

## Tourist Perceptions of the Impacts of Climate Variability and Change on Botanical Gardens

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### Abstract

This study examines visitors' perception of the impact of climate variability and change on national botanical gardens in Gauteng, South Africa. The study used data from field observations and an online questionnaire that gathered views of 324 botanical garden visitors at Walter Sisulu and Pretoria Botanical Gardens. Data were analysed using QuestionPro Analysis tools. The study found that botanical garden visitors are apprehensive about climate variability and change impacts on picnicking, bird watching, flowering patterns, walking trails and waterfalls viewing experiences, among other activities. More than half of the respondents indicated that climatic patterns play a critical role in their decision to visit the botanical gardens. Most visitors (75%) perceived that weather events induced by climate variability and change threaten botanical gardens, with drought, flooding and extreme storms singled out as some of the most significant climatic threats to botanical gardens. The study recommends that botanical gardens management streamline climate change in their medium to long-term planning to ensure climate resilience and adaptation. This calls for the implementation of mitigation and adaptation strategies to reduce the impacts of climate variability on the recreational experience in botanical gardens.

**Keywords:** tourist perceptions; climate change; urban tourism; botanical gardens; South Africa

### Introduction

Before the advent of COVID-19, tourism and recreation was recognised as one of the world's most significant and fastest growing economic sectors. The tourism sector also contributes to sustainable development by creating jobs and providing access to a formal economy for previously disadvantaged communities (Dube et al., 2018). Tourism has numerous benefits; amongst them is the sector's ability to generate foreign revenue, infrastructure development, and stimulate economies for developing and developed countries alike (Amusan & Olutola, 2017). Besides, Rogerson (2016) and Dube and Nhamo (2020a) argued that tourism is often used as a tool for poverty reduction, which also contributes to the achievement of Sustainable Development Goals (SDGs). Also, tourism is credited for enhancing living standards, elevating economic benefits, securing the environment, preserving cultural integrity, conserving natural areas and meeting the needs of people in developing and developed countries (Zolfani et al., 2015; Smith, 2013).

Given its rich tourism product, South Africa ranks as one of the leading tourist destinations in Sub-Saharan Africa and the world, given the diversity of the tourism product (Amusan & Olutola, 2017). Consequently, the country attracts many tourists from different parts of the world because of its beauty and rich cultural and natural heritage, including botanical gardens (Rasoolimanesh et al., 2020). South Africa is also considered to have a significant leisure and recreation travel segment (Friedrich et al. 2020a). Botanical gardens across the country receive over two million visitors annually seeking pleasure, education and nature enjoyment (SANBI, 2018).

Botanical gardens play a central role in tourism and recreation in South Africa and globally. Several people use the botanical gardens as important recreational centres where they can visit for picnic and relaxation. Sometimes, they are used as unique and social gardens for hosting weddings and other special events central to urban tourism (Dodd & Jones, 2010). In recent years, the popularity of botanical gardens has been on the increase as important conservation and educational centres where students go to learn about botany and conservation (Moskwa & Crilley, 2012). As such botanical gardens are considered essential recreational and conservation centres worldwide (Borsch & Löhne, 2014). Therefore, it is not surprising that the draft National Botanical Garden Expansion Strategy 2019-2030 puts botanical gardens at the centre of climate change mitigation and adaptation in South Africa (SANBI, 18). Regardless of this crucial community value evidence suggests that botanical gardens, like any other part of nature, are increasingly at risk from climate variability and change impacts, threatening their tourism, socio-cultural, environmental, and economic value (McClean et al., 2005). There is an increased awareness and concern in the global tourism and recreation industry and the populace about the dangers of climate change on human civilisation and recreational activities (Dube & Nhamo, 2020b). The relationship between tourism, recreation and climate change has increased academic interest and exploration (Dube & Nhamo, 2020b; Pandy, 2017).

Climate, weather and seasonality impact tourist satisfaction, behaviour and travel motivations (Fitchett et al., 2016; Friedrich et al., 2020a). A study by Dube and Nhamo (2020b) reports that tourists are increasingly conscious of the ramifications of climate variability on iconic tourist resorts such as Victoria Falls, Okavango Delta and Kruger National Park, to mention a few. Friedrich et al. (2020a) indicate that climate change greatly influences travel motivations for tourists. Tourists are sensitive to various weather conditions depending on the attraction and activities they want to undertake, such as rainfall, storms and wind speed, which influence the destination's recreation (Smith & Fitchett, 2020).

Botanical gardens as critical tourism and recreational facilities are not spared from the adverse impacts of climate variability and change. A study by Dube et al. (2020), for example, found that as a consequence of Cape Town's Day Zero drought, one of the most populous botanical gardens which domestic tourists frequent, the Kirstenbosch National Botanical Garden witnessed a significant decline in visitor numbers which adversely affected revenue collection at this populous attraction. This occurrence was a testament to fears raised by Botanic Gardens Conservation International (2018), who warned about the adverse impacts of climate change on botanical gardens calling for climate change action. Such studies are critical because academics in the field put botanic gardens at the centre of climate change action (Primack & Miller-Rushing, 2009; (Primack et al., 2021). Evidence suggests that climate change will likely alter the botanical gardens in several ways; nonetheless, it is unknown how the users of these critical users of botanical gardens will be affected by changes in aspects such as flowering aspects (Primack et al., 2021) and other impacts. Regardless of the evidence of vulnerabilities of botanical gardens to climate change (Entwisle et al., 2017; Thomas et al., 2022) which might impact recreational activities, there are no known climate perception studies

on botanical gardens, if any at all in Southern Africa. Therefore, this study aims to examine the perception of botanical garden visitors of the impact of climate variability and change on botanical gardens in Gauteng. The central questions of this study are: (1) What is the perceived impact of climate variability and change on national botanical gardens? (2) How do tourists perceive various climate change actions being undertaken by national botanical gardens in Gauteng to fight the climate change challenge?

