiversity. Cape Town is arguably the tourism capital of South Africa and indeed Africa and offers several attractions and activities. The iconic features are not only limited to the famous Table Mountain, but also include its coastline and the Winelands that attract wine tourism. Cape Town alone is home to more than 10 of the country's 33 Blue Flag beaches. It boasts some of the most visited attractions in the country, with the leading attractions being the V&A Waterfront with about 24 million visitors a year, and the Table Mountain Aerial Cable Way with about 1.2 million users a year (Cape Town Tourism, 2018). The Table Mountain National Park is by far one of the most visited national parks in South Africa, if not in the entire Southern African Community (SADC), as it boasts about 3.5 million visitors annually (SANParks, 2018).

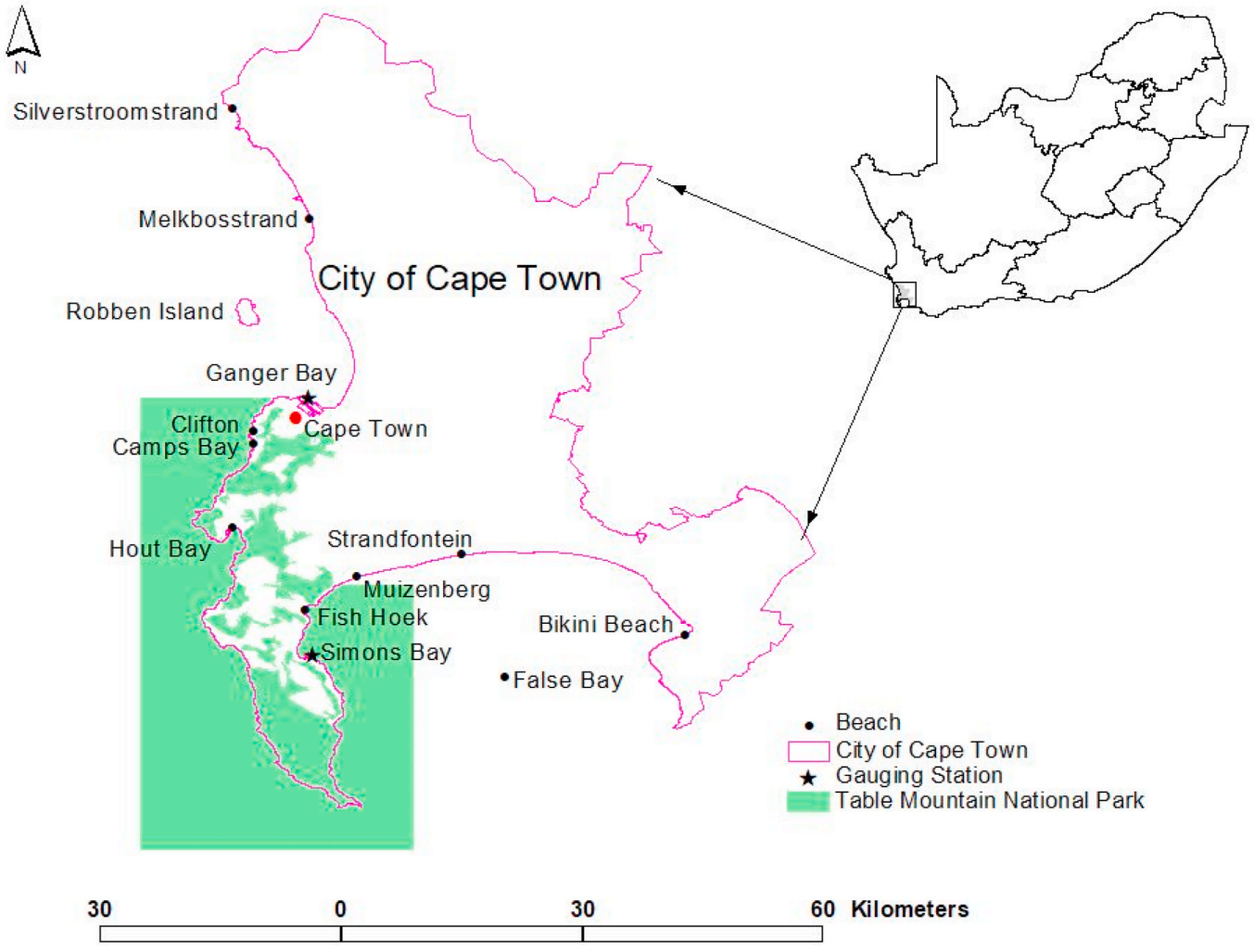

Fig. 1. Location of the study area
Source: Authors.

3.2. Data collection instruments and approach

An instrumental case study approach was utilised as it allowed for the understanding of rising sea level in Cape Town, which allowed for the refinement of theory around sea level rise as espoused by (Luck et al., 2007). The case study, which utilised a mixed-method approach allowed the authors to get an in-depth insight into the area that was under investigation (Yin, 2017). A case study approach also allowed for the use of various methodological tools that have their origins from both qualitative and quantitative research design approaches that allow for rigour and methodological and data triangulation (Creswell & Creswell, 2017). Results validation and trustworthiness was achieved by ensuring persistent observation, data triangulation, using various data sources and conducting the necessary statistical verifications as stated by Korstjens and Moser (2018).

As highlighted earlier, the primary data collection tools included annual mean sea level data from that was obtained from the National Oceanic and Atmospheric Administration (NOAA) Tides and Currents, remotely sensed data from Google Earth Pro and field observation. The three methods were used to investigate sea level trends and also to track the impact of rising sea level and other weather extremes on coastal tourism. The use of permanent sea level markers in tourism studies to track the trend of rising sea level is not new, as a similar approach has been used in a study by Sagoe-Addy and Addo (2013). The mean monthly Relative Sea Level Trend data for the Grange and Simon's Bay were extracted from the NOAA database and utilised. Records for 51 years were analysed for the period 1967 and 2018. The data used showed the monthly average sea level without the interruptions generally associated with seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures and ocean currents. The plotted values are relative to the Revised Local Reference (RLR) data as established by the Permanent Service for Mean Sea Level. Other stations that could have been utilised, such as the Hermanus station, were closed years ago.

In order to have a comprehensive picture of the impacts, additional data from secondary sources including consultants' reports, incident reports and other official reports were scrutinised to understand the extent and impact of climate change on coastal areas was also analysed as provided by the City of Cape Town. In addition, Google Earth Pro Historical Imagery was also generated and analysed to compare, measure and track changes along with coastal areas by using the Google Earth Pro analysis tools. Google Pro usage in coastal reconnaissance has been increasing over the years and has been used in a number of scientific studies, including in surveying coastal boulders in the Philippines (Haslett & Wong, 2019), and also to assess habitat and beach loss in the USA (Marbán et al., 2019).