### Literature review

Before COVID-19, tourism was one of the fastest and largest growing global industries (Nhamo et al., 2020). In South Africa, the tourism sector contributed significantly to the national economy by supporting several livelihoods (Hoogendoorn et al., 2020). The country is considered widely to have a range of tourist destinations, which rely relatively on the region's pleasing climate, characterised by warm weather and clear skies (Hoogendoorn et al. 2016; Fitchett et al. 2016:1). Beach and nature-based tourism are the country's major tourist destinations that rely heavily on ameliorating climatic conditions (Dube, 2022; Fitchett, Grant, & Hoogendoorn, 2016; Giddy, Fitchett, & Hoogendoorn, 2017). Besides, South Africa has many small towns that are providently relying on exploration, and these contribute to a variety of tourist destinations. These are centred predominantly around outdoor pursuits, including game drives, hiking, water sports and fishing (Hoogendoorn et al., 2016; Smith & Fitchett, 2020; Fitchett et al., 2016).

The interlink between global warming and exploration has long been reasonably investigated (Mushawemhuka et al., 2018). Climate and tourism have a dual relationship, with each component affecting another (Amusan & Olutola, 2017; Dube & Nhamo, 2019). Consequently, an adverse climate change negatively alters tourism. South Africa is at significant risk of climate fluctuations' long-term effects (Pandy, 2017). By the year 2100, South Africa is forecast to observe high increases in temperature as 40°C, a shift in the timing of rainfall season, quantity and severance of rainfall events, rise in sea levels, variations in wind speed and strength (Fitchett et al. 2016). The country is spatially highly variable to climate change impacts (Hoogendoorn & Fitchett, 2018). These climate change factors are gauged to threaten tourism's local economic development features in South Africa (Pandy, 2017). In Southern Africa, climate change is predicted to be more severe than in other parts of the world (Smith & Fitchett 2020). Climate change has adverse effects on South Africa's tourist attractions and activities due to poor adaptation capabilities (Hoogendoorn et al., 2016). Therefore, climate change will, directly and indirectly, affect botanical gardens in the country, as seen in Cape Town by Dube et al. (2020).

Schulman and Virta (2011) noted that botanical gardens face an adversely unforeseen plant crisis because of natural disasters, climate variability and invasion of alien species. In other settings of botanical gardens, climate change is reported to adversely affect plant phenology, physiology, anatomy, evolution and ecology (Primack & Miller-Rushing 2009; Primack et al. 2021). Climate change is feared to threaten up to 50% of vascular plants in botanical gardens with extinction within the 21<sup>st</sup> century. Increased temperatures will adversely impact plant species and put plants under pressure due to considerable shifts in habitat conditions (Hultine et al., 2016). According to Primack et al. (2021), climate change impacts plant species and influences plant conservation strategies developed in action to recognise and protect plant species affected mainly by climate change.

Botanical gardens have been central in conserving and protecting endangered plant species, making them important recreational centres. However, climate change has led to endangering of the endangered species, which acts as attraction centres (Vincent et al., 2020). As a consequence of the threat posed by climate change, there have been propositions to make

botanical gardens centres for climate change conservation and education (Chen & Sun, 2018). Faraji and Karimi (2020) shared this sentiment and noted that botanical gardens are important plant science and conservation sites. On the other hand, Cavender and Donnelly (2019) argued that botanical gardens need to save from climate change as they have a central role in urban greening to create healthier societies.

As witnessed in other areas of urban tourism, climate change poses a threat to both destinations and tourists' activities. The recent drought in Western Cape, South Africa, resulted in the plunge in tourists arrivals to the Western Cape (Dube et al., 2020). Horne et al. (2021) argued that climate change raised tourists' perceptions, particularly women. Previous perceptions studies aimed at assessing travel intentions and behaviours revealed that some changes that emanate from climate change could adversely affect tourists' travels and behaviours to even some iconic tourist destinations. Atzori et al. (2018) noted that nature tourists tend to switch destination visiting patterns and times in response to climate-induced changes. In some instances, tourists could also reconsider their travel intentions and behaviours in response to climate change impacts as part of the climate change action. In some areas, Wilkins et al. (2018) argued that in some destinations, climate change had a tendency of altering tourists spending patterns, particularly during the summer months.

According to Scott et al. (2019), the advent of climate change and its continued impact will adversely impact GDPs dependent on tourism and, ultimately, the achievement of Sustainable Development Goals. As climate changes, there are concerns that it will also alter the Holiday Climate Index, which could alter tourists travelling patterns and behaviours (Rutty et al., 2020). Therefore, both tourists destinations need to respond in a manner that addresses both the demands for mitigation and adaptation to ensure destination sustainability. This demand is particularly pertinent regarding botanical gardens, where knowledge gaps remain vast as there are no studies on climate change and tourism that have addressed the subject to date. The IPCC (2022) only mentions botanical gardens once as centres where people can learn more about climate change.

### **Study areas**

The study was conducted in two national botanical gardens in Gauteng Province, namely Walter Sisulu National Botanical Garden and Pretoria National Botanical Garden (Figure 1). The Walter Sisulu Botanical Garden is located 30km west of Johannesburg, South Africa. It was established in 1982 and was previously known as the Witwatersrand National Botanical Garden. Later, the garden was renamed Walter Sisulu Botanical Garden after the late Walter Sisulu (former ANC leader). The garden has a long history of being an iconic attraction because of the Witpoortjie waterfall, pristine forests, and picnic sites. The Witpoortjie waterfall is derived from the station where people got off the train from Johannesburg and walked down the waterfall (SANBI, 2016). Walter Sisulu Botanical Garden covers 300 hectares area of landscape and natural veld. The garden contains a variety of over 600 flowering plant species and shrubs, a record of over 230 bird species, several reptiles and mammals and indigenous trees. It is also a popular spot for two famous black Verreaux eagles residing in the garden (SAHO, 2020). In the 2017/18 financial year, this garden received 301 965 visitors (DEAT, 2018).

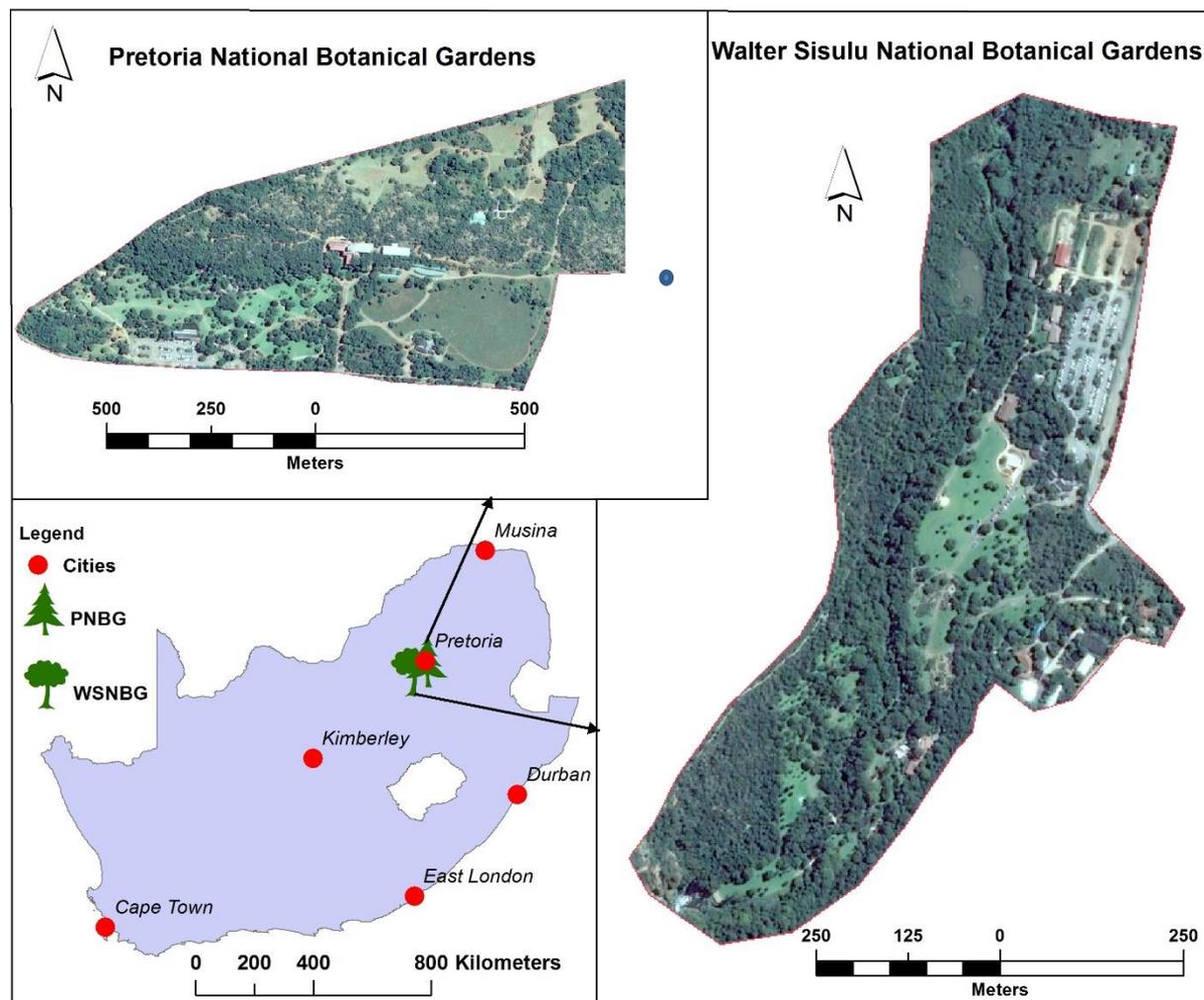


Figure 1: Map and geographical location of Walter Sisulu botanical garden and Pretoria botanical garden  
Source: Authors

The Pretoria Botanical Garden is located east of Pretoria's central business district. This garden was established in 1946 and was previously a research facility managed by the Botanical Research Institute (SANBI 2019). It serves as a recreational space and scientific research centre. The garden covers 76 hectares of the area, including South African plants, a record of about 200 bird species, a number of reptiles and small mammals (SAHO, 2019). In 2019, the Pretoria Botanical Garden hosted several events in which it was declared the world's largest Parkrun. The garden registered 52 000 participants to participate in the Parkrun (SANBI, 2019/2020). The botanical gardens are nature-based ordinarily, so they are potentially vulnerable to climate variability and change. Plants and flowers are susceptible to changes in wind, temperature and precipitation. Aspects such as droughts and temperature can affect plants, animals and other insects central to plants' performance in these gardens and waterfalls.