In order to get future estimates of the coastal sea level scenario, the Climate Central's Coastal Risk Screening Tool CoastalDEM® v1.1 was used. This Climate Central's Digital Elevation Model for coastal areas is an improvement on the legacy data, as it can reflect bare earth elevations with higher accuracy data, particularly over the United States of America and Australia. The two counties use Lidar data, which are not available in most countries. Low-resolution data are also available for the rest of the world, including Africa. This model reduces median errors in NASA's widely used SRTM DEM to near zero. The GHG emissions pathway used by the model is moderate emissions cuts (RCP 4.5), which are roughly consistent with the Paris Agreement's 2 °C target. The maps that were produced must be taken as screening tools for further investigation of risk. Global Maps produced for the world, apart from America, are based on global-scale datasets for elevation, tides, and coastal flood likelihoods. The maps produced by this model do not consider other factors such as erosion, future frequency and intensity of storms or inland flows.

Since remote sensing and other remotely recorded data were used, there was a need for physical verification and ground-truthing to confirm and triangulate the data collected to ensure that the findings are reliable. Sands and Roer-Strier (2006), recommend the use of various research tools as a means to triangulate the data to ensure internal and external validity. Ground truthing is a must for all the remote sensed data as it allows the researcher to interface with the actual subject of research, which allows for the researcher to make meanings from the data and also check for errors (Gatti et al., 2017). During the ground truthing process, the researchers moved from place to place, particularly public places such as beaches and all public infrastructure along the coastline. During the process of ground truthing, the researchers observed and took pictures of damages and evidence of erosion and other corrective measures that were being put in place by residents and city officials. A purposive sampling technique was used to also interact with local residences. Informal interviews focussed on the need to understand the observed impact of climate change on beaches and mitigation strategies were made. A discussion of the observed impacts and how they affected beachgoers who were met during the field gathering process was also made. Participation was through voluntary consent.

A total of 30 key informant interviews were conducted to validate what was emerging from the data gathered through the other sources highlighted. Hence, these interviews conducted in February 2020, were mainly for triangulation purposes and were not the main method of data generation. For the key informant interviews granted by municipal, government and tourism officials in Cape Town, a snowball sampling technique was followed with guidance from the Provincial Tourism Department in charge of Cape Town tourism. Interviews were conducted at relevant personnel official's offices and took between 15 and 30 min. The open-ended questions teased out how sea level was affecting coastal areas, tourism infrastructure, superstructures, measures that were put in place to deal with the observed and expected impact of climate change on coastal tourism and the anticipated future of tourism under climate change. Notes were taken during the interviews, and audio recordings were also made with the permission of participants.

Post the data collection process, interview data were transcribed and cleaned out, and thematic analysis was conducted following an iterative process as outlined by Roberts et al. (2019) and Jaspal (2020). Theme development was anchored on developed research questions. Secondary data was analysed using content analysis. Quantitative data were analysed using Microsoft Excel Analysis ToolPak to check for trends at a 95% confidence interval and develop graphs.

4. Presentation of data and discussion of findings

The presentation of data and discussion of findings are organised under three major sub-sections. The first sub-section focuses on the evidence of sea-level rise. The second sub-section considers the impacts of sea-level rise, mainly on False Bay. The third sub-section addresses the future of Coastal Tourism in Cape Town.

4.1. Evidence and status of sea-level rise

It emerged from tidal graphs for the Granger and Simon's Bays that the sea level is rising. There was no data for False Bay as there is no station. However, Simon's Bay tidal gauge data provide a window into the general picture that was observed within the False Bay area as a whole. Data from Simon's Bay tidal station show that there is a relative sea-level rising trend of 2.1 mm per year at a 95% confidence interval of $\pm$ 0.22 m per year. This is evident when one looks at monthly average data for 61 years that stretch from 1957 to 2018 (Fig. 2). There is also evidence of an upward trajectory, although earlier studies have witnessed lower values. Hughes and Brundrit (1991) observed a 1.9 mm per year in Simons' Town. This is slightly lower than the average for the entire False Bay region. A study by MacHutchon (2015) in the northern parts of False Bay at Monwabisi beach using LiDAR data showed a cliff retreat of about 2.2 my^{-1}. The sea-level rise at this tidal gauge corresponds with the global average sea level mean for the period 1901–1990, that was also 2.1 mm per annum (IPCC, 2019). Of concern,

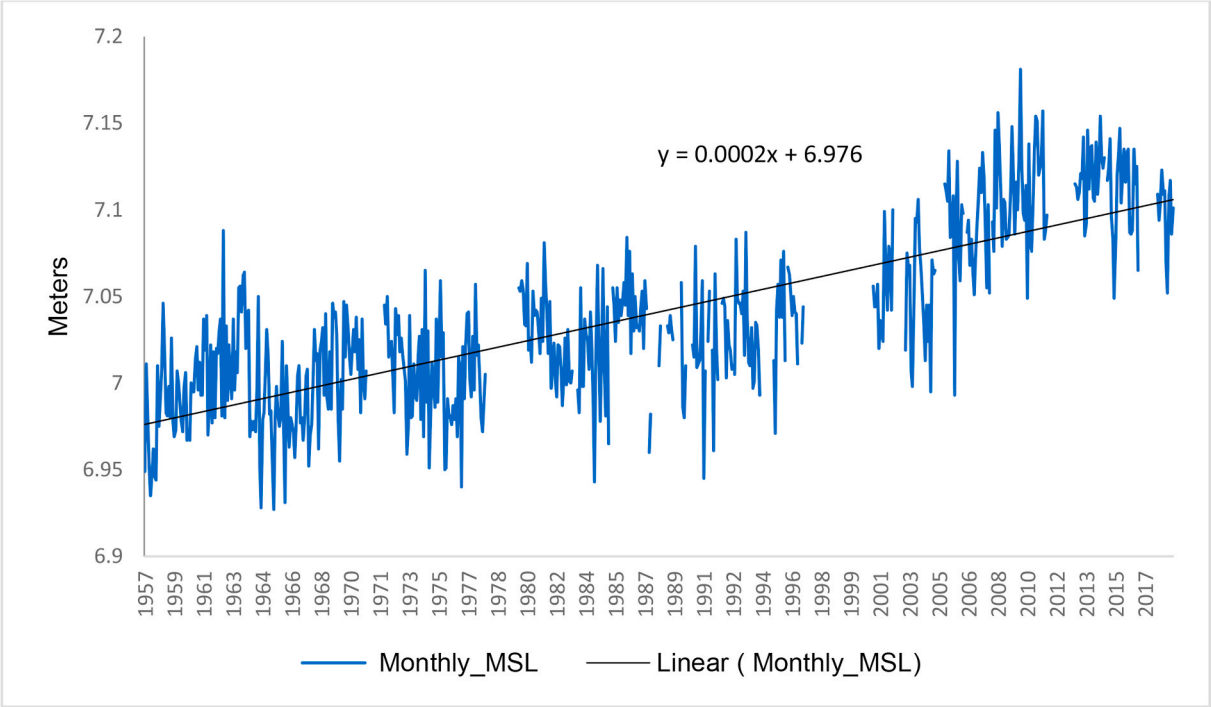

Fig. 2. Relative sea level trend simons bay, South Africa 1957-2018
Source: Authors based on data from NOAA Tides and Currents (2020).