### Research methodology

A case study research approach was utilised in this mixed-methods study. In this study, the case study approach was applied because it allows for various data-gathering techniques. Another advantage of using this method is that it enables a broader investigation into research questions and theoretical evolution (Gustafsson, 2017). The case study approach allowed the researcher to demand much prior knowledge and get a clear explanation of the problems or

issues regarding the effects of climate change on botanical gardens (Marczyk et al., 2005). The study utilised a self-administered online questionnaire survey hosted on QuestionPro. The survey question development was guided by the need to respond to the key research questions and its subquestions as a guiding principle. Similar studies have also used the same research approach and techniques (Dube et al., 2018; Dube & Nhamo, 2020b). The questionnaire questions included the number of visits to the botanical gardens in the last five years, reasons for such visitations, experiences with adverse weather conditions during visits, and the impact thereof. Only tourists who had visited in the past five years or more were allowed to participate in the survey.

In this survey, 554 respondents were invited and agreed to participate in the survey. Out of those that agreed to participate only, 324 respondents completed the survey, translating to an 83.08% completion rate. This is a significantly high completion rate. The high completion rate was achieved by self-administering the survey to visitors at the two botanical gardens in question using tablets loaded with the survey. With the permission of botanical garden officials, visitors were approached during their visit to the gardens and requested to participate in the survey. A random sampling technique was used to approach the research participants. As the study was conducted at the height of the COVID-19 pandemic, all the protocols for COVID-19 were adhered to as approved by the World Health Organization. Online surveys are a standard feature in research nowadays, with many researchers using them to collect data (Saleh & Bista, 2017). An online survey is a data-collection tool where a set of questions are sent out to the target participants responding to questions on the worldwide web (Buchanan & Hvizdak, 2009). An online survey offers countless advantages as it is cost-efficient, flexible and saves respondents and researchers time as the responses are instantly captured and analysed (Wright, 2005). The survey tool offered the researcher an opportunity to reach a broader geographic audience.

Convenience sampling was used to collect data from tourists in botanical gardens. The researcher sought to collect information about tourists' perceptions of the impact of climate-related weather events on garden operations, garden experience, aesthetics and how such events can affect future visits to the garden. Visitors were also requested to give opinions on how the botanical gardens can better respond to the impact of climate variability and change. Additional data were obtained through direct field observations aimed at familiarising with the botanical gardens and identifying climate change impact markers such as evidence of erosion, fire destruction, evidence of climate change mitigation, and adaptation measures adopted to address climate change challenges. Direct observation is a widely used approach to collecting qualitative and quantitative data (Marczyk et al., 2005). Direct observations were done to extract evidence of climate change at Gauteng botanical gardens. The research was conducted in line with the ethics requirements of the Vaal University of Technology. Data were analysed using the QuestionPro Analysis tool. QuestionPro simultaneously analysed quantitative and qualitative data. Using QuestionPro, confidence levels, standard deviation and standard errors were calculated. The confidence level for statistical analysis was set at 95%. QuestionPro text analysis tool and word cloud were used to analyse open-ended questions. QuestionPro text analysis allows text tagging and quantifying open-ended responses into common themes and patterns (Merwe, 2019).

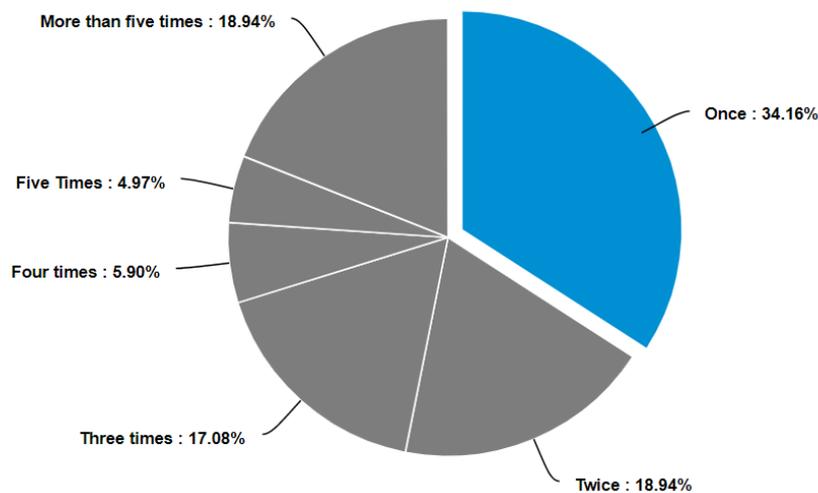
## **Results and discussions**

### ***Profile of respondents***

The study gathered views from 324 respondents. Of those 66%, females and males constituted (31%) while the remaining 3% fell into the other category. Of these respondents, 59.2% had visited only the Pretoria Botanical Garden, and 40.76% had visited the Walter Sisulu Botanical

Garden, while the remainder had visited both botanical gardens. It emerged from the study that most respondents are by and broadly knowledgeable about the gardens, given the repeat visits they made to the gardens in the last decade, as shown in Figure 2. At least close to two-thirds of respondents had visited the botanical gardens more than once, with only 34.16% having made single visits. This means that a number of the research participants had observed the changes in the garden over time. Knowledge of the garden and changes is an essential parameter to this study as it highlights that respondents are well placed to have made the relevant observations crucial to inform a considered perception.

Figure 2: Number of visits to the botanical gardens in the last 10 years (n=322)

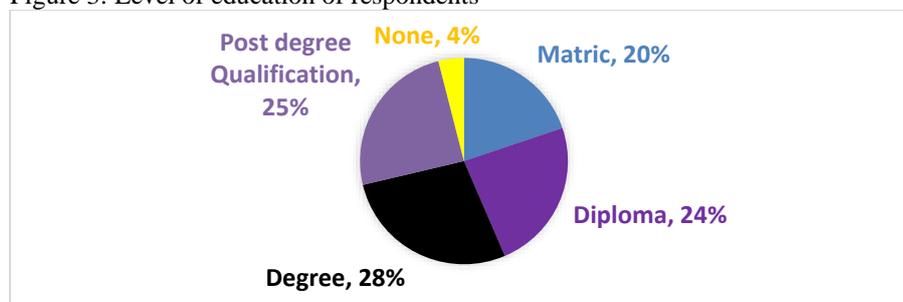


Mean: 2.854 | Confidence Interval @ 95% : [2.649 - 3.059] | Standard Deviation : 1.873 | Standard Error : 0.104

Source: Fieldwork 2021

Figure 3 shows that most respondents were at least educated with a higher degree. This indicates that a survey had high participation of educated respondents who completed a tertiary level, ensuring adequate knowledge of climate change, the impacts, and response strategies. Ordinarily, the profile of nature lovers such as ecotourists shows that these are highly educated individuals who are relatively knowledgeable and, as such, are preferred in climate change studies (Ana 2017). Also, education plays a role in shaping informed perceptions and beliefs (He & Chen 2012). As such, the findings of this study can be said to be valid and comes from a credible source.

Figure 3: Level of education of respondents

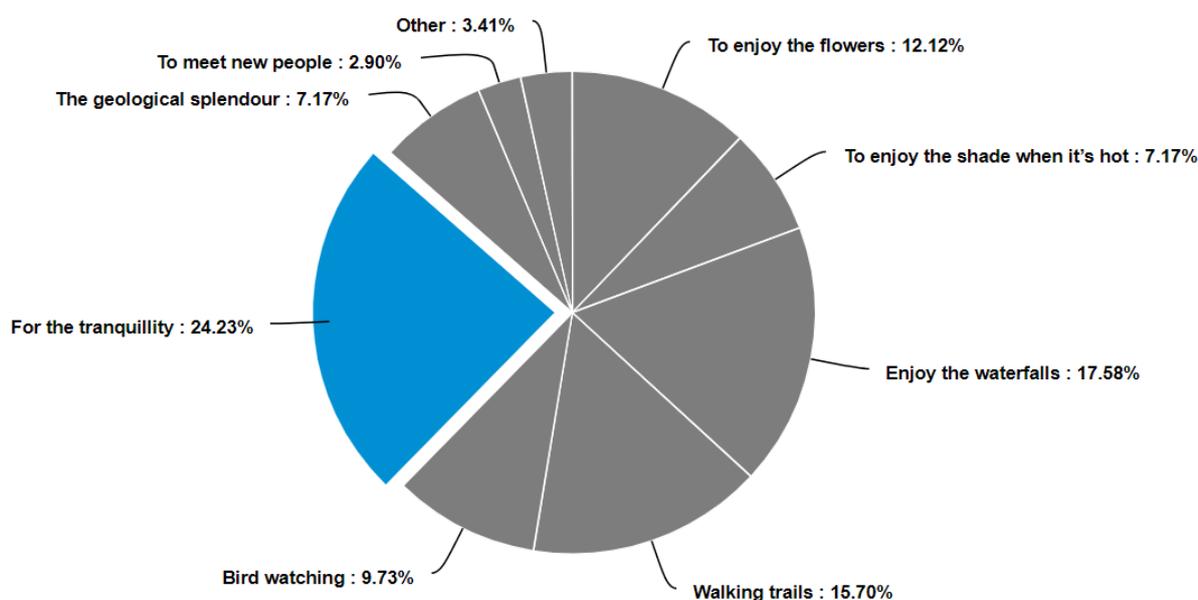


Mean: 2.703 | Confidence Interval @ 95% : [2.576 - 2.829] | Standard Deviation : 1.160 | Standard Error : 0.065

Source: Fieldwork 2021

Respondents indicated that they had made several visits to see the botanical gardens in different seasons and enjoyed activities suited to each season. However, most of these visits seem to be concentrated around the summer months, with 71% indicating that they frequent the gardens during summer-autumn 16% and spring 10%. Only very minimal numbers visit the gardens in winter at 3%. This could be because summer provides ideal conditions for outdoor activities such as picnics and the hosting of special events typically conducted in botanical gardens. The summers also coincide with the festive seasons, which see many people taking a break to relax at various tourism and recreational centres. At Walter Sisulu botanical gardens, summer is ideal for enjoying the waterfalls as it coincides with peak water flow, which is one of the most popular tourist features (see figure 4). Besides, summer is associated with greenery, and blooming vegetation in botanical gardens provide much-needed soothing shade during the peak of the summer heat, which is experienced in summer. Furthermore, the flower seasons also witness many visitors to the botanical gardens. About 10% of visitors to the botanical gardens indicated that they are attracted to the birds, with a substantial percentage alluding to the geological splendour of the gardens. Also, hikers who use the two botanical gardens are favoured for their walking trails, particularly by physical fitness enthusiasts. The activities and the attractions are potentially susceptible to climate variability and change like any other tourism activities (Hambira 2017; Santos-Lacueva et al. 2017; Scott et al. 2019).

Figure 4: Reasons for visiting botanical gardens.