however, are upward spikes that can be seen in Fig. 2, as these could be behind the extensive damage to coastal areas that were reported across the Western Cape Province by residents during fieldwork.

Measurements that were taken at Granger Bay, which is located very close to one of the most popular and luxury tourist destinations in Cape Town, the V&A Waterfront, show that in other parts of town the sea level is rising way faster than in other areas. At Granger Bay, the observations were that the relative sea-level trend is 2.18 mm per year, with a 95% confidence interval of ± 1.13 mm/year if one is to consider monthly level data (Fig. 3). Observations of sea level trends on Google Pro Earth show that Granger Bay is one of the areas in Southern Africa with the highest known rising sea level outside of the island states of Mauritius and Rodrigues, where the sea levels are rising significantly faster than in Southern Africa.

The data from these two Permanent Service for Mean Sea Level (PSML) stations confirm the outcry that was in print and electronic media, particularly in 2019, over the threat of rising sea levels in Cape Town. The sea-level rise has cost the city billions of rand over the last

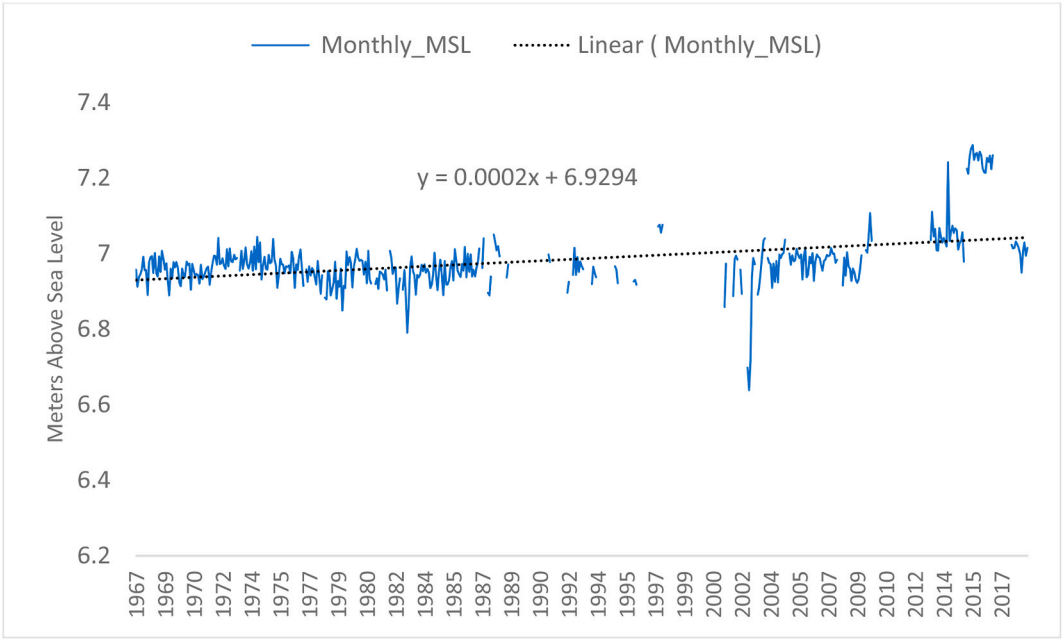

Fig. 3. Relative seal level granger bay, South Africa 1967-2018
Source: AuthorsBased on data from NOAA Tides and Currents (2020).

few years in either intervention, business loss, property damage and business disruptions. Evidence from the two tidal graphs shows episodes of extreme tidal episodes that are increasing in frequency and occurrence, a phenomenon that might have a negative impact on coastal areas. Tides at Granger Bay have since surpassed the 7m mark, signifying an upward trend if one is to compare the levels at the beginning of the time-series record. Respondents interviewed indicated that the extreme tides take place during stormy weather in the city. The pattern of the increase in the sea level does not seem to be significantly different in the area, taking into consideration data from the two stations of Granger Bay and Simon's Bay.

Indeed, field observation and interviews with residents, key informants and other secondary data revealed that the sea and tides were advancing and encroaching on human space and on some high-value properties that are in proximity to the coastal area. Given the position of Cape Town as the tourism capital of South Africa, the rising sea level poses a threat to tourism infrastructure and the attractiveness of the destination, with a potential disruption of tourism activities.

4.2. Impact of rising sea level

The study found that the various beaches around the False Bay area were facing multiple threats of rising sea levels due to coastal erosion and increased tidal activities. Most of the beaches in the area were exclusive to specific users. Undoubtedly, using extreme tides as a proxy for storm intensity and frequency as well as the magnitude of storms over the City of Cape Town has increased over the period in question. Increasing storms were having negative implications for tourism activities in the City of Cape Town. The study noted that out of the 10 Blue Flag beaches, eight were subjected to some degree of erosion. Hence, 80% of the highly-priced beaches are threatened by coastal erosion. Although they did not become part of our key focus, the following beaches were observed to be under significant threat from erosion: Fish Hoek, Melkbosstrand, Bikini, Strandfontein, Muizenberg, Camps Bay, Silwerstroomstrand and Clifton 4th beach.

As of 2019, South Africa had 45 Blue Flag beaches, and more than 20% of these were in Cape Town. This implies that about 18% of the country's prime beaches are under some degree of threat from erosion; this is indeed causing for concern as it may negatively affect tourism figures. Slater and Mearns (2018) argue that the Blue Flag beaches are essential to tourists as they give them a sense of place and security. This position seems to confirm the sentiments of Saayman and Saayman (2017), who noted that tourists in South Africa generally preferred Blue Flag beaches because of their cleanliness. Capacci et al. (2015) further noted that Blue Flag beaches were a key foreign tourism market and tended to attract the high-end tourism market. Rogerson and Rogerson (2020), warned about the decline of the coastal tourism economy in South Africa, to which the negative impacts from climate change-related extreme weather events and general environmental degradation could be contributing.