Mean: 4.401 | Confidence Interval @ 95% : [4.231 - 4.571] | Standard Deviation : 2.104 | Standard Error : 0.087

Source: Fieldwork 2021

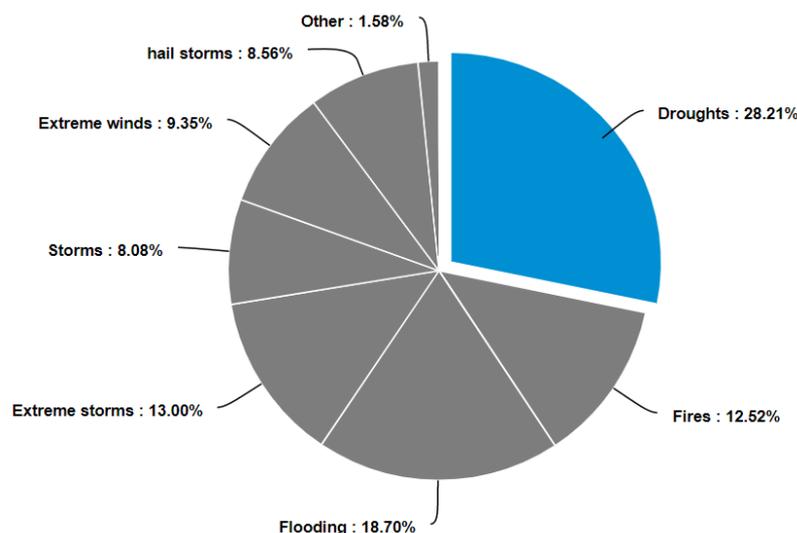
### ***Potential impacts and response to climate variability and change***

Perception is how “an individual gathers, processes and interprets information from the environment” (Alim et al., 2016). Climate and weather have a relatively high impact on tourism, tourist destinations and tourist perceptions, affecting tourists' experiences at a destination (Zhang 2016). Climate and weather-related events influence tourism activities and affect travel patterns and behaviours (Sandra et al., 2015). In that light, tourists were asked to state if they believed that extreme weather events attributed to climate change are indeed a threat to botanical gardens, to which 75% were affirmative. Only a minority (13%) believed

that climate change does not threaten botanical gardens, with the remaining (13%) unsure. The large number of respondents who said that climate change is a threat to botanical gardens is testimony to recognising climate change as a threat to the global economy, biodiversity and other activities as has been the norm across the world (Lovisolo 2021; Weiskopf et al., 2020). The perceptions of tourists are in line with other empirical studies that pointed to the vulnerability of botanical gardens in South Africa and other parts of the world (Dube et al., 2020; Thomas et al., 2022). A staggering 84% of the respondents reported that extreme weather events had adverse experiences in the botanical gardens, with the remainder (16%) not having had an unpleasant experience in the botanical gardens that can be linked to climate change. An unpleasant experience in a tourism-related industry attributed to climate change impacts is not new, as Brownlee et al. (2013) observed that climate change adversely affected visitor experience at botanical gardens.

The visitors highlighted what they think are the biggest climatic threats to botanical gardens, as shown in Figure 5. More than a third of the respondents identified drought as a significant threat to the botanical garden. This was unsurprising given the potential adverse impacts of droughts that adversely impacted nature-based tourism activities in South Africa and beyond. The Kirstenbosch Botanical Gardens suffered a decline in visitor arrivals due to the drought (Dube et al., 2020). Given that the botanical gardens are predominantly nature centres, a drought can disrupt vegetation and flower growth with an adverse consequence on the aesthetics of the gardens. Droughts can also, directly and indirectly, result in species losses due to die-offs. Akinyoyenu et al. (2018) noted that botanical gardens lost vegetation species in Nigeria because of climate change. Similar trends were recorded in other botanical gardens globally, with Hultine et al. (2016) citing the decline in some of the iconic succulent plants in botanical gardens and calling for increased conservation efforts. Such developments have potentially adverse impacts on visitor experience, primarily if the droughts affect their experiences.

Figure 5: Major climatic threats to botanical gardens



Mean: 3.304 | Confidence Interval @ 95% : [3.144 - 3.465] | Standard Deviation : 2.056 | Standard Error : 0.082

Source: Fieldwork 2021

It is also important to note that droughts have been noted to have adverse impacts on water-based tourism features elsewhere in the region. Droughts led to a massive decline in water flow

at the Victoria Falls waterfalls in Zimbabwe and Zambia at the height of the 2016 and 2019 droughts (Dube & Nhamo, 2020a). Therefore, it is well-founded fear for visitors to Walter Sisulu to fear for possible deterioration of the Witpoortje Falls, principally fed by about six springs located in Roodepoort. The upper basin of the Crocodile River that feeds onto the Witpoortje Falls is particularly vulnerable to rainfall and temperature changes. According to Leketa and Abiye (2019:1), on the impact of climate change on the Crocodile River, "if temperatures were increased by 1.5 °C and rainfall decreased by 20%, this would decrease of 39% in total streamflow and 28% in baseflow." This would undoubtedly have an adverse impact on the water flow at the waterfalls, much to the dismay of tourists. It would also adversely affect the aquatic life in that river.

Other weather events cited as particularly concerning are flooding, storms, and fire. Flooding is problematic for parts of the Walter Sisulu Botanical Garden located along the Crocodile River that feeds onto the Witpoortje Falls. The Crocodile River Field observations revealed that flooding is closely associated with storms and cloud bursts becoming more frequent in Johannesburg and the greater Gauteng region (Mawasha & Britz, 2021; Nhamo et al., 2021). In the past, such events had led to flooding, which resulted in damaged bridge infrastructure and walking trails cutting off certain parts of the garden.

Thunderstorms can be problematic as Gauteng, where the botanical gardens are located, often experiences violent storms that can curtail recreational activities and cause fires. Besides, fires were reported to be a menace to Walter Sisulu Botanical Garden. With large sections of the garden lying at the periphery of settlements and some areas of the garden being on wetland, fires that break out are most damaging to the environment as part of the botanical garden has a wetland that is drying up as a result of droughts. Fires in peat can be quite prolonged and transform the ecosystem. These fires also threaten infrastructure in the garden and produce a lot of atmospheric, land and general aesthetic pollution. Such pollution makes the garden unsuitable for any recreation activities or special events that are sometimes hosted in the gardens. Under climate change, fires are expected to be more frequent and intense (Restaino & Safford 2018), which could prove challenging and disruptive for recreational activities in Walter Sisulu Botanical Gardens.

Extreme weather events are problematic and disruptive to the aesthetics of botanical gardens. Visitors love the botanical gardens for the beautiful scenery and aesthetics. Botanical gardens are often used to photograph during special events such as weddings, graduation ceremonies, and other special events. Therefore, the disruptive nature of extreme weather events undermines the aesthetic integrity of botanical gardens, which can cause the loss of their recreation value. It is expected that an increase in the number and occurrence of extreme weather events might increase the number of days that are unsuitable for visiting the botanical gardens, which might affect the annual number of visitors and revenue that is badly needed for conservation.

Besides the loss in the aesthetic value of botanical gardens, visitors complained that extreme weather events hurt bird species. Both gardens have bird species that form part of the attraction. At least 311 respondents noted that they had witnessed a decline in bird species in the gardens. Such loss could be attributed to habitat loss and reduced habitat quality in and outside the botanical garden. This warrants attention by garden officials and society as this could adversely affect bird watchers to the two botanical gardens.

The other concern was a general decline in biodiversity in the gardens. About 312 (80%) visitors felt that the botanical gardens were losing biodiversity because of climate change. A loss in biodiversity has far-reaching implications beyond botanical gardens and impacts people's quality of life in urban environments where these gardens are located. Loss of biodiversity has been of grave concern globally in the recent past, as noted by the

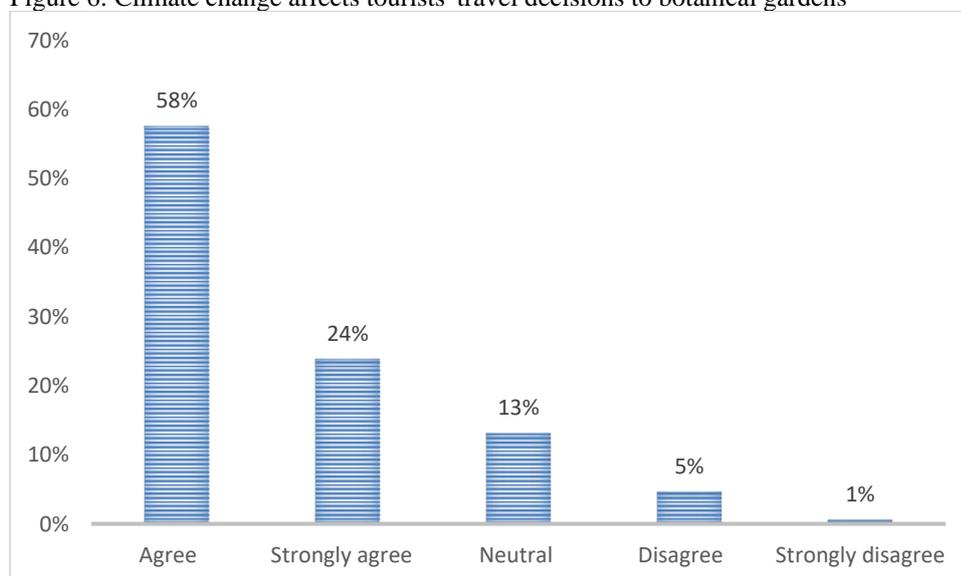
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services-IPBES (2019).

Several of the activities visitors undertake in the gardens are adversely affected by extreme weather events. Most respondents (41%) identified picnics activities as the most undermined activity by severe weather events. About 22% complained about the impact of extreme weather events on walking trails 22%, bird watching 13%, waterfall viewing 12%, guided tours 9% and 3% of other activities. It would seem the extreme weather events would curtail several activities in the botanical gardens in Gauteng, with possible implications for repeat visits from tourists.

As much as visitors believed that climate variability and change impacted botanical gardens, tourists were divided as to their opinion on the impact of botanical garden operations on climate change. At least 41% of respondents noted that botanical garden operations impacted climate change, with the other 41% indicating that the garden operations, including visitors, had no impact on climate change. This is not unique, as other studies have previously demonstrated that several tourists and visitors are still denying their contribution to climate change (Dube et al., 2018). This means there is a need to raise more education and awareness in botanical gardens and other protected areas about the environmental impacts of human activities, which are often ignored or understated.

Visitors were asked to account for whether the impacts of travel decisions can be potentially affected by climate change (figure 6). Again about 75% indicated that climate could play a central role in shaping travel decisions to botanical gardens. This is a critical finding as it means botanical garden planning has to consider climate change as it can affect future visitor numbers with consequences on revenue. Wilkins et al. (2018) had earlier noted that climate change could cause delays and/or trip cancellations and ultimately affect satisfaction and stay at a destination.