The Bikini Beach that is located in the high-end market area of Gordon's Bay is one of the Blue Flag beaches under threat from high-tide erosion. During high-tide episodes, a larger part of the beach usually gets covered in water, which leaves some bare rocks and limiting the sand beach area to a tiny area. It was also observed that because of the rising sea level and tidal action, the nearby boat and yacht club is exposed to tidal action. To this end, water often overtops the slipway, posing a threat to boats. As a control measure, dolo reinforcements were utilised to try and reduce the impact of the tides. However, field observations showed that there was overtopping of the dolos by tides. A few tourists who posted comments on the beach's Google Review platform noted that even though the beach is located in a beautiful and secure area, safety from tides and intense wave action is a concern, especially during storms. In addition, the rising sea level will undoubtedly demand that more dolos or some other alternative be put in place to protect the yacht club, which is a significant revenue generator for that area.

Field observations and evidence from interviews also noted that Harbour Island is one of the areas under threat from rising sea levels, coastal erosion and high tides. First-hand accounts observed tides wreaking havoc on this resort that is used by luxury boats and yachts as well as the food outlets in the area. The tides were overtopping the sea defence made of stones. The tides threaten the eateries and car park and splash over to where boats dock on the island. Other observations during the fieldwork include watching tourists who were trying to take photographs being tossed away by high-splash water from ocean tides. To minimise this impact, an alternative and better design, possibly using several dolos can assist in building a defence for some parts of Harbour Island to ensure tourists safety.

Another attraction in the False Bay area that is under constant threat of high tide as a result of the rising sea level and high storm intensity in the area is the Strand Area. It emerged during fieldwork that the Beach Road that runs along the Strand Beach is severely damaged from erosion, with pavements that are used for jogging and beach strolls also damaged. The tides also threaten the bathing facilities that service the beach area. Of concern is the impact of the damage to the roads, which often requires repairs at a considerable cost to the municipality. In order to mitigate flooding from the advancing ocean, the municipality has embarked on an exercise to build concrete slabs along the road as a shield to ensure that water does not inundate the road. This measure might not be adequate in the event of big tides. Given the increase and intensity, a better defence may be needed to protect tourism and housing facilities close to this beach.

The other beach along the False Bay coastal area that was flagged as a danger point is Monwabisi. It mainly services domestic tourists and residents and is located close to Khayelitsha, a township hosting predominantly and previously disadvantaged black and coloured communities. According to key informant QW, they noted that

> "… the beach has suffered massive damage in recent years as a result of storms and tides, which led to damage to the tidal pool and other support facilities at the resort."

This assertion was also confirmed by field observations and remote sensed data, which showed that due to erosion, the major road that links the beach road and Baden Powell Drive had been damaged and cut off (Fig. 3). Further confirmations revealed that the road regularly floods. About a 113 m portion of the road was sliced off and replaced by the extension of the ocean. In 2005 the road was navigable, but at the time of fieldwork, it was no longer navigable by cars. Measurements using Google Earth Pro indicate that between 2005 and 2019, the length of the road that was damaged due to encroaching erosion was about 126 m. The sea had encroached into the land surface by about 26 m, which led to the total cut off of the road into two road sections that are distinct (Fig. 4). About 400 m^2 of land was eroded by the advancing ocean between 2005 and 2019. This has led to some residents in the area accusing the City of Cape Town metropolitan municipality of neglect. This neglect was evident in several Google Reviews for the beach. Indications from the municipality were that hard engineering methods of controlling the erosion were failing. Records showed that the municipality had, as of 2014, spent about US$113,000 to repair the infrastructure at Monwabisi to address human and natural damage resulting from tides, erosion and the rising sea level. Reports indicated that the surrounding area is also susceptible to wave runs of about 1.7 m, which often lead to severe erosion and inundation of some areas that have an elevation of about 3.7 m.

Given that the beach under consideration is a multipurpose facility and prized asset by the community, the destruction of infrastructure, including roads, can push tourists to exclusive beaches such as the Clifton beaches. This can lead to overpopulation in some areas. Tempers have often flared on beaches in South Africa during summer, resulting in racial fights and tensions in the most unequal and racial divided communities of the Western Cape. Increased investment in and costs of

Fig. 4. Damaged part of the road due to coastal erosion
Source: Authors, based on Google Earth Pro Imagery.

infrastructure maintenance can result in funds being diverted from other critical services delivery matters such as housing and water, that is much needed to address the backlog in housing.

Other vulnerable areas around False Bay include beaches and tourism facilities in Milnerton, Simon's Town, Kalk Bay, Glencairn and Fish Hoek. The average sea level increase for these areas was discussed earlier, with evidence showing that the area is experiencing severe challenges. The sea-level rise is estimated at 2.1 mm per year. Indications are that as of 2019 Cape Town authorities have spent about US $233,000 to rehabilitate the Fishermans Lane Parking rock revetment. It also emerged that the implications of coastal marine facilities that support tourism are under severe threat from the rising sea level, tides and erosion. On the Glencairn and Fish Hoek beaches, erosion threatens the recreation facilities such as holiday homes, the car park, yacht club, the railway line and the main coastal road, which may affect tourists' movement and revenue collection.

The coast along Simon's Town and Muizenberg has a long-running railway line (Fig. 5a and b). The railway line in some places runs literally on the shoreline, with some sections already on the beach due to erosion. Residents interviewed who reside along the coastline concurred that the railway line is often cut off during high tides. At times, sand gets deposited along the railway line, cutting off the network, which in some cases takes days to clear. These cause major disruptions for people and goods movement in those areas. The route also provides an essential link to the Table Mountain National Park and Cape of Good Hope, which are major tourist attractions.

Several beaches are reportedly in danger along the coastline of Cape Town, including those that are out of the False Bay area. Our investigations revealed that the highest rising sea level in Southern Africa outside of island states such as Mauritius and Seychelles was recorded at Granger Bay, where the sea level is rising by an annual average of 2.18 mm per year. Considering the NOAA tidal map, this positions Cape Town as the city with the second fastest-rising sea level, after Mombasa, along Africa's coastline. Granger Bay PMSL is only a few hundred meters from Cape Town's central business district, just off the Transnet Harbour and about 900 m from the V&A Waterfront. These are touted as the most visited tourist attractions in Africa, with an average of 24 million tourists visiting it annually. In 2018 about 23.3 million tourists visited the V&A Waterfront, which was a decline of 4% from the previous year (Cape Town Tourism, 2018).