Figure 6: Climate change affects tourists' travel decisions to botanical gardens



Source: Fieldwork 2021

### ***Role of botanical gardens in climate change action***

The survey revealed that most respondents (65%) were generally fearful that climate change would adversely affect the recreational function of botanical gardens. In the same breath, visitors were asked to suggest some solutions to climate change in botanical gardens. One of the proposed solutions was to ensure that botanical gardens reduce their energy and, by proxy,

carbon emissions to deal with the threats of climate change and assist the world on a better climate trajectory (Figure 7). Achieving carbon neutrality has been pushed as one solution to tackling the climate emergency that is facing the world (Aram et al., 2022; Fankhauser et al., 2022;). This suggestion finds resonance with the Paris Agreement and the Sustainable Development Goals (Agenda 2030) as an antidote to the impending dangerous climate if emissions are not drastically cut. The world will need to cut at least 45% of carbon emissions from 2010 levels by 2030 (Li & Qin 2019) to avoid dangerous climate backlash.

Figure 7: Word Cloud on suggested solutions to climate change challenges in botanical gardens



Source: Fieldwork 2021

Visitors indicate that there was a need for botanical gardens to go green through energy conservation, reduce water use, plant indigenous trees, invest in climate change awareness projects, and embark on greening activities. The suggested solutions are all necessary to adopt by botanical gardens in Gauteng, the country at large, as these will foster a spirit of green and sustainable living amongst the visitors. With evidence from the field observation indicating that some of the buildings aren't designed to ensure resource efficiency, there might be a need to invest in green buildings or retrofit the design of the existing building as a first step toward cutting the carbon footprint of the botanical gardens. According to Mzingo and Arens (2014), green buildings could cut as much as 50% of greenhouse gas emissions, reduce water and waste produced by a building. Consequently, green buildings can limit the impacts of climate change (Knowles, 2008).

Tourists also suggested that botanical gardens should plant more trees to absorb carbon dioxide and mitigate greenhouse gas emissions produced by human activity. Trees play an essential role in carbon sequestration, capturing and storing excess carbon dioxide (Derouin, 2019). The issue of trees is also critical as they can also assist in cooling the atmosphere in the botanical gardens during the hot summer months and provide ample shade for picnics.

There were also calls for the botanical gardens to increase environmental awareness on climate change, recycling, responsible consumption and indigenous plants. There are crucial issues that fall directly within the mandate of botanical gardens and the South African National Biodiversity Institute (SANBI), the custodian of the botanical gardens. It is of utmost importance for botanical gardens to improve their environmental sustainability, minimise environmental impacts and increase environmental awareness among visitors (Erdogan & Tosun, 2009). The call resonates with Chen and Sun (2018) and Cavender and Donnelly (2019) that botanical gardens be centres for sustainable, conservation, and environmental science education.

Raising environmental awareness is essential in examining their damage perception of critical environmental aspects for improving personal interactions with surrounding nature (Garcia et al., 2012). It is also crucial for botanical gardens to cooperate with other businesses to build strategic plans to reduce climate change impacts. Scott et al. (2016) stated that adaptation strategies hamper resilient tourism operations and destinations due to a lack of knowledge and communication about climate change impacts and adaptation strategies.

### **Conclusions and recommendations**

Results show that most participants believed that climate change is a threat to botanical gardens, with drought singled out as the most significant threat to botanical gardens. Drought was observed to disrupt flowering and vegetation in the gardens. Similar threats were also observed in other gardens that experienced a decline in succulent plants. Flooding, storms and fire were the most disturbing factors in both gardens. Such events affect the visitor experience of botanical gardens. In many respects, the extreme events are problematic to the aesthetics and enjoyment of visitors to botanical gardens. It emerged that an increase and occurrence of extreme weather events could also affect visitor numbers to the gardens, resulting in a loss of revenue. The study also revealed that bird species were witnessed to be hurt by extreme weather events. Such effects were seen to lead to a decline in bird species. Besides, biodiversity was also revealed as the other concern in the garden, with most visitors concerned that botanical gardens are losing biodiversity because of climate change. Due to global warming and rainfall patterns, loss in vegetation and biodiversity was also a significant concern. Given the activities tourists undertake in the gardens, picnics were identified as the most undermined activity by extreme weather events. The study revealed that climate change affects tourists' travel decisions to botanical gardens, affecting their experience of visiting botanical gardens. Regardless of these findings, the respondents suggested that botanical gardens need to shrink their carbon footprint to deal with the threats of climate change.

The study makes a significant contribution to understanding climate change impacts in these critical urban tourism and recreational centres. There seem to be similarities in the impacts that have been felt in other tourism destinations and botanical gardens concerning the impacts of climate change. Nonetheless, the perceived lack of concrete actions being taken to address climate change in botanical gardens is concerning, given that in other areas, botanical gardens act as learning hubs for green living where visitors can go and learn about sustainable ways of living. Therefore, there is a need for the parent organisation tasked with protecting botanical gardens to do more to ensure responsiveness regarding their role in climate change protection action. The observed impacts of extreme weather events such as droughts call for botanical gardens to do more in Waterwise gardens, where water efficiency is a must. Addressing water challenges in water-stressed countries such as South Africa is critical in ensuring that botanical gardens aren't severely disrupted by climate change impacts in the provision of critical ecosystem services which botanical gardens provide. The adoption of nature-based solutions in addressing some of these challenges, such as the growth of

indigenous plants as suggested by visitors, can play a dual purpose of saving water and ensuring continuity of the gardens even amid the threat of climate change. The vulnerability of some of the infrastructure calls for botanical gardens to be proactive in retrofitting some buildings to ensure energy efficiency and climate resilience. Disaster preparedness and management have to be budgeted to ensure that in case of climate-related disasters, the botanical gardens are better prepared for such challenges.

Given the limited studies on botanical gardens and climate change studies, there is a need for increased research attention in these areas from all facets and geographic areas to improve understanding, which will feed into policy and practice in botanical gardens.

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