Evidence suggests that parts of this most visited attraction in Africa are under threat from the rising sea level. It was observed during the fieldwork that although numerous dolos were put on the seafront at the V&A Waterfront, some of these were being pushed away by surging tides – resulting in parts of the area around the V&A Waterfront being eroded, especially those areas where dolos were not deployed (Fig. 6). This led to portions south-west of the V&A Waterfront being closed off for repair works as of February 2020. The street parking that is on the north-western part of the area is visibly eroded and chiselled from the seaside with a walkway that has collapsed already. Given that the broken ramp is used by tourists for jogs and sea viewing, this will certainly harm tourism, as some parts are currently in a dangerous state.

Further threats to coastal erosion due to the rising sea level in Cape Town were observed in other famous tourist sites such as areas around the Green Point Stadium, Sea Point and the Clifton Beaches. The Clifton Beaches form part of the Blue Flag beaches and stretch all the way beyond Camp's Bay, another populous tourist beach and attraction. It was reported that the tides are getting stronger as they now occasionally encroach onto the pavements and roads that are surrounding the coastal areas. Several images from authentic internet sites bear testament to this. One Camp's Bay resident noted: "Quite often we have seen tides coming inland and flooding the road and the restaurants and shops on the other side of the road. As such, shop operators normally use sandbags to try and deal with the situation, and this lasts for days. The impact of the tides can be quite intimidating."

The ocean in Cape Town is a significant part of the socio-economic life of communities there, regardless of whether they use it for recreation and sports. The increasing impacts of climate change seem to disrupt the rhythm that the Cape Town people have with the coastal areas: a phenomenon that is getting worse. The municipality is having to shoulder increasing costs of repair from damages that are induced by the rising sea levels and the increased storm activity that often triggers high tides. Besides the few selected profiled beaches, some of the beaches which are in a similar or near similar situation with tourism value around Cape Town include the following: Bloubergstrand, Big Bay, Sunset Beach, Lagoon Beach, Three Anchor Bay, Bakoven, Kommetjie, Ocean View, Misty Cliffs, Scarborough, Smitswinkel Bay, Castle Rock, Glencairn, Muizenberg, Boulders Beach (Penguin Colony Beach), Kalk Bay Harbour and the Atlantic Seaboard.

The rising sea level manifests itself on the beaches through visible

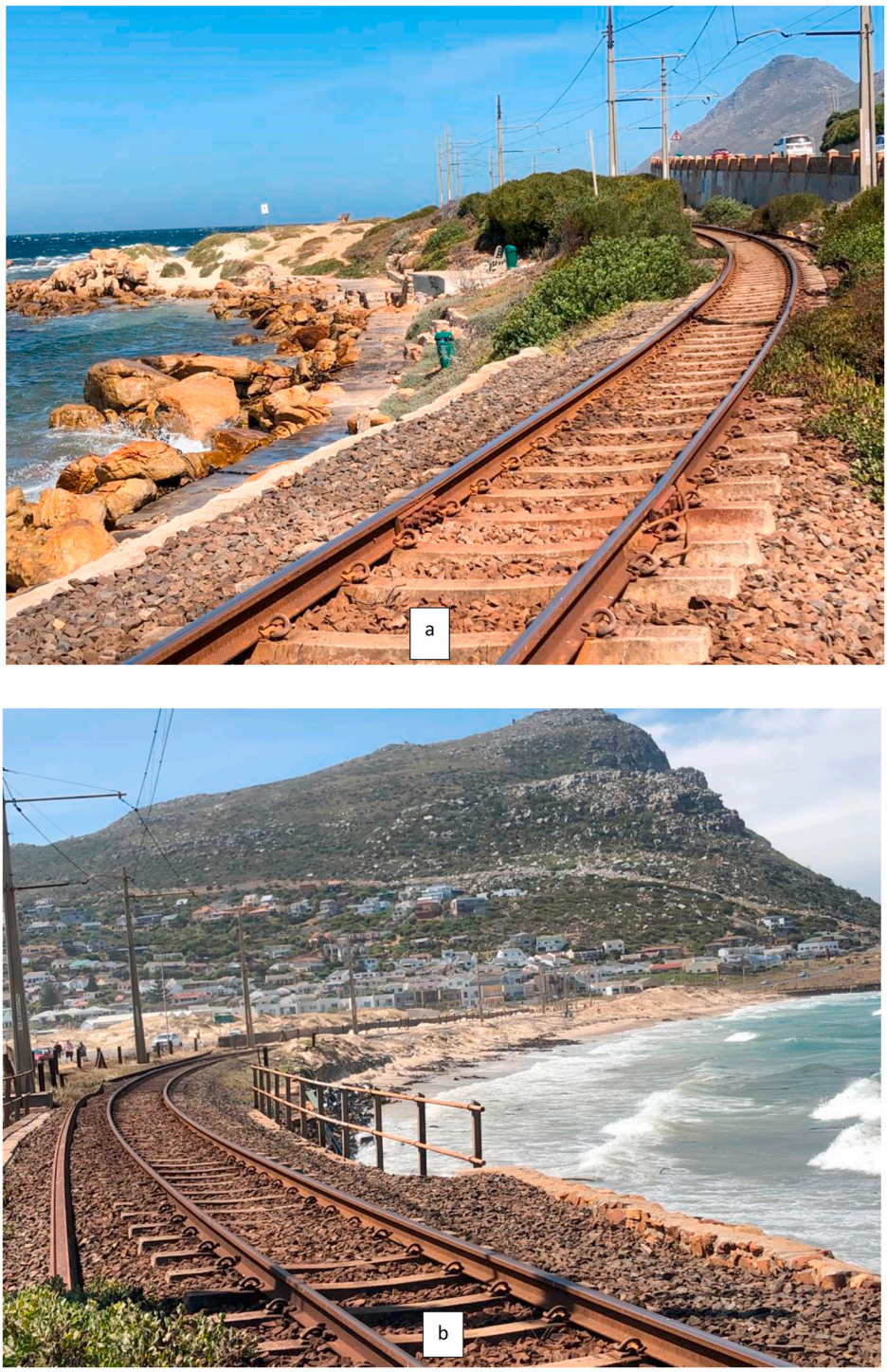

Fig. 5. a and b Showing the railway line running along the shoreline (right-hand side of the road)
Source: Authors (2020).

erosion and damaged roads, pavements and car parks that cost the city of Cape Town millions of dollar to repair and to upgrade the facilities. A report by Business News (2019), quoting Mayco member for Spatial Planning and Environment, Marian Nieuwoudt for the City of Cape Town, shows that Cape Town had either committed or spent US$3.2 million on addressing infrastructure issues caused by the rising sea level. Increased extreme weather events are a challenge for the coastal area. In recent memory, the June 2017 violent storm in Cape Town resulted in wind speeds of 120 km, which caused one of the highest recorded wave heights in memory of 11 m at Cape Point (CSIR, 2017). Because of the June storm that lasted for 48 h, the Big Bay beach was closed after a dune had collapsed due to massive erosion on the beach, injuring a municipal worker. The incident led to the temporary closure of the beach. This beach is famous for surfing and its beautiful sunset views. The respondents noted that they had observed increased frequency and intensity of violent sea storm activity, often triggering high sea waves and tides. The highest wave was recorded in 1978, reaching a height of 20.5 m on the Cape Peninsula (CSIR 2017).

One responded noted that “Increased intensity and frequency of storms in Cape Town often lead to damage of boats, destruction of

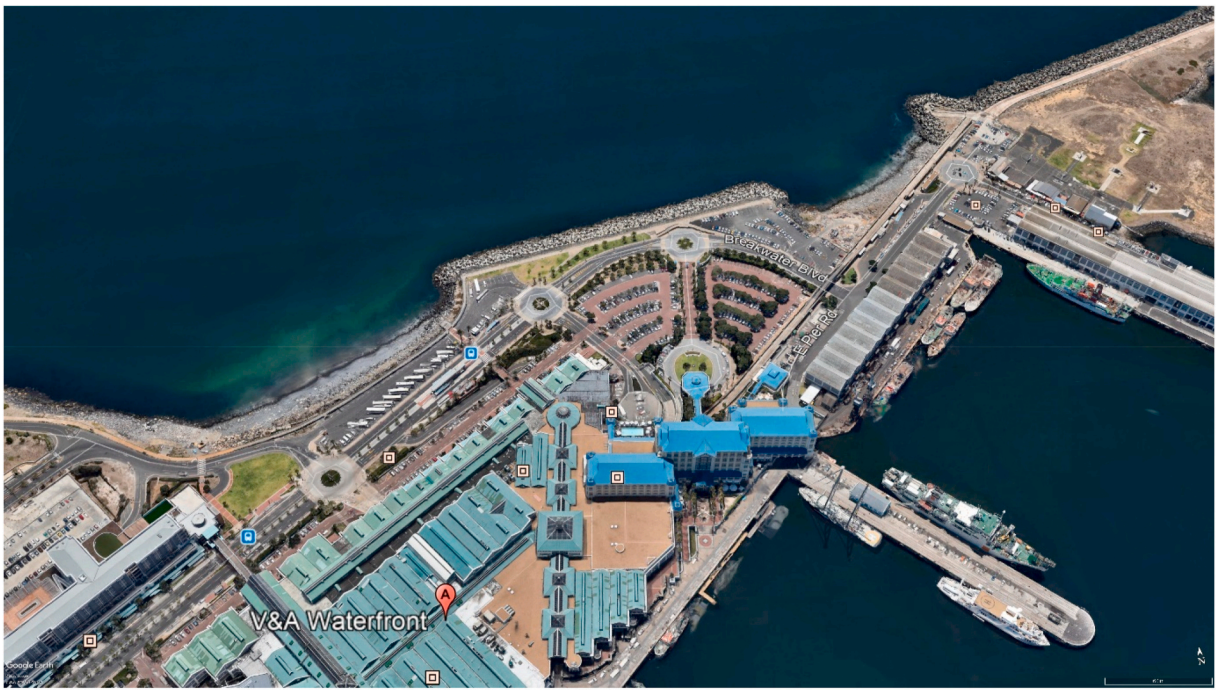

Fig. 6. Map of the V&A Waterfront showing some of the most vulnerable parts of the facility in the north
Source: Authors, based on Google Earth Pro (2020).

slipways and mooring of boats breaking down, which can disturb those who have yachts and tourism businesses – something that often happens. The findings are in line with other studies that have noted damage to infrastructure as one of the challenges that the tourism industry was dealing with due to extreme weather events inland, particularly at Victoria Falls (Dube & Nhamo, 2018, 2020; Mushawemhuka et al., 2018). This study also confirms earlier assertions by Fitchett et al. (2016), who observed that climate change was a threat to coastal

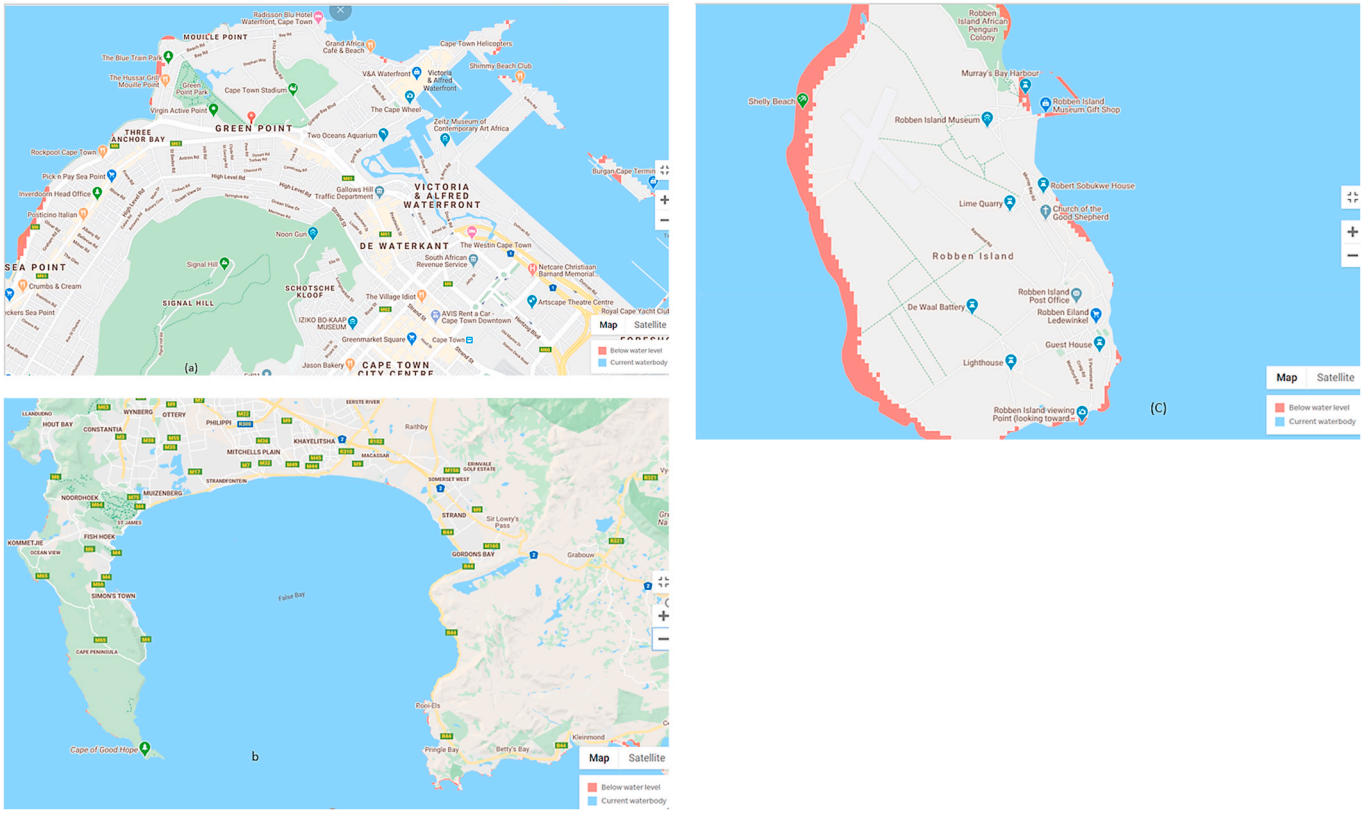

Fig. 7. a–c: Selected land projected to be below the annual flood level in 2050 for Cape Town due to rising sea level (the map excludes potentially protected areas).
Source: CoastalDEMv1.1.

tourism. One respondent argued that "due to increased storm activity, beaches and dunes are not having enough time to recover, and this tends to increase the impact of high tides. Beaches and dunes are natural barriers to ocean wave action." The assertions confirm observations by the Board and National Research Council (2012), who pointed out that increased storm activity could trigger width changes to beaches, mainly as a result of climate variability. The issue of decreasing sand on beaches that reduces the attractiveness of the beaches to tourists presents another challenge that has the potential to reduce revenue.

The third and last sub-section focuses on the future of tourism in Cape Town.

4.3. The future of Coastal Tourism in Cape Town

The Climate Central Coastal Screening Tool (CoastalDEM v1.1), was used to map out the coastline of Cape Town to see the projected future for 2050. A significant part of the City of Cape Town's beaches and harbour will be affected by the rising sea level. This could potentially have a negative impact on coastal marine tourism and its contribution to the national economy. Given the projections, the city should anticipate a rise in maintenance cost for beaches along its coastline, as the private sector does not seem to be in a position to protect its businesses or properties from the advancing sea. At least 41 beaches will be affected at varying levels by rising sea levels by 2050. The impact will be on several tidal pools, braai areas along the beach, picnic sites and other important tourist facilities. The Shelly Beach (Fig. 7c), Robben Island Museum, Murray's Bay Harbour, Church of the Good Shepherd and the Robben Island viewing point are some of the areas that are expected to be inundated by the rising sea level by 2050. Robben Island is a World Heritage site and one of the most visited tourist attractions in Cape Town, as it boasts over 300,000 tourists per annum. Key political figures were incarcerated there during the apartheid era in South Africa, such as Nelson Mandela, Walter Sisulu, Govern Mbeki and Oliver Reginal Tambo. In the financial year 2016–2017, a total of 373,443 people visited the resort, with 306,912 visitors in the 2017–2018 financial year. It is not certain how the rise in sea level will affect tourists' visits to this attraction.

Given that Cape Town has a long coastline of over 300 km with a significant portion of this under threat from the impacts of climate change, there is an urgent need to find ways of achieving sustainable development, despite the challenges posed by climate change. The SDG 14.7 talks about the need to ensure sustainable development using marine resources, including through sustainable management of fisheries, aquaculture and tourism (UN, 2015). In the same realm, South Africa's Integrated Coastal Management Act seeks to achieve more or less the same objectives of ensuring sustainable development through the sustainable utilisation of oceans. This objective is also outlined in the government's ocean socio-economic development blueprint, Operation Phakhisa, which also feeds into the government's National Development Plan (Operation Phakisa, 2020).

Given that the coastal marine environment is under threat from rising sea levels, the SDG 13.1 highlight the need to strengthen resilience and enhance adaptive capacity to climate-related hazards and natural disasters in all countries, particularly the developing countries. In line with the need to reduce the risk of the impact of the rising sea level, the City of Cape Town has been making an effort to protect and maintain the integrity of its coastline through various means. These include engaging citizens through a range of means on various fora, including print and electronic media. Of interest to this study is its efforts to deal with erosion, increased tides and the rising sea level. It was noted that the City Council had been engaged in trying to keep an eye on the behaviour of the ocean for some time, with five consultancy reports that documented coastal management issues.

In addition, some initiatives are being undertaken by both the private sector and government in order to address the triple challenges of the rising sea level, increased tides and associated erosion. However, most of the piecemeal private initiatives are either ineffective or have been found to exacerbate the problem of coastal erosion. The city has embarked on a project of putting up dolos on its coastline as a major initiative to protect property from the advancing sea. The V&A Waterfront, for example, has the highest population of dolos (Figs. 8 and 9). This could be a testament to the need by the city to protect the most visited tourist attraction in Africa from the rising sea level, which is highest around that area.

In as much as the City Council is trying to put up dolos and stone works to try and reduce the impact of tides and consequently erosion and any other associated destruction, there seem to be challenges. The tidal action seems to be stronger. Some dolos are being broken. In some cases, the tidal force was directed to other areas that are not protected and given the force of the tides, property and infrastructure were destroyed. It is not clear how a piecemeal approach to coastal defence would assist, but the city has been overwhelmed by the demand for defence and repair costs. Along the Cape Point and the Strand railings and pavement, concreting (building sea walls) is used to protect people from being washed to the sea in the event of a surprise tidal wave. Regardless of this, both the field observation and interviews revealed that overtopping occasionally occurs. This form of defence is hardly enough to protect such areas from the raging seas in the same way dolos can attempt to.

There are also efforts undertaken to rehabilitate the beaches suffering from erosion, with efforts underway at Hout Bay. In this case, sand traps are used (Fig. 10). Using the historical imagery tool from Google Earth Pro, we found that there was some measure of success in increasing the amount and width of sand at the beach. Other methods being employed at this beach include the use of gabions to stabilise the slope; in some instances, vegetation has indeed started to grow. This reclamation can assist in maintaining the tourism attractiveness of this beach that is being threatened by coastal erosion. What is of concern though, is that beaches in marginalised communities remain largely unattended to; a case in point being the Monwabisi beach that services the Khayelitsha community and has a collapsed road. The coastal railway line also remains vulnerable in Simon's Town area, and more railway interruptions are likely in the future.

More worrying, however, is how there is continued development and investment in tourism infrastructure along the coastal line. The development and construction of a hotel and other properties in early 2003 in such a fragile ecosystem are concerning. The area is highly vulnerable to both the rising sea level and coastal erosion. The properties that were developed on the Lagoon Beach in Milnerton such as hotels, a golf course and holiday apartments and residential areas, Woodbridge Island and all other facilities to the west and some to the near east side of Marine Drive remain at risk. This should not have been allowed in the first place – more so when one considers the legislative framework such as the National Environmental Management Act: Integrated Coastal Management Amendment Act 2014. The Act stipulates requirements for developments on coastlines and coastal set-back management line. The Google Pro Imagery analysis shows that there was a rush to construct properties in this area.

5. Conclusions and recommendations

The study examined the implications of rising sea level on coastal tourism in Cape Town, South Africa. It emerged that the mean rising sea level for Cape Town is on average 2 mm per year. The study found that in line with the global trends coastal tourism in South Africa and in this case, Cape Town is threatened by rising sea levels and the consequent increasing extreme tidal activity compounded by climate change. As a consequence of climate change, several tourism infrastructures in Cape Town such as several popular beaches, bays, tidal pools, beach facilities and connecting roads and rail infrastructure are under threat from the impact of rising sea level and coastal erosion. This calls for concrete strategies and new approach of planning and managing tourism areas

Fig. 8. Dolos piled up in defence of the coastline.

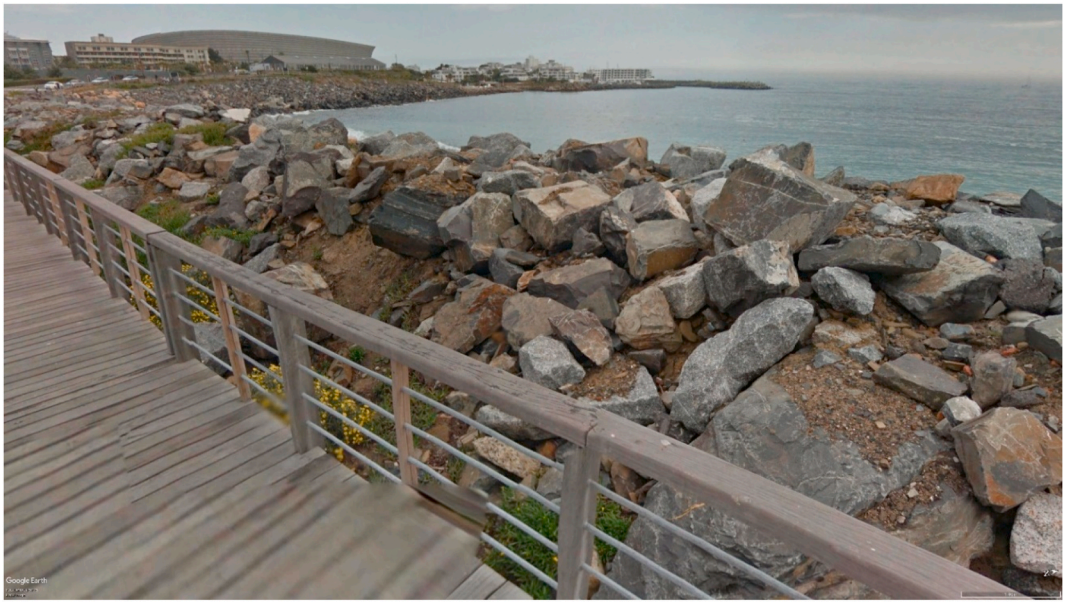

Fig. 9. Stones lined up to protect the coastline just off V&A Waterfront
Source: Fieldwork (2020).

and facilities which can have an impact on tourism infrastructure spending so as to ensure tourism resilience going forward.

Projected rising sea level is expected to result in more tourism infrastructure being exposed to the impact of sea level rise in the coastal tourism city which is the case in other coastal areas in other parts of the world. Flooding is also likely to emerge as one of the biggest threats to coastal tourism in the area. Current data shows that already some critical luxury tourism facilities such as V&A Waterfront have some of their

Fig. 10. Sand traps at Hout BaySource: Authors.

sections suffering from severe sea erosion. In future other resorts such as the Robben Island World Heritage Site, Cape Point and several Blue Flag beaches will witness increased threat from the sea. The rising sea level, therefore, poses a risk to tourism establishments which can change tourists' patterns and trends in the future. Chances are some beaches will disappear due to coastal erosion and survival of some beaches will depend on restoration efforts and future climatic patterns.

Given the centrality of coastal tourism to the city of Cape Town, the study reveals that there is a need for tourism managers to pay serious attention to the impact of rising sea level on their operations and business. New and improved management plans and risk assessments need to be undertaken at an individual site level so as to have a deeper understanding of the threats for each tourism site along the coast. This has to be done with a view to developing a risk-adjusted strategy that buffers sites against the impacts of climate change.

As is known that climate adaptation will come at a great cost to both business and government, there is an urgent need for government to support climate-resilient mechanisms for the city to give it a fighting chance against climate change. In some instances, there might be a need to relocate some of the tourism businesses and infrastructure such as rail lines to ensure business and people safety given the frequency and magnitude of risk along the coastline. There is also an urgent need to deal with the impact of big storms that trigger higher tides, leading to overtopping of the coastal defence system. More developments and investments are needed in the early warning system. Of equal importance is to assist communities in building resilience through conscientisation and by capacitating them in disaster management to be able to respond swiftly to climate emergencies. Lastly, a functional coastline that is inclusive of all the social, economic and environmental realities must be agreed on and enforced in the city.

The study further recommends future work and continuous monitoring of coastal weather so as to keep check of the adequacy of the risk strategies for the sector. Additional studies should focus on finding solutions to increasing sea level rise that is customised to the city of Cape Town. Further studies can also be conducted to investigate the impact of rising sea levels on destination perception.

Study limitations

Given the long length of the coastline, the researchers could not ground truth every inch of it. Such a pathway could alter the narrative of the study. In addition, the study relies on a small sample of key informants who might have their own biases. Climate models have their own limitations, and the findings must be understood in that context.

Credit Author Statement

This serves to declare that myself Kaitano Dube on my behalf and on behalf of the co-authors are the sole authors of the article Rising sea level and its implications on coastal tourism development in Cape Town, South Africa which we have submitted for publication consideration in the Journal of Outdoor Recreation and Tourism. All the authors participated enough to be considered authors of the article. We further attest that all third part material has been acknowledged. The research was conducted in line with ethical provisions as provided by researcher institutions. There is no conflict of interest in conducting and writing of the article.

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